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DEPARTMENT
OF
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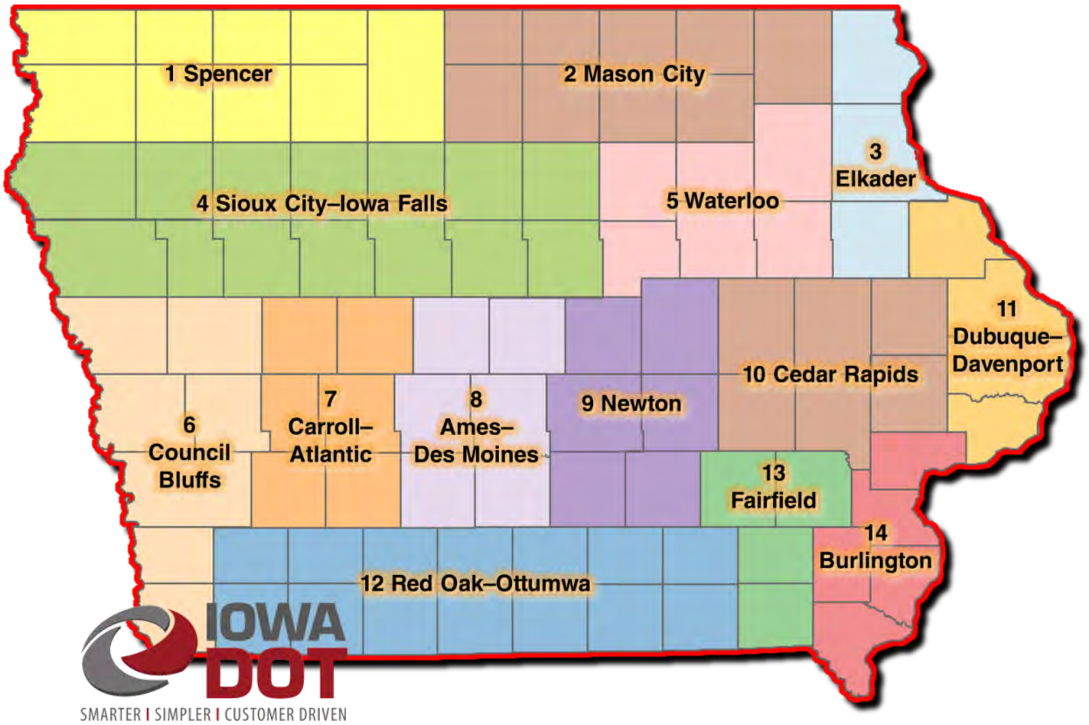

Iowa Regional Coordinate System

Handbook and User Guide

Version 2.10
September 16, 2014

www.iowadot.gov/rtn/IaRCS.aspx

Abstract

This document provides the history, development, best practice methods, and technical details of a new coordinate system for the State of Iowa. The Iowa Regional Coordinate System (IaRCS) is based on a set of 14 “low distortion” map projection zones with parameters that have been defined such that linear distortion is negligible within the counties that define the zone. Distances computed between points in the grid coordinate system will nearly equal the actual horizontal distance between the same points on the ground (within a tolerance of ±25 parts per million, or ±0.13 foot per mile). The IaRCS has been designed such that it can be readily used with a wide variety of software platforms for surveying, engineering, GIS, and cartographic mapping applications. It is important to realize that rectangular grid coordinates for all of the IaRCS zones may be calculated with formulas through computer programs that would have seemed too complicated in the past, but now may be considered routine. These same computer programs also make it a relatively simple procedure to perform transformations, that is, to change the coordinates of points from one coordinate system to another. While having 14 coordinate system zones for the state of Iowa may seem cumbersome, actual user application through highly precise GNSS and terrestrial measurement devices provide for a level of mapping accuracy that is beneficial to all mapping professionals.

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Richard Nava, Geodetic Analysis, LLC
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Mark Armstrong, PLS, National Geodetic Survey, Oregon Advisor

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Living Document

This IaRCS Handbook and User Guide is intended to be a "living document" and will be updated as new information becomes available.

The IaRCS was created with state funds and volunteer effort for the benefit of surveying, engineering, GIS, and mapping professionals in the State of Iowa. Iowa is now one of several states that have created new coordinate systems based on "low distortion" map projections.

Contact Information for Revision to Document

If there are topics that should be added, covered in more depth, clarified, modified or revised to incorporate specific workflows, please contact:

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Chapter 1. History of Coordinate Systems at the Iowa DOT

1.1. History and Development of the Iowa Regional Coordinate System (IaRCS)

In a paper presented before the Surveying and Mapping Division of the American Society of Civil Engineers in 1935 it was reported that during 1932 and 1933, at the request of an engineer employed by the North Carolina Highway Commission, the Coast and Geodetic Survey cooperated with the State of North Carolina to develop a system of plane coordinates. This led to development of state plane coordinate systems for the 48 states and was completed in 1934. The paper reported that Iowa was one of several states making extensive use of the state plane coordinate system.

In September 1936 the Federal Board of Surveys and Maps made a recommendation that its member organizations adopt the system of plane coordinates devised for each state by the Coast and Geodetic Survey. It was also recommended that the appropriate state plane coordinates system be shown on all maps and charts which may have value for engineering purposes, but which because of their nature or extent require a geographic base.

It has taken many years for the Iowa Department of Transportation to adopt the recommendation that it use coordinate systems projected from a true geographic base to produce engineering plans and maps. Until the mid-1980s most plans and maps were produced from alignments using arbitrary direction and drafted using stations and offsets from alignments. There was no real geographic basis to this system.

In the mid-1980s when electronic data collection devices and computerized mapping were introduced it was realized that utilizing coordinate systems made mapping easier than using alignments with all their curves and angles. While it made mapping easier there was no geographic basis. Each project had its own coordinate system that had an arbitrary origin and an estimated relationship to north.

In 1993 the definition for Iowa State Plane North Zone and South Zone was enacted into Chapter 355 of the Iowa Code. This coincided with an effort by the Design Office of the Iowa Department of Transportation to utilize the state plane coordinate system as a basis for survey control for many of its major projects. Design engineers and surveyors were concerned that differences in length would be too noticeable when compared with computed inverses between state plane coordinate pairs and distances measured using modern survey equipment. The differences in length, it was realized, could exceed 100 parts per million. This was considered unacceptable.

One solution to this problem, although geodetically faulty, is to modify the state plane coordinate system for each project. This system is also known as “Local Datum Plane Coordinates” (LDPC) where a central project point is held fixed to its actual state plane coordinate value, and all other project coordinates are scaled about it by a factor that will closely agree with survey measurements. While this gives each project a true geographic basis at one central point it also creates the potential for causing confusion. One concern is that scaled project coordinates can be mistaken for true state plane coordinates. In addition, the scaled system is no longer truly geographic, which caused problems when combining with other datasets. For example, geographic imagery overlaid will only be approximate, and adjacent project maps will overlap with some variance in orientation.

This document describes a geodetically sound method of developing a system of low distortion map projections. The system is based on true conformal projections designed to cover specific portions of urban and rural areas of the state. This system, the Iowa Regional Coordinate System (IaRCS), will serve both the Department of Transportation and measurement professionals statewide.

1.2. Approach for IaRCS Design and Implementation

The following elements were used in the design and implementation of the IaRCS:

1. A maximum statewide distortion limit of 1:40,000 = ±25 parts per million (ppm) = ±0.13 foot/mile
2. Bases on two common and easy-to-implement conformal map projections: The Transverse Mercator and Lambert Conformal Conic (single parallel).
3. For Lambert Conformal Conic zones, the latitude of grid origin is the same as the standard parallel.
4. Linear units is the U.S. survey foot, also referred to herein as “US foot” and “sft.”
5. Zones will cover as large an area as possible and still meet the distortion criteria, so as to minimize the total number of zones.
6. The defined extent of each zone conforms to county boundaries.
7. All zones have positive northing and easting coordinates within the zone area.
8. Each zone has unique coordinates that differ from those in other zones by a significant amount so as not to be confused with one another.
9. The false easting of each zone defined as the zone number × 1,000,000 + 10,500,000 (e.g., Zone 6 has false easting = 6 × 1,000,000 + 10,500,000 = 16,500,000 sft). Intent is that easting coordinates help identify the zone.
10. The northings and eastings for each zone are designed to be markedly different than Iowa State Plane coordinates (both NAD 27 and NAD 83) and UTM.
11. Referenced to the National Spatial Reference System (NSRS), currently defined geometrically as NAD 83 (based on the GRS-80 ellipsoid). The projection parameters are not affected by a specific realization of NAD 83, since all of these realizations reference the GRS 80 ellipsoid.
12. Projections created are referenced to NAD 83 “generically” with specific realization of NAD 83 (such as HARN, CORS96, NSRS2007, 2011) stated in the metadata associated with the observed project datasets.
13. Stakeholders were involved in development and review of the IaRCS (internal IaDOT staff, local and state surveying associations, etc.).
14. Implementation of the IaRCS includes publishing all defining parameters and making them readily available to the public.
15. Involve software vendors so that the IaRCS can be included in their software.
16. Interact with NGS in the future to discuss the possibility of the IaRCS and other state legislated zones being included on NGS datasheet output files, including OPUS output results
17. The vertical datum will be the current NAVD 88. The geoid model used is part of the metadata belonging to a full coordinate system definition; however the vertical datum and geoid are independent of the IaRCS projection zone parameters.
18. There is no requirement for a site “calibration” or “localization” for determining IaRCS coordinates.

1.3. Why the Iowa State Plane Coordinate System is Deficient for Certain Modern Day Uses

As noted previously, the State Plane Coordinate system was first studied in 1933 by the U.S. Department of Commerce, Coast and Geodetic Survey and eventually adopted for Iowa law (legal status), most recently in 1993. Iowa State Plane is based on the two-parallel Lambert Conformal Conic Projection with two zones, North and South (zone numbers 1401 and 1402, respectively). By using two zones, the north-south width of each zone could be kept within 115 miles (less than the typical state plane zone width of 158 miles, as shown in Figure 1.3.1). By defining a scale of exactly 1 on the standard parallels, the maximum distortion (at the topographic surface) was limited to approximately one part in 8,300 (120 parts per million).

The State Plane system presents the following issues for the surveying, engineering, and GIS communities:

- Does not represent ground distances except near the standard parallels
- Does not minimize distortion over large areas and at varying elevations
- Does not reduce convergence angles

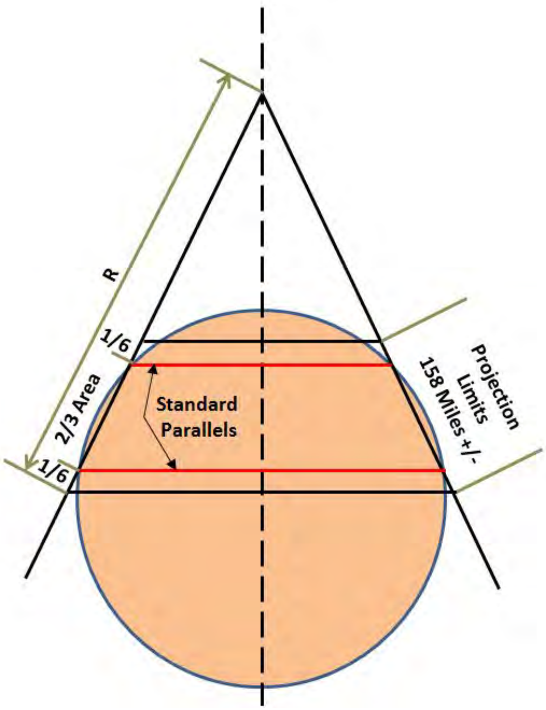

Figure 1.3.1. *Iowa State Plane Two parallel Lambert Conformal Conic Pro-*

Currently State Plane coordinates are available for all horizontal control points published by the National Geodetic Survey (NGS) on NGS Datasheets, and are also generated for all point coordinates determined by the NGS Online Positioning User Service (OPUS). The Iowa State Plane Coordinate System still maintains some limited advantages for general surveying and mapping (GIS) at a statewide level, such as depicting physical, cultural, and human geography over large areas of the state. It also works well for mapping long linear facility lines such as highways, electrical transmission, and pipelines, which crisscross the state. The State Plane Coordinate System provides for a common reference (map projection) for conversions (transformations) between other coordinate systems including the zones of the IaRCS. Figure 1.3.2 depicts total linear distortion (at the topographic surface of the Earth) for both the North and South Iowa State Plane zones.

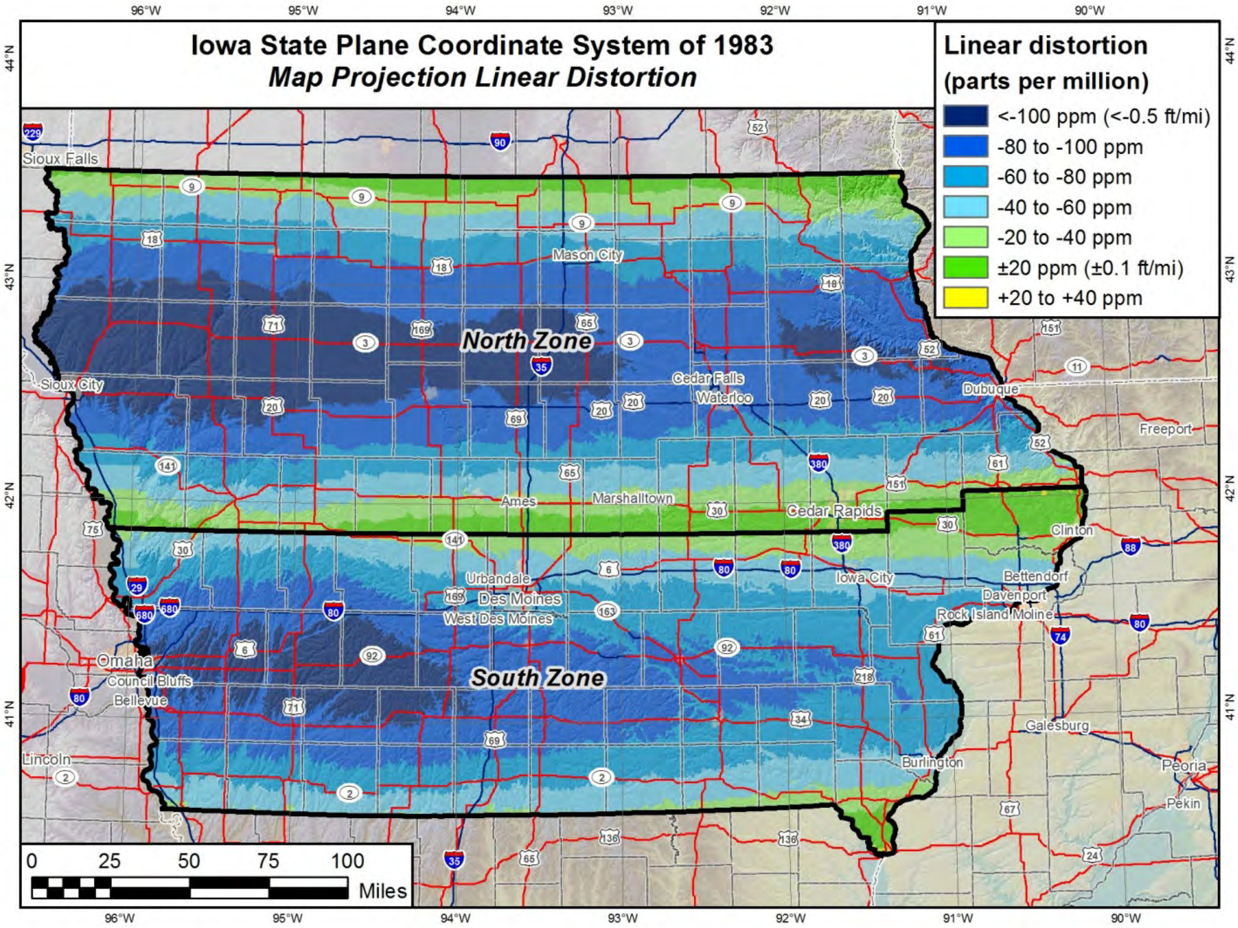

Figure 1.3.2. Linear distortion at the topographic surface for both zones of the Iowa State Plane Coordinate System of 1983.

1.4.1. Iowa State Plane Coordinate System Definitions

IOWA NORTH ZONE (designation 1401)

Iowa State Plane North - NAD 1983
Lambert Conformal Conic Two Standard Parallel Projection (Secant)

Central Meridian:	93° 30’ W
Latitude of Origin:	41° 30’ N
Standard Parallel (South):	42° 04’ N
Standard Parallel (North):	43° 16’ N
False Northing:	1,000,000 m (3,280,833.333 US survey feet)
False Easting:	1,500,000 m (4,921,250.000 US survey feet)
Max linear distortion:	1:8,200 (-122 ppm) *Note:* This is distortion with respect to the topographic surface. Maximum distortion with respect to the ellipsoid is 1:18,300 (-54.6 ppm) and occurs along the central parallel.

North Zone County Coverage:

Allamakee, Benton, Black Hawk, Boone, Bremer, Buchanan, Buena Vista, Butler, Calhoun, Carroll, Cerro Gordo, Cherokee, Chickasaw, Clay, Clayton, Crawford, Delaware, Dickinson, Dubuque, Emmet, Fayette, Floyd, Franklin, Greene, Grundy, Hamilton, Hancock, Hardin, Howard, Humboldt, Ida, Jackson, Jones, Kossuth, Linn, Lyon, Marshall, Mitchell, Monona, O'Brien, Osceola, Palo Alto, Plymouth, Pocahontas, Sac, Sioux, Story, Tama, Webster, Winnebago, Winneshiek, Woodbury, Worth, and Wright.

IOWA SOUTH ZONE (designation 1402)
Iowa State Plane South - NAD 1983
Lambert Conformal Conic Two Standard Parallel Projection (Secant)
Central Meridian: -93° 30’ (W)
Latitude of Origin: 40° 00’
Standard Parallel (South): 40° 37’
Standard Parallel (North): 41° 47’
False Northing: 0 m (0 US survey feet)
False Easting: 500,000 m (1,640,416.667 US survey feet)
Max linear distortion: 1:8,900 (-112 ppm) *Note:* This is distortion with respect to the topographic surface. Maximum distortion with respect to the ellipsoid is 1:19,400 (-51.6 ppm) and occurs along the central parallel.

South zone County Coverage:
Adair, Adams, Appanoose, Audubon, Cass, Cedar, Clarke, Clinton, Dallas, Davis, Decatur, Des Moines, Fremont, Guthrie, Harrison, Henry, Iowa, Jasper, Jefferson, Johnson, Keokuk, Lee, Louisa, Lucas, Madison, Mahaska, Marion, Mills, Monroe, Montgomery, Muscatine, Page, Polk, Pottawattamie, Poweshiek, Ringgold, Scott, Shelby, Taylor, Union, Van Buren, Wapello, Warren, Washington, and Wayne.

1.5. Low Distortion Map Projections General Issues

1.5.1. Low Distortion Map Projection Systems

Low distortion map projections (like those within the IaRCS coordinate system) are based on true conformal projections designed to cover specific portions of urban and rural areas of the state. For conformal projections (e.g., Transverse Mercator, Lambert Conformal Conic, Stereographic, Oblique Mercator, regular Mercator, etc.), linear distortion is the same in every direction from a point. That is, the scale at any particular point is the same in any direction and figures on the surface of the Earth tend to retain their original form on the map. The term “low distortion” refers to minimizing the linear horizontal distortion from two affects: 1) representing a curved surface on a plane and 2) departure of the elevated topography from the projection surface due to variation in topographic height of the area covered. See Section 2.2 for more information on map projection distortion.

The <u>advantages</u> of a low distortion projection are:

- Grid coordinate distances closely match the same distance measured on the ground.
- Allow for larger areas to be covered with less distortion.
- Reduced convergence angle (if the central meridian is centered within the zone).
- Quantitative distortion levels can be determined from location and topographic height.
- Clean zone parameter definitions compatible with common surveying, engineering, and GIS software.
- Easy to transform between other coordinate systems.
- Maintains a relationship to the National Spatial Reference System (NSRS) by allowing direct use of published NSRS control coordinates (i.e., latitude, longitude, and ellipsoid height).
- Can cover entire cities and counties making them useful for regional mapping and GIS.

1.5.2. Projection Grid Coordinates

Because calculations relating latitude and longitude to positions of points on a given map can become quite involved, rectangular grids have been developed for the use of surveyors, engineers, and GIS mapping professionals. In this way, each point may be designated merely by its distance from two perpendicular axes on the “plane” map. The *Y* axis normally coincides with a chosen central meridian, *y* increasing north. The *X* axis is perpendicular to the *Y* axis at a latitude of origin on the central meridian, with *x* increasing east. Commonly, *x* and *y* coordinates are called "eastings" and "northings," respectively, and to avoid negative coordinates may have "false eastings" and "false northings" added to relate to the projection grid origin.

Chapter 2. Projected Coordinate Systems

2.1. Types of Conformal Map Projections Used for the IaRCS

2.1.1. Lambert Conformal Conic Projection

As the name implies, this Lambert projection is conformal (preserves angles with a unique scale at each point). This projection superimposes a cone over the sphere of the Earth, with either one reference parallel tangent (or above the globe in the typical case of a low distortion projection) or with two standard parallels secant (a straight line that intersects with the globe in two places). Specifying a "central meridian" orients the cone with respect to the ellipsoid. Scale error (distortion with respect to the ellipsoid) is constant along the parallel(s). Typically, it is best used for covering areas long in the east–west direction, or, for low distortion applications, where topographic height changes more-or-less uniformly in the north-south direction. The Lambert Conformal Conic projection for the IaRCS is designed using a single parallel. The cone of the projection is typically scaled up from the ellipsoid to "best fit" an area and range of topographic height on the Earth's surface (see Figure 2.2.3).

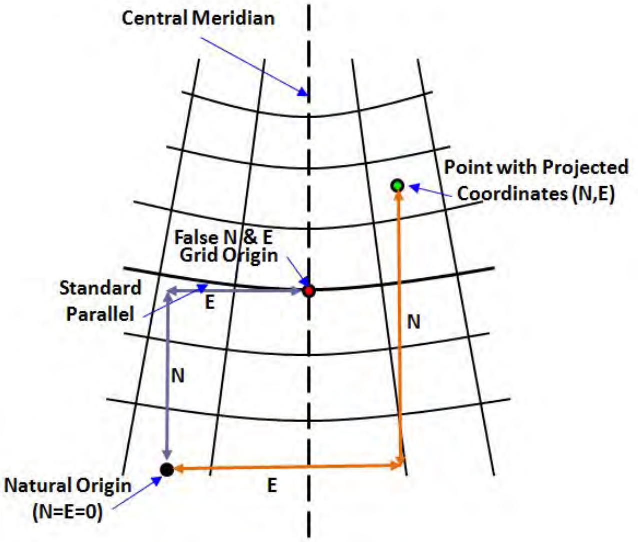

Figure 2.1.1. *Diagram for Lambert Conformal Conical projection with one standard parallel.*

2.1.2. Transverse Mercator Projection

The Transverse Mercator is a conformal projection with a developable surface that can be visualized as a cylinder. The cylinder is superimposed over the reference ellipsoid in a "transverse" orientation, i.e., with the cylinder axis in the equatorial plane. The curved surface of the cylinder coincides with a "central meridian" along which the scale is constant. This projection is used for many State Plane zones and the familiar UTM (Universal Transverse Mercator) map projection series, and it is probably one of the most commonly used projections for large-scale mapping. This projection works particularly well for areas long in the north–south direction, and for low distortion applications where topographic height changes more-or-less uniformly in the east-west direction.

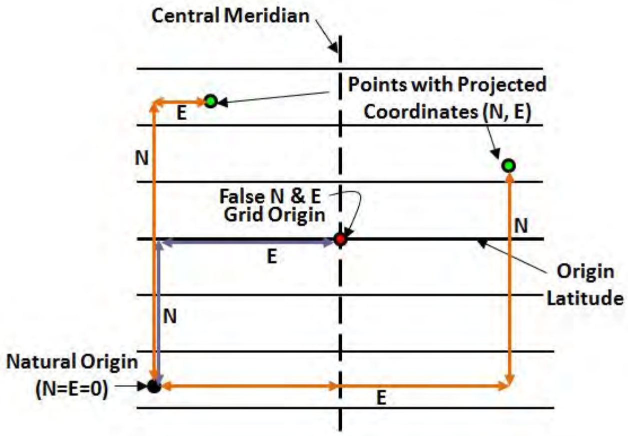

Figure 2.1.2. *Diagram for Transverse Mercator projection.*

2.2. Managing Map Projection Distortion

2.2.1. Distortion is Unavoidable

Johann Carl Friedrich Gauss's (1777–1855) Theorema Egregium (Remarkable Theorem) mathematically proved that a curved surface (such as the Earth's ellipsoid model) cannot be represented on a plane without distortion. Since any method of representing a sphere's surface on a plane is a map projection, all map projections produce distortion and every distinct map projection distorts in a distinct way. For low distortion projections, deciding on the type of map projection that best minimizes distortion for an area of the earth may not be an obvious or clear-cut task.

2.2.2. Two General Types of Map Projection Distortion

<u>1. Linear distortion</u> - The difference in horizontal distance between a pair of grid (map) coordinates when compared to the true (ground) horizontal distance is shown by *δ* in tables 2.2.2.1 and 2.2.2.2 (and schematically in figures 2.2.2.1 and 2.2.2.2). This may be expressed as a ratio of distortion length to ground length: E.g., feet of distortion per mile; parts per million (= mm per km). *Note:* 1 foot / mile = 189 ppm = 189 mm / km.

Linear distortion can be positive or negative:
<u>Negative</u> distortion means the grid (map) length is <u>shorter</u> than the "true" horizontal (ground) length.
<u>Positive</u> distortion means the grid (map) length is <u>longer</u> than the "true" horizontal (ground) length.

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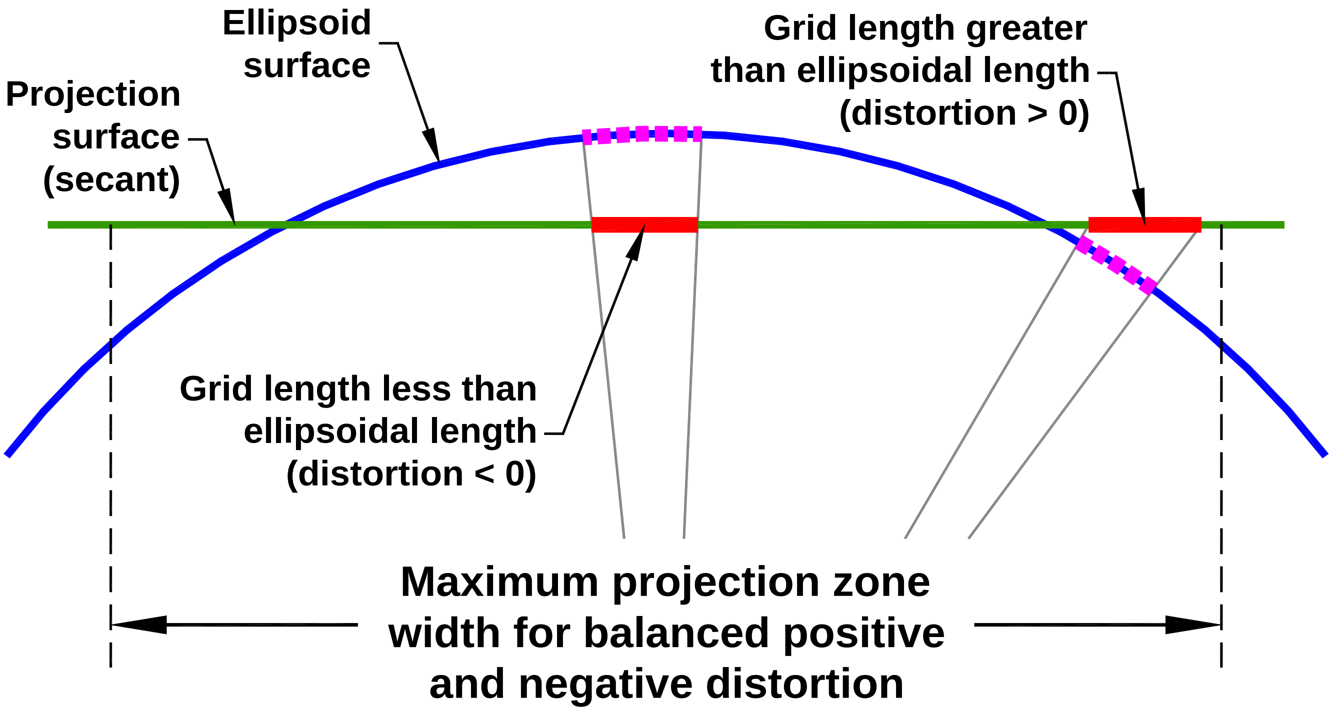

Figure 2.2.2.1. *Linear distortion due to earth curvature.*

Table 2.2.2.1. *Maximum linear distortion for various projection zone widths.*

Maximum zone width for secant projections (km and miles)	**Maximum linear horizontal distortion, δ**		
	Parts per million (mm/km)	**Feet per mile**	**Ratio (absolute value)**
25 km (16 miles)	±1 ppm	±0.005 ft/mile	1 : 1,000,000
57 km (35 miles)	±5 ppm	±0.026 ft/mile	1 : 200,000
81 km (50 miles)	±10 ppm	±0.05 ft/mile	1 : 100,000
114 km (71 miles)	±20 ppm	±0.1 ft/mile	1 : 50,000
180 km (112 miles)	±50 ppm	±0.3 ft/mile	1 : 20,000
255 km (158 miles) e.g., SPCS*	±100 ppm	±0.5 ft/mile	1 : 10,000
510 km (317 miles) e.g., UTM†	±400 ppm	±2.1 ft/mile	1 : 2,500

*State Plane Coordinate System; zone width shown is valid between ~0° and 45° latitude

†Universal Transverse Mercator; zone width shown is valid between ~30° and 60° latitude

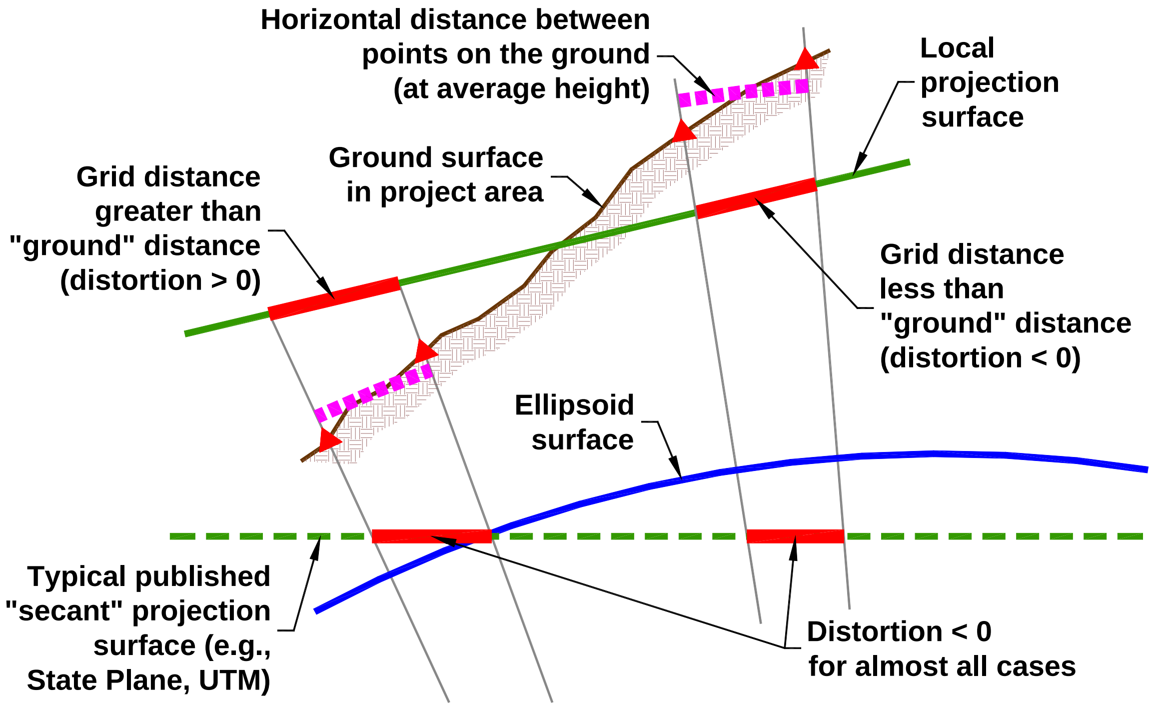

Figure 2.2.2.2. *Linear distortion due to ground height above ellipsoid.*

Table 2.2.2.2. *Linear distortion at various heights with respect to projection surface.*

Height below (–) and above (+) projection surface	Maximum linear horizontal distortion, *δ*		
	Parts per million (mm/km)	**Feet per mile**	**Ratio (absolute value)**
±30 m (±100 ft)	±4.8 ppm	±0.025 ft/mile	~1 : 209,000
±120 m (±400 ft)	±19 ppm	±0.10 ft/mile	~1 : 52,000
±300 m (±1000 ft)	±48 ppm	±0.25 ft/mile	~1 : 21,000
+600 m (+2000 ft)*	–96 ppm	–0.50 ft/mile	~1 : 10,500
+1000 m (+3300 ft)**	–158 ppm	–0.83 ft/mile	~1 : 6,300
+4400 m (+14,400 ft)†	–688 ppm	–3.6 ft/mile	~1 : 1,500

*Approximate mean topographic height of North America (US, Canada, and Central America)
** Approximate mean topographic height of western coterminous US (west of 100°W longitude)
† Approximate maximum topographic height in coterminous US

Rule of Thumb: A 30 m (100-ft) change in height causes a 4.8 ppm change in distortion

Creating an LDP and minimizing distortion by the methods described in this document only makes sense for conformal projections. For conformal projections (e.g., Transverse Mercator, Lambert Conformal Conic, Stereographic, Oblique Mercator, regular Mercator, etc.), linear distortion is the same in every direction from a point. For all non-conformal projections (such as equal area projections), linear distortion generally varies with direction, so there is no single unique linear distortion (or "scale") at any point.

<u>2. Angular distortion</u> - For conformal projections, this equals the *convergence* (*mapping*) *angle* (γ). The convergence angle is the difference between grid (map) north and true (geodetic) north. Convergence angle is zero on the projection central meridian, positive east of the central meridian, and negative west of the central meridian, as shown in table 2.2.2.3 below.

The magnitude of the convergence angle increases with distance from the central meridian, and its rate of change increases with increasing latitude.

Table 2.2.2.3 shows "convergence angles" at a distance of one mile (1.6 km) east (positive) and west (negative) of projection central meridian (for both Transverse Mercator and Lambert Conformal Conic projections).

Table 2.2.2.3. *Convergence angle 1 mile from central meridian at various latitudes.*

Latitude	Convergence angle 1 mile from CM	Latitude	Convergence angle 1 mile from CM
0°	0° 00′ 00″	50°	±0° 01′ 02″
10°	±0° 00′ 09″	60°	±0° 01′ 30″
20°	±0° 00′ 19″	70°	±0° 02′ 23″
30°	±0° 00′ 30″	80°	±0° 04′ 54″
40°	±0° 00′ 44″	89°	±0° 49′ 32″

Usually convergence is not as much of a concern as linear distortion, and it can only be minimized by staying close to the projection central meridian (or limiting surveying and mapping activities to equatorial regions of the Earth). Note that the convergence angle is zero for the regular Mercator projection, but this projection is not suitable for large-scale mapping in non-equatorial regions. In topographically rugged areas (such as much of the western US), distortion due to variation in ground height is greater than that due to curvature. **The total linear distortion of grid (map) coordinates is a combination of distortion due to Earth curvature and distortion due to ground height above the ellipsoid.**

2.2.3. Six Steps for Designing a Low Distortion Projection (LDP)

1. **Define project area and choose *representative* ellipsoid height (not elevation)**

- The *average* height of an area may not be appropriate (e.g., for projects near a mountain).
    - ○ Usually no need to estimate height to an accuracy of better than about ±20 ft, especially since the scale based on the height will be refined during the design process.
- Note that as the size of the area increases, the effect of Earth curvature on distortion increases, and it must be considered in addition to the effect of topographic height.
    - ○ E.g., for areas wider than about 35 miles perpendicular to the projection axis (i.e., ~18 miles either side of projection axis), distortion due to curvature alone exceeds 5 parts per million (ppm). The "projection axis" is defined in step #2.

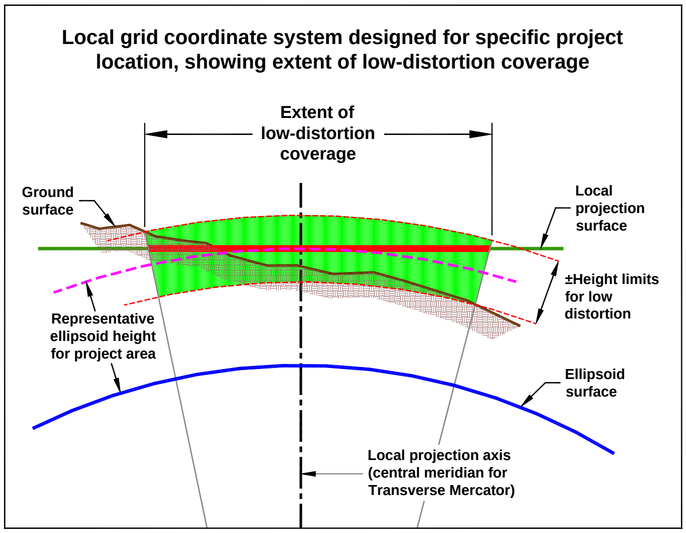

Figure 2.2.3. *Diagram shows the effect of scaling the projection to a representative height above the ellipsoid.*

2. **Choose projection type and place projection axis near centroid of project area**

- Select a well-known and widely used ***conformal*** projection, such as the Transverse Mercator (TM) or one-parallel Lambert Conformal Conic (LCC).
    - ○ The "projection axis" is the line along which projection scale is constant (with respect to the ellipsoid). It is the central meridian for the TM projection, the standard (central) parallel for the one-parallel LCC projection, the (implicitly defined) central parallel for the two-parallel LCC projection, and the skew axis for the OM projection.
    - ○ Place the central meridian of the projection near the east-west "middle" of the project area to minimize convergence angles (i.e., the difference between geodetic and grid north).
- IMPORTANT: In some cases it may be advantageous to offset the projection axis from the project centroid, for example if topographic height increases gradually and more-or-less uniformly with distance from the projection axis. Such techniques can dramatically improve LDP performance.

3. **Scale projection axis to representative ground height**

- Compute map projection axis scale factor "at ground": $k_0 = 1 + \frac{h_0}{R_G}$
    - ○ For TM projection, k_0 is the central meridian scale factor.
    - ○ For one-parallel LCC projection, k_0 is the standard (central) parallel scale factor.

- R_G is the geometric mean radius of curvature, $R_G = \dfrac{a\sqrt{1-e^2}}{1-e^2 \sin^2\varphi}$, where

  φ = geodetic latitude of point, and for the GRS-80 ellipsoid:
  a = semi-major axis = 6,378,137 m (exact) = 20,925,604.474 US survey feet
  e^2 = first eccentricity squared = $2f - f^2$
  f = geometric flattening = 1 / 298.257222101

  - Alternatively, can initially approximate R_G since k_0 will likely be refined in Step #4:

Table 2.2.3. *Geometric mean radius of curvature at various latitudes for the GRS-80 ellipsoid (rounded to nearest 1000 meters and feet).*

Latitude	R_G (meters)	R_G (feet)	Latitude	R_G (meters)	R_G (feet)
0°	6,357,000	20,855,000	50°	6,382,000	20,938,000
10°	6,358,000	20,860,000	60°	6,389,000	20,961,000
20°	6,362,000	20,872,000	70°	6,395,000	20,980,000
30°	6,367,000	20,890,000	80°	6,398,000	20,992,000
40°	6,374,000	20,913,000	90°	6,400,000	20,996,000

4. **Check distortion at points distributed throughout project area**

- Best approach is to compute distortion over entire area and generate distortion raster with contours. This allows analysis of performance "everywhere" and ensures optimal low-distortion coverage.
- Distortion computed at a point (at ellipsoid height *h*) as $\delta = k\left(\dfrac{R_G}{R_G + h}\right) - 1$
  - Where k = projection grid point scale factor (i.e. distortion with respect to ellipsoid at a specific point). Note that computation of *k* is rather involved, and is often done by commercially available software.
  - Multiply δ by 1,000,000 to get distortion in parts per million (ppm).

5. **Keep the definition SIMPLE and CLEAN!**

- Define the scale factor to no more than SIX decimal places, e.g., 1.000206 (exact).
  - *Note:* A change of one unit in the sixth decimal place equals distortion caused by a 21-foot change in height.
- Defining central meridian and latitude of grid origin to nearest whole arc-minute is usually adequate (e.g., central meridian = 111°48'00" W).
- Define grid origin using whole values with as few digits as possible (e.g., false easting = 50,000 for a system with maximum easting coordinate value < 100,000). Note that the grid origin definition has no impact whatsoever on the map projection distortion.
  - It is strongly recommended that the coordinate values everywhere in the design area be distinct from other coordinate system values for that area (such as State Plane or UTM) in order to reduce the risk of confusing the LDP with other systems.

    - *Note:* In some applications, there may be an advantage to using other criteria for defining the grid origin. For example, it may be desirable for northing and easting coordinates to never equal one another within the design area. In other cases it may be useful to make the coordinates distinct from State Plane by using larger rather than smaller coordinates, especially if the LDP covers a very large area.

6. ***Explicitly* define linear unit and geometric reference system (i.e., geodetic datum)**

    - E.g., Linear unit = US survey foot; Geometric reference system = North American Datum of 1983.
        - The US survey foot is longer than the international foot by 2 ppm. Because coordinate systems typically use large values, it is critical that the type of foot used be identified (the values differ by 1 foot per 500,000 feet).
    - *Note:* The reference system realization (i.e., "datum tag") should not be included in the coordinate system definition (just as it is not included in State Plane definitions). However, the datum tag *is* an essential component for defining the spatial data used within the coordinate system. For NAD 83, the NGS convention is to give the datum tag in parentheses after the datum name, usually as the year in which the datum was "realized" as part of a network adjustment. Common datum tags for horizontal control are listed below:
        - "2011" for the current NAD 83 (2011) epoch 2010.00 realization, which is referenced to the North America tectonic plate.
        - "2007" for the (superseded) NSRS2007 (National Spatial Reference System of 2007) realization. Functionally equivalent to the superseded "CORS" datum tag and referenced to an epoch date of 2002.00 for most of the coterminous US.
        - "199*x*" for the various supersede HARN (or HPGN) realizations, where *x* is the last digit of the year of the adjustment (usually done for a particular state. The Iowa HARN is 1996 (HARN is "High Accuracy Reference Network" and HPGN is "High Precision Geodetic Network").

The objective of LDP design is to cover the largest area with the least distortion possible. These goals are at odds with one another, since distortion increases as the size of the projected area increases. Thus LDP design is an optimization problem that does not typically yield a single unique "best" solution. Because of this, it is important that LDPs be designed collaboratively to allow input of all stakeholders affected by the design. This allows stakeholders to work together and resolve conflicting objectives and select optimal designs before a system is finalized. An added benefit to this approach is that the participants gain "ownership" over the design which leads to greater satisfaction in the final product. This is all important because once a design is implemented it can be very difficult to change, especially since the design can be incorporated into project plans, software, and even state statute.

2.3.4. IaRCS Map Projection Parameter Units

All of the IaRCS map projection parameters are provided in U.S. survey feet. Careful attention is needed when entering these map projection coordinate systems into the coordinate system management section of your GPS (GNSS) surveying, engineering, or GIS vendor software. When converting the provided data (false northing, false easting, etc.) to meters (or other desired units), be sure to carry out the values to full sufficient significant figures and check that the units are accepted by the software in the units you provide. Each software vendor (in the future) may elect to provide updated versions of their coordinate system management software with the IaRCS zones already installed.

Chapter 3. IaRCS Map Projection Zone Definitions and Coordinates

3.1. Map of Iowa Regional Coordinate System Zones

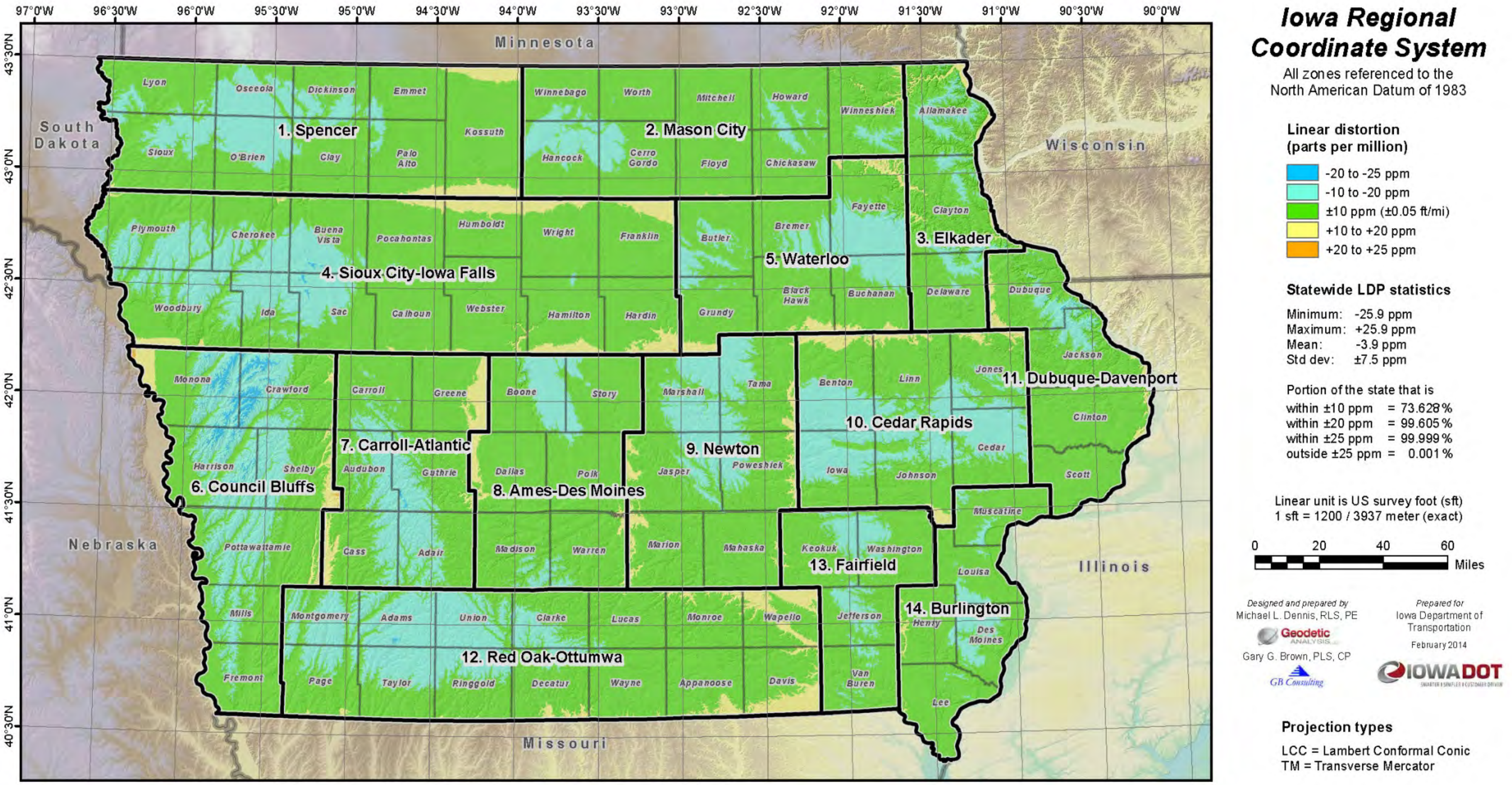

Figure 3.1. *Index map of IaRCS zones, showing distortion within each zone.*

3.2. Projection Parameters for Iowa Regional Coordinate System

- All zones are referenced to the North American Datum of 1983
- “LCC” = Lambert Conformal Conic projection; “TM” = Transverse Mercator projection
- For LCC projection, origin latitude is standard parallel (projection axis)
- Linear unit is the US survey foot (sft), where 1 sft = 1200 / 3937 meter (exact)

Table 3.2. *IaRCS projection parameters for each zone.*

Zone num	Zone name	Pro-jection type	Origin latitude		Central meridian		Projection axis scale	False northing (sft)	False easting (sft)
			(deg-min)	(decimal deg)	(deg-min)	(decimal deg)			
1	Spencer	LCC	43°12'N	43.200000	095°15'W	-95.250000	1.000 052	9,600,000	11,500,000
2	Mason City	LCC	43°10'N	43.166667	092°45'W	-92.750000	1.000 043	9,800,000	12,500,000
3	Elkader	TM	40°15'N	40.250000	091°12'W	-91.200000	1.000 035	8,300,000	13,500,000
4	Iowa	LCC	42°32'N	42.533333	094°50'W	-94.833333	1.000 045	8,600,000	14,500,000
5	Waterloo	LCC	42°39'N	42.650000	092°15'W	-92.250000	1.000 032	8,900,000	15,500,000
6	Council Bluffs	TM	40°15'N	40.250000	095°44'W	-95.733333	1.000 039	6,600,000	16,500,000
7	Carroll-Atlantic	TM	40°15'N	40.250000	094°38'W	-94.633333	1.000 045	6,800,000	17,500,000
8	Ames-Des Moines	TM	40°15'N	40.250000	093°43'W	-93.716667	1.000 033	7,000,000	18,500,000
9	Newton	TM	40°15'N	40.250000	092°49'W	-92.816667	1.000 027	7,200,000	19,500,000
10	Cedar Rapids	LCC	41°50'N	41.833333	091°40'W	-91.666667	1.000 020	8,000,000	20,500,000
11	Dubuque-Davenport	TM	40°15'N	40.250000	090°32'W	-90.533333	1.000 027	7,600,000	21,500,000
12	Red Oak- Ottumwa	LCC	40°55'N	40.916667	093°45'W	-93.750000	1.000 037	6,200,000	22,500,000
13	Fairfield	TM	40°15'N	40.250000	091°55'W	-91.916667	1.000 020	6,400,000	23,500,000
14	Burlington	TM	40°15'N	40.250000	091°15'W	-91.250000	1.000 018	6,200,000	24,500,000

3.3. IaRCS Projected Coordinates at Centroid of Each Zone

Table 3.3 gives IaRCS projected coordinates for each zone. The northing and easting values are given to the nearest 0.0001 US survey foot (sft) to facilitate checking of projected coordinate computations.

A list of IaRCS projected coordinates for NAD 83(2011) epoch 2010.00 NGS control stations in Iowa is given in Appendix B. A corresponding list giving distortion values for these NGS control stations is given in Appendix C. Both these lists can be used as checks on coordinate and distortion computations.

Table 3.3 *Projected coordinates (in US survey feet) of centroid for each zone of the IaRCS.*

Zone num	Zone name	Latitude (deg-min-sec)	Longitude (deg-min-sec)	Latitude (decimal degrees)	Longitude (decimal degrees)	Northing (sft)	Easting (sft)
1	Spencer	43°12'24.11513''N	95°14'41.63871''W	43.206698647222	-95.244899641667	**9,602,441.7567**	**11,501,359.9478**
2	Mason City	43°13'00.82041''N	92°50'49.95565''W	43.216894558333	-92.847209902778	**9,818,323.3443**	**12,474,084.7219**
3	Elkader	42°52'56.79489''N	91°21'38.68240''W	42.882443025000	-91.360745111111	**9,259,298.5162**	**13,456,913.6913**
4	Sioux City-Iowa Falls	42°33'50.96262''N	94°45'02.43989''W	42.564156283333	-94.750677747222	**8,611,244.7249**	**14,522,268.8622**
5	Waterloo	42°37'44.94131''N	92°17'02.35383''W	42.629150363889	-92.283987175000	**8,892,402.8672**	**15,490,852.8889**
6	Council Bluffs	41°33'29.10132''N	95°36'26.13048''W	41.558083700000	-95.607258466667	**7,076,635.3081**	**16,534,507.0448**
7	Carroll-Atlantic	41°41'08.74973''N	94°39'59.84405''W	41.685763813889	-94.666623347222	**7,323,142.0446**	**17,490,906.3318**
8	Ames-Des Moines	41°41'13.66480''N	93°45'50.24425''W	41.687129111111	-93.763956736111	**7,523,635.0768**	**18,487,082.4340**
9	Newton	41°42'34.26941''N	92°48'26.79864''W	41.709519280556	-92.807444066667	**7,731,787.5821**	**19,502,518.3197**
10	Cedar Rapids	41°54'44.04572''N	91°36'53.95693''W	41.912234922222	-91.614988036111	**8,028,756.9352**	**20,514,066.8414**
11	Dubuque-Davenport	42°03'58.00264''N	90°38'58.36948''W	42.066111844444	-90.649547077778	**8,261,756.7920**	**21,468,442.6981**
12	Red Oak-Ottumwa	40°52'13.01700''N	93°47'20.76210''W	40.870282500000	-93.789100583333	**6,183,102.0615**	**22,489,185.3927**
13	Fairfield	41°08'07.30631''N	91°56'59.28336''W	41.135362863889	-91.949800933333	**6,722,572.3521**	**23,490,872.3865**
14	Burlington	41°02'07.16105''N	91°19'19.74889''W	41.035322513889	-91.322152469444	**6,486,127.3642**	**24,480,093.7773**

3.4. IaRCS Performance Statistics

The IaRCS design objective of keeping distortion within ±25 ppm everywhere in the state was achieved. The overall performance statistics are shown in Figure 3.1 and are given below.

Percent area of state with distortion within:

±10 ppm = ±0.05 ft/mile = 1:100,000 → **73.628%**
±20 ppm = ±0.11 ft/mile = 1:50,000 → **99.605%**
±25 ppm = ±0.13 ft/mile = 1:40,000 → **99.999%**

Only 0.001% of the area of the state has distortion that exceeds a magnitude of 25 ppm. The linear distortion statistics for each IaRCS zone and the entire state are given in Table 3.4. Note that 6 of the 14 zones have distortion entirely within ±20 ppm, and that nowhere in the state does IaRCS distortion exceed a magnitude of 26 ppm (0.14 ft/mile).

Table 3.4. *IaRCS linear distortion statistics (ppm).*

Zone num	Zone name	Minimum	Maximum	Mean	Standard deviation
1	Spencer	-18.8	17.8	-3.6	±7.0
2	Mason City	-19.8	20.4	-4.0	±5.3
3	Elkader	-19.9	18.6	-3.6	±6.6
4	Sioux City-Iowa Falls	-21.8	22.7	-2.9	±7.8
5	Waterloo	-21.3	21.7	-4.7	±7.6
6	Council Bluffs	-25.9	25.9	-5.7	±9.1
7	Carroll-Atlantic	-22.5	23.4	-4.2	±8.0
8	Ames-Des Moines	-19.2	18.9	-3.0	±6.2
9	Newton	-19.6	19.3	-3.8	±7.7
10	Cedar Rapids	-19.9	22.4	-5.8	±8.1
11	Dubuque-Davenport	-22.4	23.5	-0.8	±6.3
12	Red Oak-Ottumwa	-21.7	22.1	-3.3	±8.6
13	Fairfield	-14.4	14.1	-5.7	±5.0
14	Burlington	-16.7	17.6	-4.0	±5.6
	Entire state	**-25.9**	**25.9**	**-3.9**	**±7.5**

Chapter 4. Using the IaRCS in Software and Performing Checks

4.1. Adding IaRCS Coordinate System Definitions to Software

To use IaRCS coordinates for surveying, engineering, and GIS applications, the IaRCS must be defined in the software packages used to perform the work. IaRCS zone parameters (as given in Table 3.2) are entered into the appropriate "coordinate system management/definition" module of the software. This chapter is designed to get you started, but it is recommended that you consult the "help" documentation and tutorials of the particular vendor software you plan to work with. Also, for future reference please go to the IaRCS web page (**www.iowadot.gov/rtn/IaRCS.aspx**) for updates and downloads.

Because of the number and variability of commercial software packages, and the frequency of software updates, this Handbook and User Guide does not give specific instructions for defining the IaRCS in vendor software. However, Esri projection (*.prj) files are available from the IaRCS website at **www.iowadot.gov/gis/Projections/zipped_files/LDP/LowDistortionProjections_PRJ.zip**.

Note that the *.prj files are specifically referenced to the NAD 83(2011) epoch 2010.00 realization. Any particular "realization" of NAD 83 results in an associated set of coordinates on the stations that provide access to the datum, without changing how the datum is related to the Earth. The projection parameters and reference ellipsoid (GRS-80) are identical for all realizations of NAD 83. In principle, lines of latitude and longitude are the same, but the coordinates differ due to the how they are determined, as well as to motion (such as plate tectonics). The NAD 83 realization is therefore associated with the data. If the data are referenced to NAD 83(2011) epoch 2010.00, that will result in coordinates at a point that differ from other realizations. The realization is a critical part of the metadata, but it has no effect on the map projection parameters. That is, the relationship between latitude and longitude and the IaRCS (or State Plane) northings and eastings is the same for all NAD 83 realizations.

Consider as an example how different realizations will result in different coordinates at a specific NGS survey control station in Iowa, HUBBARD WEST BASE (PID NK0704). This control station has provided surveyors access to the NAD 83 datum since its inception in 1986 (and to the NAD 27 datum for several decades prior). The NAD 83 geographic (geodetic) coordinates for this station have been updated three times relative to different NAD 83 datum realizations. From Appendix B, the geographic coordinates of HUBBARD WEST BASE referenced to NAD 83(2011) epoch 2010.00 are 42°11'17.95886''N, 93°21'58.33308''W. These geographic coordinates yield IaRCS Zone 8 coordinates (in US survey feet) of 7,706,471.80 N, 18,594,984.49 E. Because of changes in the way the position of this station was determined (including different observation types, amount of data, computation methods, and adjustment constraints, as well as tectonic motion), the geographic coordinates were different for earlier realizations of NAD 83. From the NGS Datasheet, the coordinates of HUBBARD WEST BASE referenced to the original NAD 83(1986) realization were 42°11'17.96422''N, 93°21'58.33233''W, which give IaRCS coordinates of 7,706,472.34 N, 18,594,984.55 E. The difference in coordinates between these two realizations of NAD 83 is 0.54 ft N, 0.06 ft E. It can be seen by this example that including datum realization information in database metadata and coordinate system definition files is a critical part of maintaining accurate coordinates for geospatial data.

Table 4.1 gives the changes in coordinates for NGS control station HUBBARD WEST BASE corresponding to all four NAD 83 realizations in Iowa. Note that the coordinate changes are specific to this station; changes at other locations will in general be different.

Table 4.1. *Change in NAD 83 coordinates for NGS station HUBBARD WEST BASE (PID NK0704) for each realization ("datum tag") in Iowa from original (1986) through current (2011).*

NAD 83 datum tag	**NAD 83 geodetic coordinates associated with each datum tag (i.e., realization)**		**IaRCS Zone 8 coordinates projected from geodetic coordinates**		**Horizontal change in coordinates**
	Latitude	**Longitude**	**Northing (sft)**	**Easting (sft)**	
1986	42°11'17. 96422'N	93°21'58.33233''W	**7,706,472.340**	**18,594,984.549**	
					0.569 ft
1996	42°11'17.95867''N	93°21'58.33355''W	**7,706,471.778**	**18,594,984.459**	
					0.036 ft
2007	42°11'17.95889''N	93°21'58.33393''W	**7,706,471.800**	**18,594,984.431**	
					0.064 ft
2011	42°11'17.95886''N	93°21'58.33308''W	**7,706,471.798**	**18,594,984.495**	

Coordinate transformations between the various realizations of NAD 83 have been developed by NGS (such as NADCON). However, these transformations are not appropriate for all applications, and the documentation for each should be reviewed to ensure suitability. Typically these transformations are ***not*** of sufficient accuracy for surveying and engineering applications. In such cases more rigorous methods are necessary and can be done with respect to the desired NAD 83 reference coordinates, such as reprocessing data, recomputing coordinates, or performing custom local transformations.

Over time, most commercial software manufacturers will add the IaRCS to their standard coordinate system libraries. When that occurs, there will be no need to manually enter the zone parameters. But in some cases it still may be necessary to change the NAD 83 realization in commercial software coordinate system definitions (such as *.prj files) if a dataset is referenced to the wrong realization. This can occur, for example, if a dataset is referenced to "NAD 83" (without any modifier), which is often interpreted by software as original NAD 83(1986). Another example is an existing project referenced to an earlier realization, such as NAD 83(2007), rather than the current 2011 realization. Although changing the NAD 83 realization can be done, such changes should only be made after it has been verified that the change is necessary, appropriate, and correct.

Iowa Department of Transportation uses Bentley Microstation CADD software with similar projection functionality to modern GIS software. IaRCS zones are defined in a geographic configuration file (*.dty) that allows any drawing in an IaRCS geographic coordinate system to be overlaid and coincide with another drawing from another geographic coordinate system, such as State Plane or UTM. The configuration file that allows this (and the instructions for placing it in the startup configuration) is linked to the IaRCS website at **www.iowadot.gov/design/caddtools/IowaRCS.zip**.

The latitude and longitude centroid coordinates for each zone in Table 3.3 can be used as a check to ensure commercial software is giving the correct IaRCS projected coordinates. A list of IaRCS coordinates for NGS NAD 83(2011) epoch 2010.00 control stations in Appendix B can also be used as a check. Distortion values can be checked for these NGS station using the values in Appendix C.

Note regarding the relationship between NAD 83 and WGS 84: For the purposes of entering the IaRCS projection parameters into particular vendor software, the datum should be defined as NAD 83 (which uses the GRS-80 reference ellipsoid for all realizations). Some commercial software implementations assume there is no transformation between WGS 84 and NAD 83 (i.e., all transformation parameters are zero). Other implementations use a non-zero transformation, and in some cases both types are available in a single software package. The type of transformation used will depend on specific circumstances, although often the zero transformation is the appropriate choice (even though it is not technically correct). Check with software support to ensure the appropriate transformation is being used for your application.

Note regarding the vertical component of a coordinate system definition: A complete 3-D coordinate system definition must include a vertical "height" component. Yet the IaRCS pertains exclusively to horizontal coordinates. So although the vertical component is essential for most applications, it is not part of the IaRCS and must be defined separately. Typically the vertical part consists of ellipsoid heights relative to NAD 83 (when using GNSS) and/or orthometric heights ("elevations") relative to the North American Vertical Datum of 1988 (NAVD 88). These two types of heights are related (at least in part) by a hybrid geoid model, such as GEOID12A, as well as some sort of vertical adjustment or transformation to match local vertical control for a project. The approach used for the vertical component usually varies from project to project and requires professional judgment to ensure it is defined correctly. Providing such instructions is beyond the scope of this Handbook and User Guide.

4.2. Low Distortion Projects in GIS

Modern GIS software incorporates on-the-fly projections. This allows users to simultaneously display data from differing coordinate systems in a common coordinate system on the computer screen. Low distortion projection systems can thus be easily and seamlessly incorporated for display of GIS databases. An advantage to LDPs is the fact that the historical data need not be modified. Past data can still reside in its original coordinate system and merely be re-projected in real time into the new coordinate system for use with new LDP data. Thus, as future LDPs are developed, multiple round-off error will not propagate with each time a new projection is applied. This will allow cities and counties to adopt the new LDPs while still using their original data without modification. New data can be acquired in the best LDP for the area and still be used with the historical data or other data collected by other agencies in different coordinate systems with minimal effort by the user.

Many cities and counties in Iowa use GIS data to manage their resources. Because the IaRCS zones are defined by county boundaries, the IaRCS will usually provide excellent coverage for the entire service area of an agency.

GIS calculations of route distances, cut/fill volumes, etc. will be more accurate with use of LDPs because of the minimized distortion. Existing coordinate systems may be adequate for large, statewide analyses where data resolution is low (e.g. large grids cell sizes > 30m). The development of LDPs allows for new high resolution data (e.g. small grid cell sizes 0.1m to 2m) and digital terrain models (DTM) from LIDAR and other new technologies to be analyzed with minimal distortion in GIS environments when studies are performed on a localized county or city areas. Existing coordinate systems would provide a substantial amount of distortion when analyzing these DTMs. Hence, LDPs will allow for the development of more accurate GIS databases and help bridge the gap between GIS and surveying for mapping.

4.2.1. Managing GIS Data

Geographic Information System managers administer data. Data includes spatial and attribute information that is provided from many sources. The spatial data locates features across the landscape while the attributes provide characteristics of the features. GIS managers use the same reference frameworks as surveyors to define positions in space.

Nearly all GIS operations require accurate locations of geographic features. Accurate locations allow GIS users to integrate and/or combine information from various sources. Critical to the accurate locations of features is a record of the coordinate system and associated projection parameters. GIS managers often incorporate surveyed data into geographic databases. Conversion of coordinate information into a different map projection system from which it was collected is usually necessary. Critical to this process is a well-defined set of existing and desired map projection parameters.

The newly defined IaRCS low distortion projections provide another reference system in which data will be collected. By having detailed descriptions of properties of the map projection, GIS software can re-project and transform the geographic locations of dataset elements into any appropriate coordinate system. This allows the integration of multiple GIS layers, a fundamental GIS capability.

A GIS or mapping project based on one of the new low distortion coordinate systems has significant advantages. The design of the coordinate system allows field based measurements (data collection) to be directly utilized in the GIS without translation, saving time and reducing error. The size, position and orientation of features in the system can match ground conditions, increasing confidence and reducing the need for repetitive observation.

4.3. Checking Distortion Using Distances (Grid vs. Ground)

Each IaRCS zone was developed so that grid and ground distances match very closely (within about ±25 ppm everywhere). If you are working near the fringe of a zone, or at elevations significantly (more than about a hundred feet) above or below the elevation limits of the zone's low distortion area, then you may want to check the ppm result between control points in your project. To do this, pick the two farthest points in your project that you can measure directly between with an EDM (total station). Measure the horizontal ground distance between the points and record the ground distance measurement. Then inverse the IaRCS grid distance between the same two points. Subtract the grid distance from the ground distance, divide this difference by the ground distance, and multiply it by 1 million to get distortion in parts per million. For example:

1. Horizontal ground distance (from EDM) = 1239.998 sft
2. Inversed IaRCS grid distance (computed) = 1239.987 sft
3. Inversed minus measured distance = -0.011 ft
4. (-0.011 / 1239.998) × 1,000,000 = ***-8.9 parts per million (ppm)***

This type of test can also be performed using GPS (GNSS) data. A simple but reasonably accurate way to do this is to use a delta XYZ GPS (GNSS) vector to estimate the horizontal ground distance between points. Neglecting curvature, this can be computed as:

$$H = \sqrt{\Delta X^2 + \Delta Y^2 + \Delta Z^2 - \Delta h^2}$$

Where: ΔX, ΔY, ΔZ are the GPS vector components (as ECEF Cartesian coordinate deltas)
Δh = change in ellipsoid height between vector end points

Accounting for curvature increases this horizontal ground distance, but for distances of less than 20 miles (about 30 km), the increase is less than 1 ppm (i.e., less than 3 cm).

The curvature correction factor can be approximated as:

$$C = (2R \sin^{-1}(H \div 2R)) \div H$$

where R is the earth radius. A value of 20,920,000 feet works well for Iowa. The (straight) horizontal distance is multiplied by the correction factor to get the curved horizontal ground distance. Note that there is no need to account for refraction, because the GPS vector is computed, not observed.

A more rigorous method for computing the ground distance is to first accurately compute the ellipsoid distance, and then scale it by the ellipsoid height of the endpoints to determine the ground distance.

Step 1. Ellipsoid Distance. The Vincenty method can be used for computing an accurate ellipsoid distance. This computation is beyond the scope of this document, but it can be done using the NGS Geodetic Toolkit at **www.ngs.noaa.gov/TOOLS/Inv_Fwd/Inv_Fwd.html**.

In addition, many surveying and mapping software programs can perform this calculation (although it is recommended that commercial software be checked against the NGS version).

Step 2. Ground Distance = $(((h_1+h_2)/2) + R_G)/ R_G$ x [Vincenty ellipsoid distance from step 1]
Where:

h_1 & h_2 are the ellipsoid heights of the endpoints.

R_G is the geometric mean ellipsoid radius of curvature: $R_G = \dfrac{a\sqrt{1-e^2}}{1-e^2\sin^2\varphi}$

a = semi-major axis = 6,378,137 m (exact) = 20,925,604.474 sft
e^2 = first eccentricity squared = $2f - f^2$
f = geometric flattening = 1 / 298.257222101

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Chapter 5. Legislative Adoption and Registration with the NGS

5.1. IaRCS Administrative Code Adoption

As the IaRCS is currently being used and is generally accepted by a wide audience of Iowa professional surveyors, engineers, GIS, cartographic, and academic professionals around the state, effort will be made to include definition of the IaRCS in Chapter 193(C) of the Iowa Administrative Code. This effort will be made in cooperation with the Society of Land Surveyors of Iowa (SLSI) and the Iowa Engineering and Land Surveying Examining Board. Inclusion will encourage fundamental viable acceptance by engineering, surveying, and mapping professionals within the state as well as other Federal agencies such as the BLM, NGS, FEMA, etc.

5.2. NGS Policy on Registration of the IaRCS

The Iowa Department of Transportation, SLSI, and other concerned organizations will be urged to promote adoption of the IaRCS by the National Geodetic Survey (NGS), guided by their policy on changes to plane coordinate systems. The existing NGS policy on plane coordinate systems is given below.

NGS "POLICY ON CHANGES TO PLANE COORDINATE SYSTEMS", April 11, 2001
(**www.ngs.noaa.gov/INFO/Policy/SPCS4.html**)

The National Geodetic Survey (NGS) recognizes there may be States that want to implement changes to their existing North American Datum of 1983 (NAD 83) State Plane Coordinate System (SPCS) parameters or to create and employ supplemental plane coordinate projections. These changes could include: changing the number of zones, changing existing zone boundaries, and/or changing the geometric parameters (e.g., false northing/easting, origin, central meridian, etc.), and/or creating additional coordinate systems. NGS also recognizes that State and local surveying, mapping, and Geographic Information System (GIS) agencies may develop grid systems to support a variety of agency or local activities that may be in conflict with the policy detailed below. This policy details only those elements which must be met for NGS to publish these coordinate systems as part of the National Spatial Reference System (NSRS).

While NGS does not encourage States to change the current definition of the existing SPCS, NGS does recommend any proposed changes be thoroughly discussed in detail with NGS technical staff, including the NGS State Geodetic Advisor, if such an office exists in the State, prior to submitting a request to the Director, NGS.

NGS will adopt changes to SPCS or add supplemental projections into NSRS only under the following conditions:

1. All requests for changes must be submitted in writing to the Director, NGS, and must be co-signed by those State agencies and organizations most involved in the use, collection, and distribution of spatial data including, but not limited to, the State Department of Transportation, State Office of GIS, and state land surveyor professional organizations. Hereafter these groups are referred to as the "State." Required agencies and organizations will be determined by NGS on a state-by-state basis. A similar request must also be submitted to the U.S. Geological Survey (USGS) to ensure integrity of NSRS with USGS national mapping products and services.
2. All new SPC zones or supplemental projections shall use the two basic map projections, the Lambert Conformal Conic or the Mercator (transverse or oblique), defined at the surface of the ellipsoid of the current Datum (Geodetic Reference System 1980 - GRS 80).

3. All changes must be adopted by State Law (or State Regulation when such Regulation is regulated by public notices and hearings and no opposition exist). Such Law must include a complete description of the revised SPCS zones and geometric parameters. A specified conversion factor between meters and feet (U.S. Survey or International) is strongly recommended to be included in the legislation. NGS will publish coordinates only in those legislated units.
4. Zones will continue to be defined by International, State and county boundaries, and by the counties contained therein. (See Federal Register Notice "Policy on Publication of Plane Coordinates," Vol. 42, Nol. 57, pages 15943-15944, published March 24, 1977.)
5. SPCS changes will ensure that the resulting coordinate differences are sufficiently large (by at least 10,000 meters) to ensure that no confusion will exist with the current NAD 83 coordinate values.
6. A naming convention shall be developed that ensures a distinct labeling between the existing and revised new coordinate zones.
7. Should NGS estimate significant expenses resulting from changes to the existing SPCS, NGS may require State reimbursement. These costs would be for coordinate conversion, data base extraction and publication software required to support computation, publication and distribution of new coordinate values as part of NSRS.
8. To facilitate public awareness, the State shall develop an education program that includes an article detailing the rationale for the development of the changes, the process of review and examination of the issues, the final design criteria, and a workshop or seminar to be presented at a State-wide surveying and mapping conference. The article shall be submitted for publication in one or more surveying and mapping periodicals (e.g., American Congress on Surveying and Mapping Bulletin, Professional Surveyor, or P.O.B. magazines). In addition, this article will be made available on the web sites of the sponsoring agencies defined as the "State." Any requests for technical support from NGS requiring travel expenses for NGS personnel shall be reimbursed by the State.

References

Armstrong, M.L., Singh, R., and Dennis, M.L., 2010. *Oregon Coordinate Reference System Handbook and User Guide*, version 2.0, Oregon Department of Transportation, Geometronics Unit, Salem, Oregon, USA, 89 pp., **ftp.odot.state.or.us/ORGN/Documents/ocrs_handbook_user_guide.pdf**.

Hager, J.W., Behensky, J.F., and Drew, B.W., 1989. The Universal Grids: Universal Transverse Mercator (UTM) and Universal Polar Stereographic (UPS), *DMA Technical Manual 8358.2*, Defense Mapping Agency, Fairfax, Virginia, USA, 49 pp., "TM8358_2.pdf" *in* **earth-info.nga.mil/GandG/publications/tm8358.2/TM8358_2.pdf**.

Hager, J.W., Fry, L.L., Jacks, S.S. and Hill, D.R., 1990. Datums, Ellipsoids, Grids, and Grid Systems, *DMA Technical Manual 8358.1*, Edition 1, Defense Mapping Agency, Fairfax, Virginia, USA, 150 pp., **earth-info.nga.mil/GandG/publications/tm8358.1/toc.html**.

Henning, W. (lead author), 2011. *National Geodetic Survey User Guidelines for Single Base Real Time GNSS Positioning*, version 2.1, National Geodetic Survey, Silver Spring, MD, USA, 151 pp., **www.ngs.noaa.gov/PUBS_LIB/NGSRealTimeUserGuidelines.v2.1.pdf**. *[appendices D and E discus "calibrations/localizations" and low distortion projections, respectively. Note that these appendices do not appear on versions of this document after v2.1]*

Iliffe, J.C. and Lott, R., 2008. *Datums and Map Projections: For Remote Sensing, GIS and Surveying*, 2nd edition, Whittles Publishing, United Kingdom, 192 pp.

Snyder, J.P., 1987. *Map Projections – A Working Manual*, U.S. Geological Survey Professional Paper 1395, U.S. Government Printing Office, Washington, D.C., USA, 383 pp, **pubs.er.usgs.gov/djvu/PP/PP_1395.pdf**.

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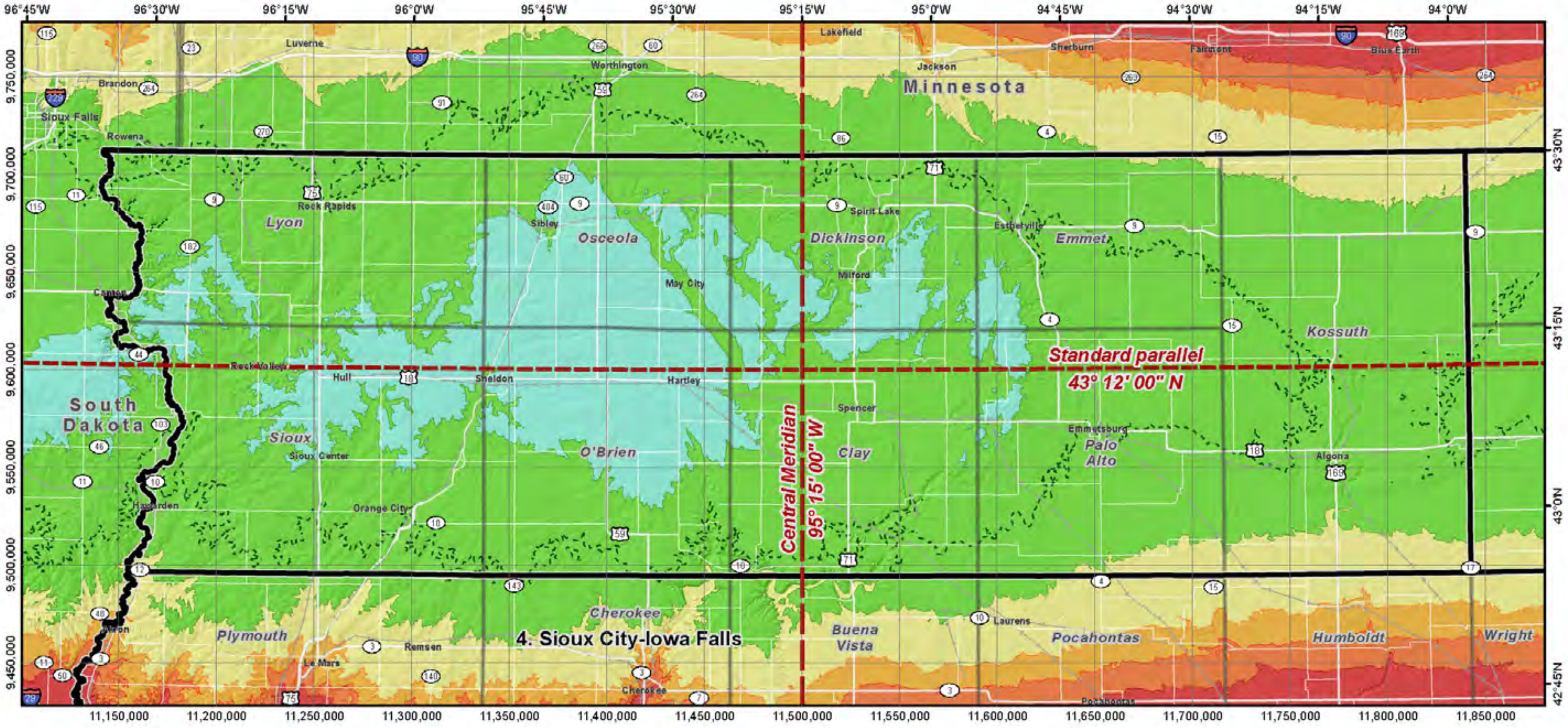
Van Sickle, J., 2004. *Basic GIS Coordinates*, CRC Press LLC, Boca Raton, Florida, USA, 173 pp.

Vincenty, T., 1975. Direct and inverse solutions of geodesics on the ellipsoid with application of nested equations, *Survey Review*, Vol. 23, No. 176, pp. 88-93, **www.ngs.noaa.gov/PUBS_LIB/inverse.pdf**.

Appendix A.

IaRCS individual zone distortion maps

Zones are numbered 1-14,
and are listed on pages A-1 through A-14



Iowa Regional Coordinate System

Zone 1: Spencer

Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983

Standard parallel & grid origin: 43° 12' 00" N
Central meridian: 95° 15' 00" W
False northing: 9,600,000.000 sft
False easting: 11,500,000.000 sft
Standard parallel scale: 1.000 052 (exact)

Grid North

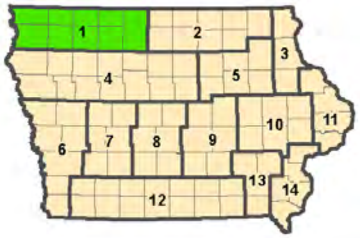
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion
(parts per million)

- - - Zero distortion
- ■ <-30 ppm (<-0.16 ft/mi)
- ■ -25 to -30 ppm
- ■ -20 to -25 ppm
- ■ -10 to -20 ppm
- 🟩 ±10 ppm (±0.05 ft/mi)
- 🟨 +10 to +20 ppm
- 🟧 +20 to +25 ppm
- 🟧 +25 to +30 ppm
- 🟥 >+30 ppm (>+0.16 ft/mi)



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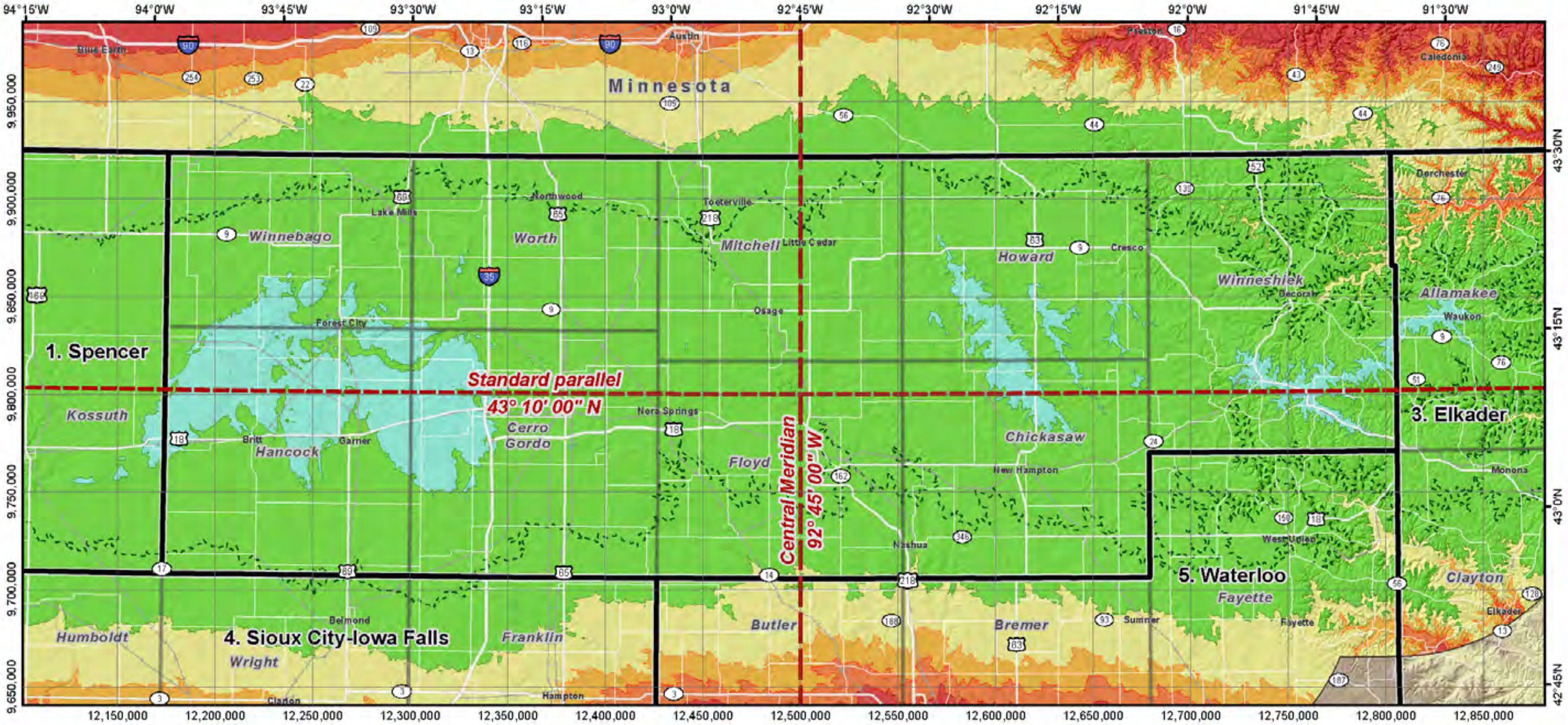

Iowa Regional Coordinate System

Zone 2: Mason City

Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983

Standard parallel & grid origin:	43° 10' 00" N
Central meridian:	92° 45' 00" W
False northing:	9,800,000.000 sft
False easting:	12,500,000.000 sft
Standard parallel scale:	1.000 043 (exact)

Grid North

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion
(parts per million)

- - -	Zero distortion
🟦	<-30 ppm (<-0.16 ft/mi)
🟦	-25 to -30 ppm
🟦	-20 to -25 ppm
🟦	-10 to -20 ppm
🟩	±10 ppm (±0.05 ft/mi)
🟨	+10 to +20 ppm
🟧	+20 to +25 ppm
🟥	+25 to +30 ppm
🟥	>+30 ppm (>+0.16 ft/mi)

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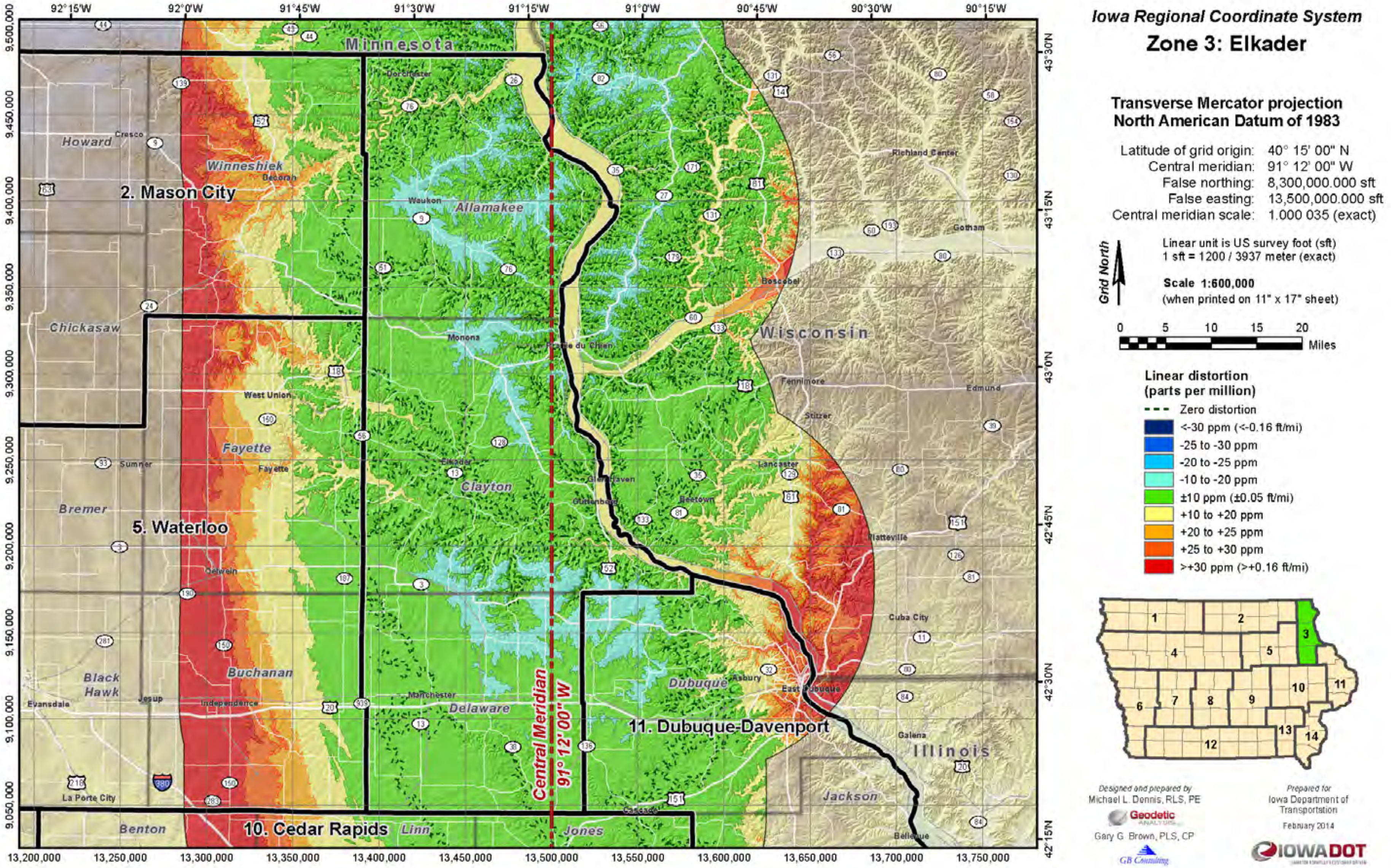
Iowa Regional Coordinate System
Zone 3: Elkader
Transverse Mercator projection
North American Datum of 1983
Latitude of grid origin: 40° 15' 00" N
Central meridian: 91° 12' 00" W
False northing: 8,300,000.000 sft
False easting: 13,500,000.000 sft
Central meridian scale: 1.000 035 (exact)
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)
Scale 1:600,000
(when printed on 11" x 17" sheet)
Grid North
0 5 10 15 20 Miles
Linear distortion (parts per million)
Zero distortion
<-30 ppm (<-0.16 ft/mi)
-25 to -30 ppm
-20 to -25 ppm
-10 to -20 ppm
±10 ppm (±0.05 ft/mi)
+10 to +20 ppm
+20 to +25 ppm
+25 to +30 ppm
>+30 ppm (>+0.16 ft/mi)
Central Meridian 91° 12' 00" W
2. Mason City
5. Waterloo
10. Cedar Rapids
11. Dubuque-Davenport
Minnesota
Wisconsin
Illinois
Howard
Winneshiek
Allamakee
Chickasaw
Fayette
Clayton
Bremer
Black Hawk
Buchanan
Delaware
Dubuque
Benton
Linn
Jones
Jackson
92°15'W
92°0'W
91°45'W
91°30'W
91°15'W
91°0'W
90°45'W
90°30'W
90°15'W
43°30'N
43°15'N
43°0'N
42°45'N
42°30'N
42°15'N
9,500,000
9,450,000
9,400,000
9,350,000
9,300,000
9,250,000
9,200,000
9,150,000
9,100,000
9,050,000
13,200,000
13,250,000
13,300,000
13,350,000
13,400,000
13,450,000
13,500,000
13,550,000
13,600,000
13,650,000
13,700,000
13,750,000
1 2 3 4 5 6 7 8 9 10 11 12 13 14
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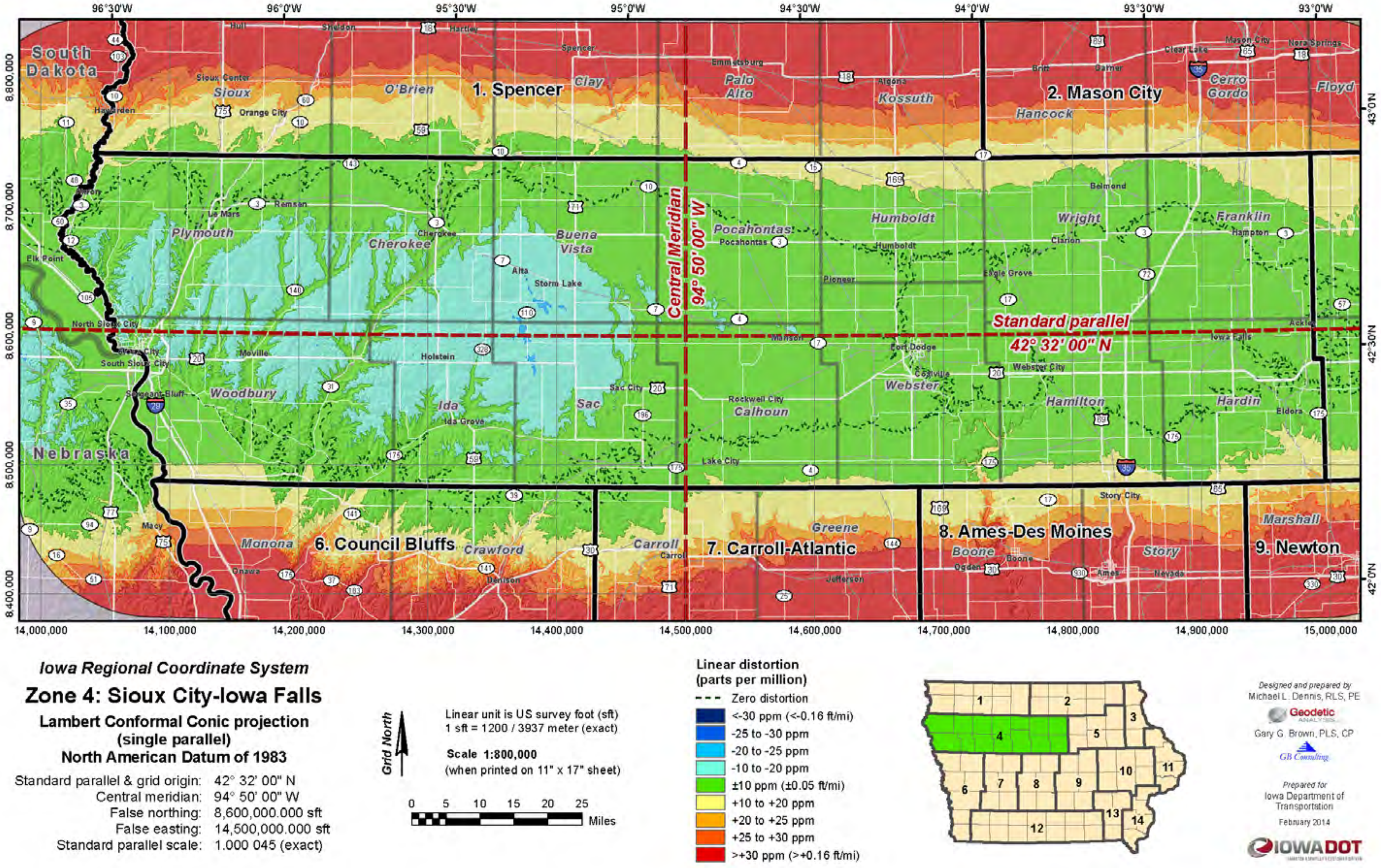

Iowa Regional Coordinate System

Zone 4: Sioux City-Iowa Falls

Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983

Standard parallel & grid origin:	42° 32' 00" N
Central meridian:	94° 50' 00" W
False northing:	8,600,000.000 sft
False easting:	14,500,000.000 sft
Standard parallel scale:	1.000 045 (exact)

Grid North

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:800,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 25 Miles

Linear distortion
(parts per million)

- - - Zero distortion
🟦 <-30 ppm (<-0.16 ft/mi)
🟦 -25 to -30 ppm
🟦 -20 to -25 ppm
🟦 -10 to -20 ppm
🟩 ±10 ppm (±0.05 ft/mi)
🟨 +10 to +20 ppm
🟧 +20 to +25 ppm
🟧 +25 to +30 ppm
🟥 >+30 ppm (>+0.16 ft/mi)

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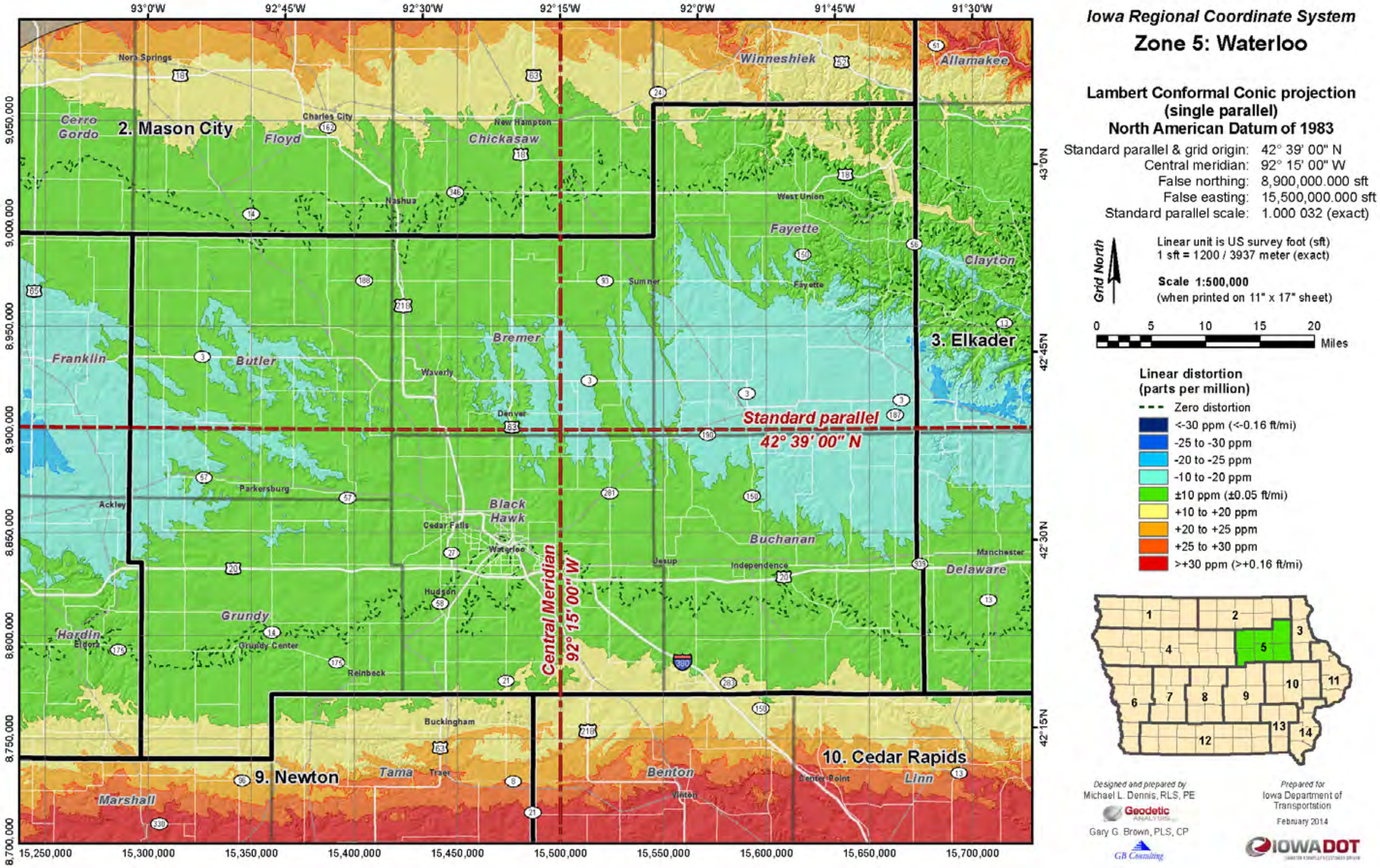
Iowa Regional Coordinate System
Zone 5: Waterloo
Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983
Standard parallel & grid origin: 42° 39' 00" N
Central meridian: 92° 15' 00" W
False northing: 8,900,000.000 sft
False easting: 15,500,000.000 sft
Standard parallel scale: 1.000 032 (exact)
Grid North
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)
Scale 1:500,000
(when printed on 11" x 17" sheet)
0 5 10 15 20 Miles
Linear distortion
(parts per million)
Zero distortion
<-30 ppm (<-0.16 ft/mi)
-25 to -30 ppm
-20 to -25 ppm
-10 to -20 ppm
±10 ppm (±0.05 ft/mi)
+10 to +20 ppm
+20 to +25 ppm
+25 to +30 ppm
>+30 ppm (>+0.16 ft/mi)
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Standard parallel
42° 39' 00" N
Central Meridian
92° 15' 00" W
2. Mason City
3. Elkader
9. Newton
10. Cedar Rapids
Cerro Gordo
Floyd
Chickasaw
Winneshiek
Allamakee
Fayette
Clayton
Franklin
Butler
Bremer
Black Hawk
Buchanan
Delaware
Grundy
Hardin
Marshall
Tama
Benton
Linn
Nora Springs
Charles City
New Hampton
Nashua
West Union
Sumner
Fayette
Waverly
Denver
Parkersburg
Ackley
Cedar Falls
Waterloo
Hudson
Jesup
Independence
Manchester
Eldora
Grundy Center
Reinbeck
Buckingham
Traer
Vinton
Center Point
93°0'W
92°45'W
92°30'W
92°15'W
92°0'W
91°45'W
91°30'W
43°0'N
42°45'N
42°30'N
42°15'N
9,050,000
9,000,000
8,950,000
8,900,000
8,850,000
8,800,000
8,750,000
8,700,000
15,250,000
15,300,000
15,350,000
15,400,000
15,450,000
15,500,000
15,550,000
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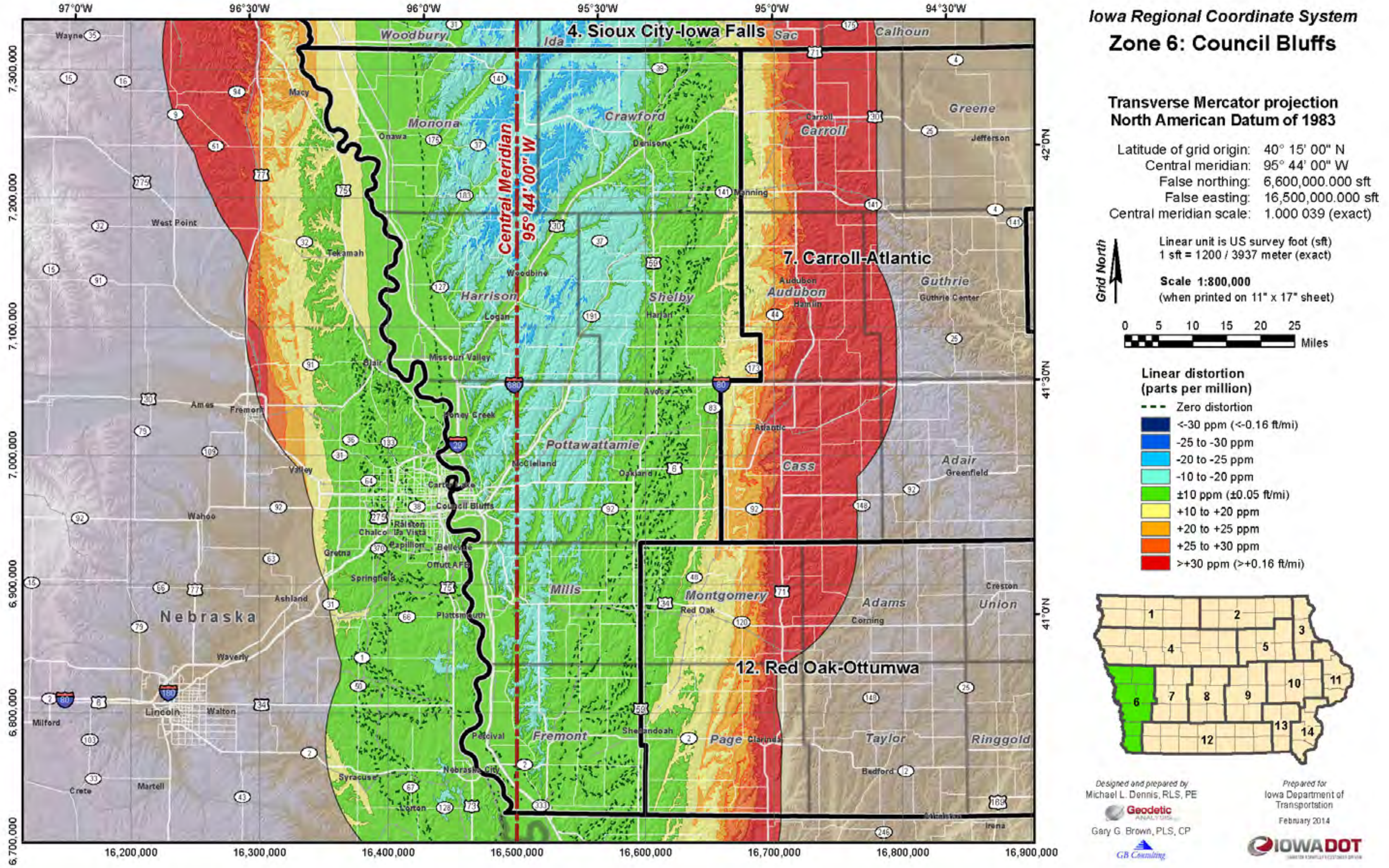
12
13
14



Iowa Regional Coordinate System

Zone 6: Council Bluffs

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	40° 15' 00" N
Central meridian:	95° 44' 00" W
False northing:	6,600,000.000 sft
False easting:	16,500,000.000 sft
Central meridian scale:	1.000 039 (exact)

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:800,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 25 Miles

Linear distortion
(parts per million)

- - - - Zero distortion
- 🟦 <-30 ppm (<-0.16 ft/mi)
- 🟦 -25 to -30 ppm
- 🟦 -20 to -25 ppm
- 🟦 -10 to -20 ppm
- 🟩 ±10 ppm (±0.05 ft/mi)
- 🟨 +10 to +20 ppm
- 🟧 +20 to +25 ppm
- 🟧 +25 to +30 ppm
- 🟥 >+30 ppm (>+0.16 ft/mi)

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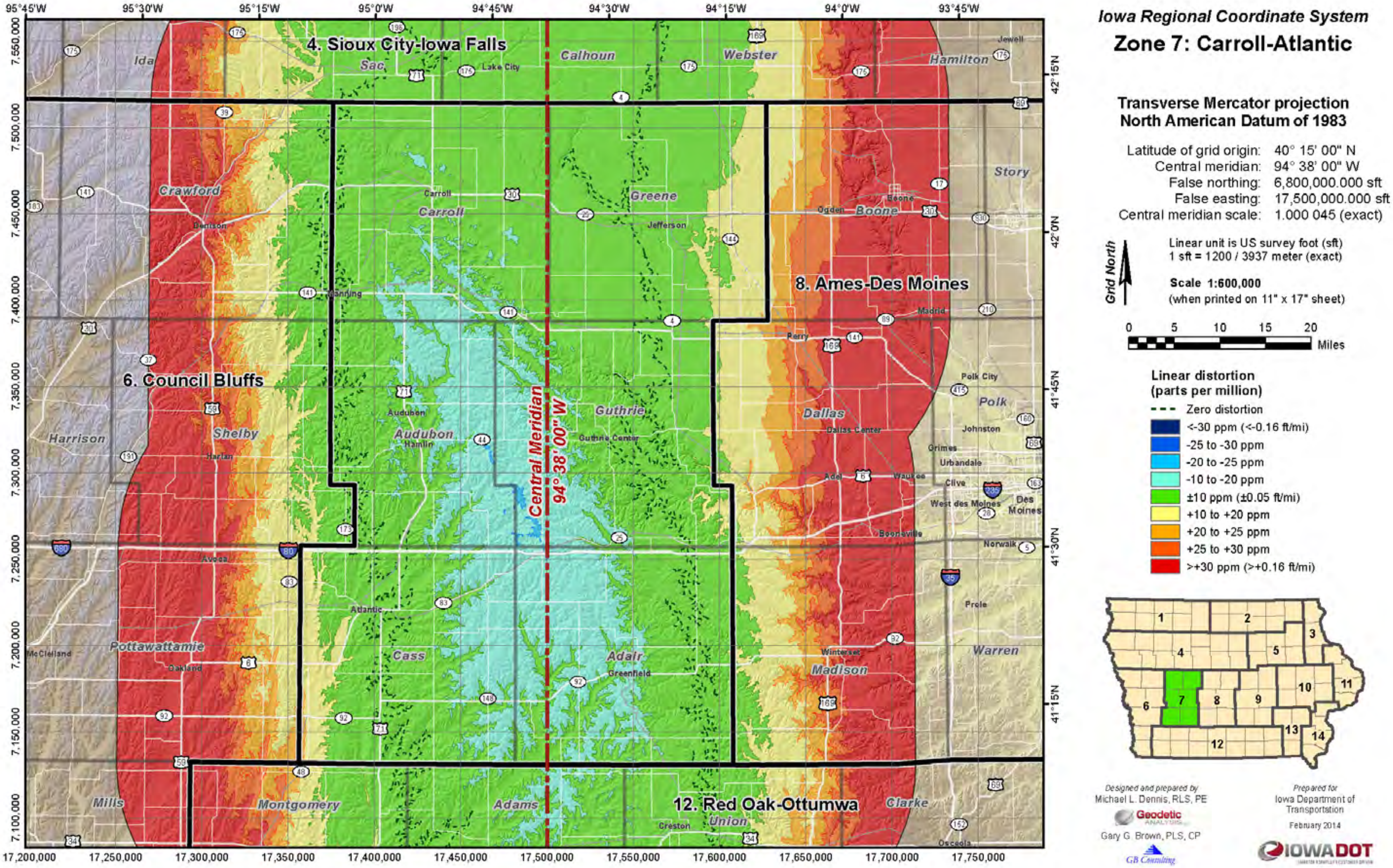

Iowa Regional Coordinate System

Zone 7: Carroll-Atlantic

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	40° 15' 00" N
Central meridian:	94° 38' 00" W
False northing:	6,800,000.000 sft
False easting:	17,500,000.000 sft
Central meridian scale:	1.000 045 (exact)

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion
(parts per million)

- --- Zero distortion
- 🟦 <-30 ppm (<-0.16 ft/mi)
- 🟦 -25 to -30 ppm
- 🟦 -20 to -25 ppm
- 🟦 -10 to -20 ppm
- 🟩 ±10 ppm (±0.05 ft/mi)
- 🟨 +10 to +20 ppm
- 🟧 +20 to +25 ppm
- 🟧 +25 to +30 ppm
- 🟥 >+30 ppm (>+0.16 ft/mi)

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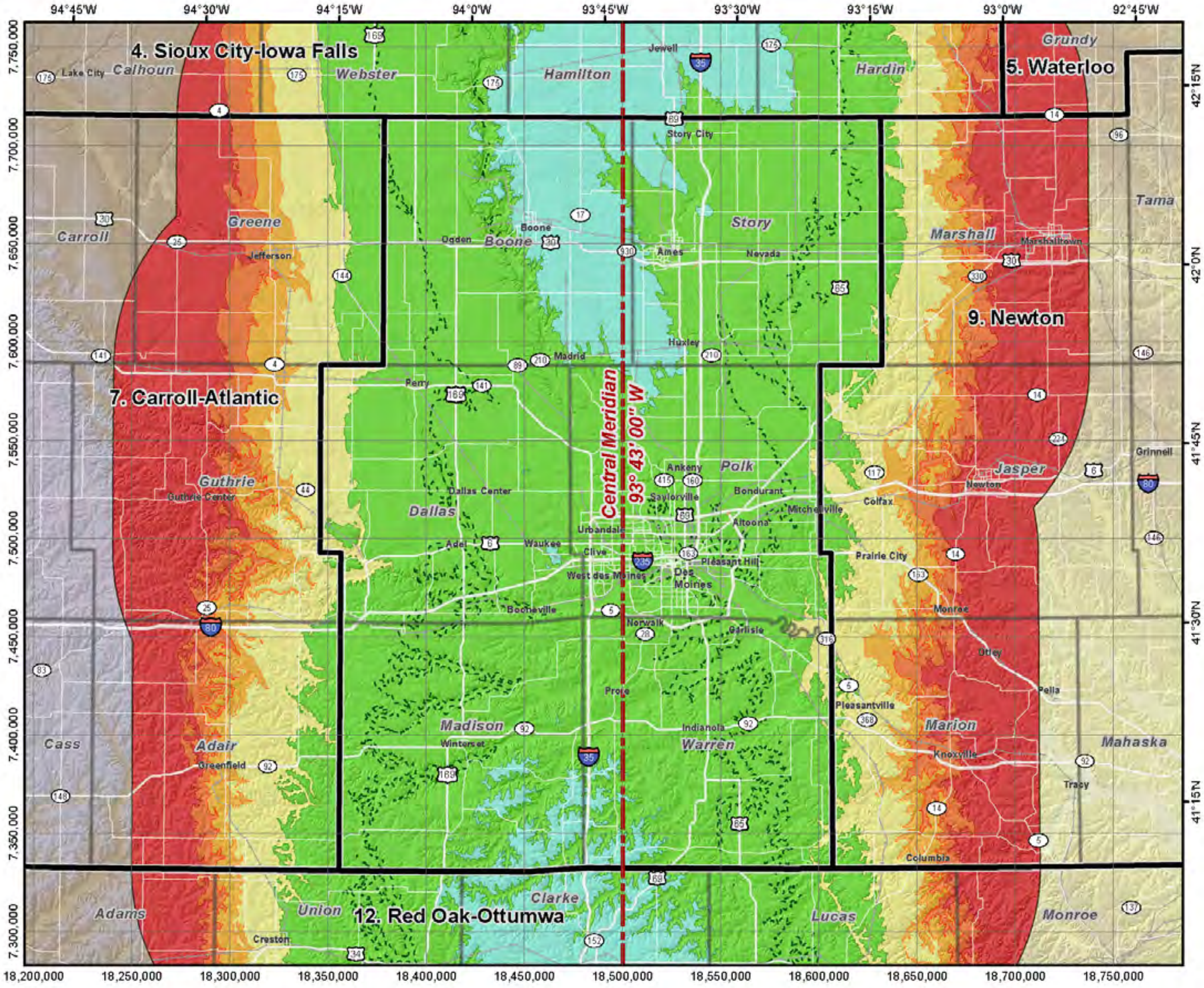


Iowa Regional Coordinate System

Zone 8: Ames-Des Moines

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	40° 15' 00" N
Central meridian:	93° 43' 00" W
False northing:	7,000,000.000 sft
False easting:	18,500,000.000 sft
Central meridian scale:	1.000 033 (exact)

Grid North

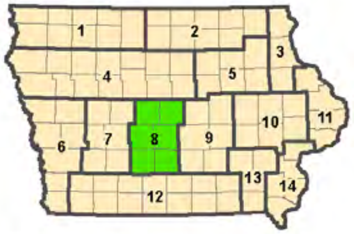
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion
(parts per million)

- - - Zero distortion
🟦 <-30 ppm (<-0.16 ft/mi)
🟦 -25 to -30 ppm
🟦 -20 to -25 ppm
🟦 -10 to -20 ppm
🟩 ±10 ppm (±0.05 ft/mi)
🟨 +10 to +20 ppm
🟧 +20 to +25 ppm
🟧 +25 to +30 ppm
🟥 >+30 ppm (>+0.16 ft/mi)



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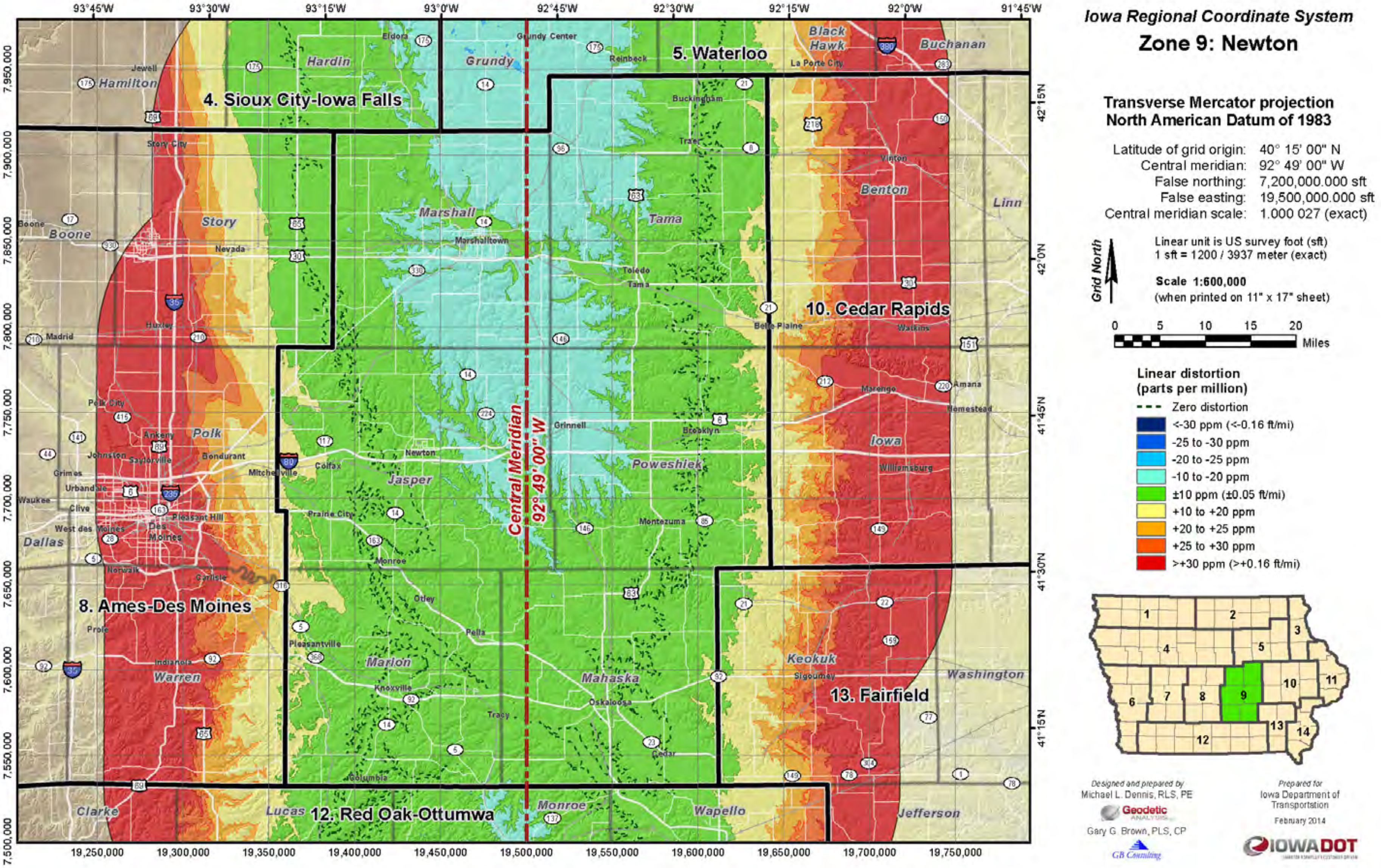

Iowa Regional Coordinate System

Zone 9: Newton

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	40° 15' 00" N
Central meridian:	92° 49' 00" W
False northing:	7,200,000.000 sft
False easting:	19,500,000.000 sft
Central meridian scale:	1.000 027 (exact)

Grid North

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion (parts per million)

- - - - Zero distortion
- 🟦 <-30 ppm (<-0.16 ft/mi)
- 🟦 -25 to -30 ppm
- 🟦 -20 to -25 ppm
- 🟦 -10 to -20 ppm
- 🟩 ±10 ppm (±0.05 ft/mi)
- 🟨 +10 to +20 ppm
- 🟧 +20 to +25 ppm
- 🟧 +25 to +30 ppm
- 🟥 >+30 ppm (>+0.16 ft/mi)

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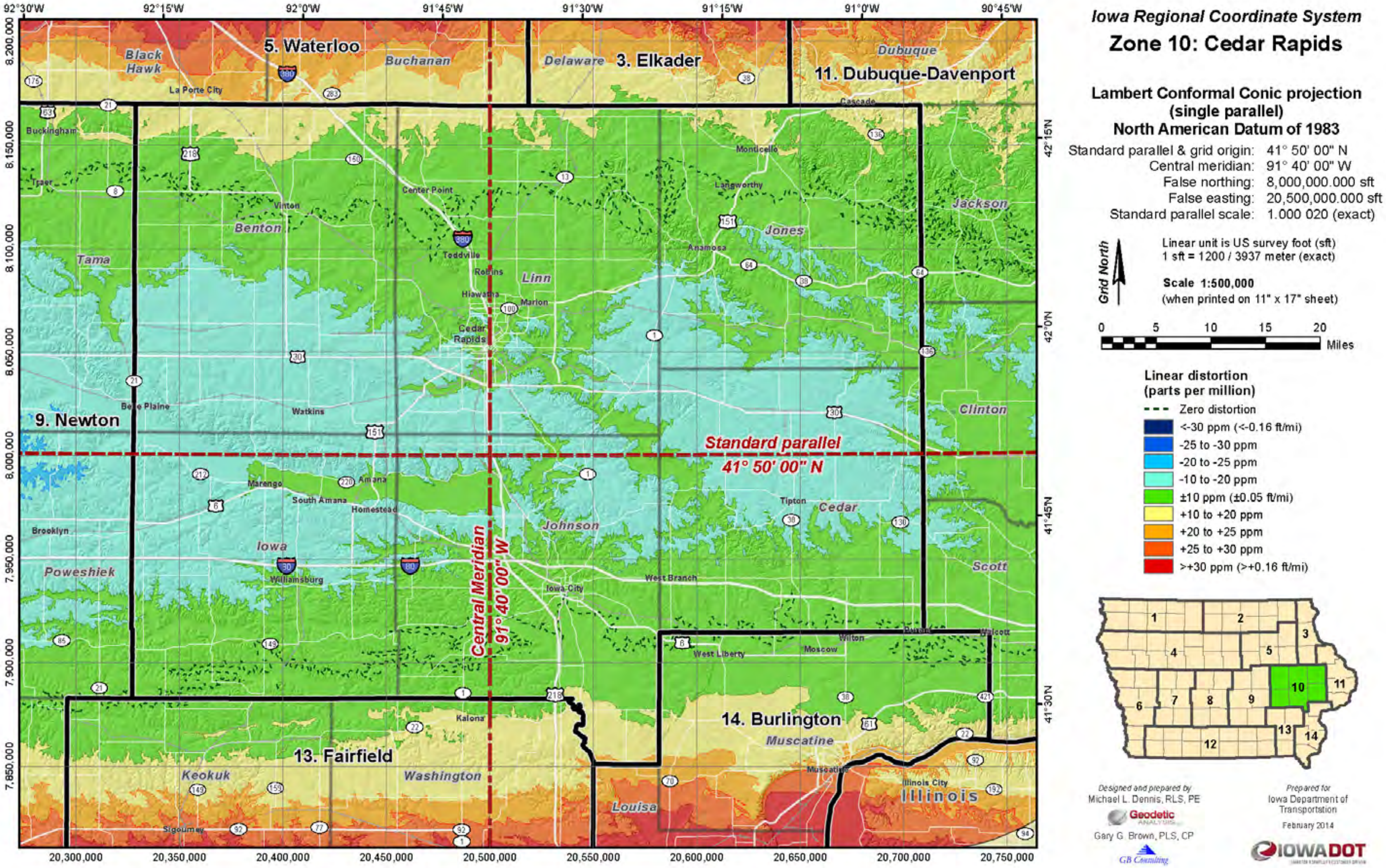

Iowa Regional Coordinate System

Zone 10: Cedar Rapids

Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983

Standard parallel & grid origin: 41° 50' 00" N
Central meridian: 91° 40' 00" W
False northing: 8,000,000.000 sft
False easting: 20,500,000.000 sft
Standard parallel scale: 1.000 020 (exact)

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:500,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion
(parts per million)

- - - Zero distortion
▇ <-30 ppm (<-0.16 ft/mi)
▇ -25 to -30 ppm
▇ -20 to -25 ppm
▇ -10 to -20 ppm
▇ ±10 ppm (±0.05 ft/mi)
▇ +10 to +20 ppm
▇ +20 to +25 ppm
▇ +25 to +30 ppm
▇ >+30 ppm (>+0.16 ft/mi)

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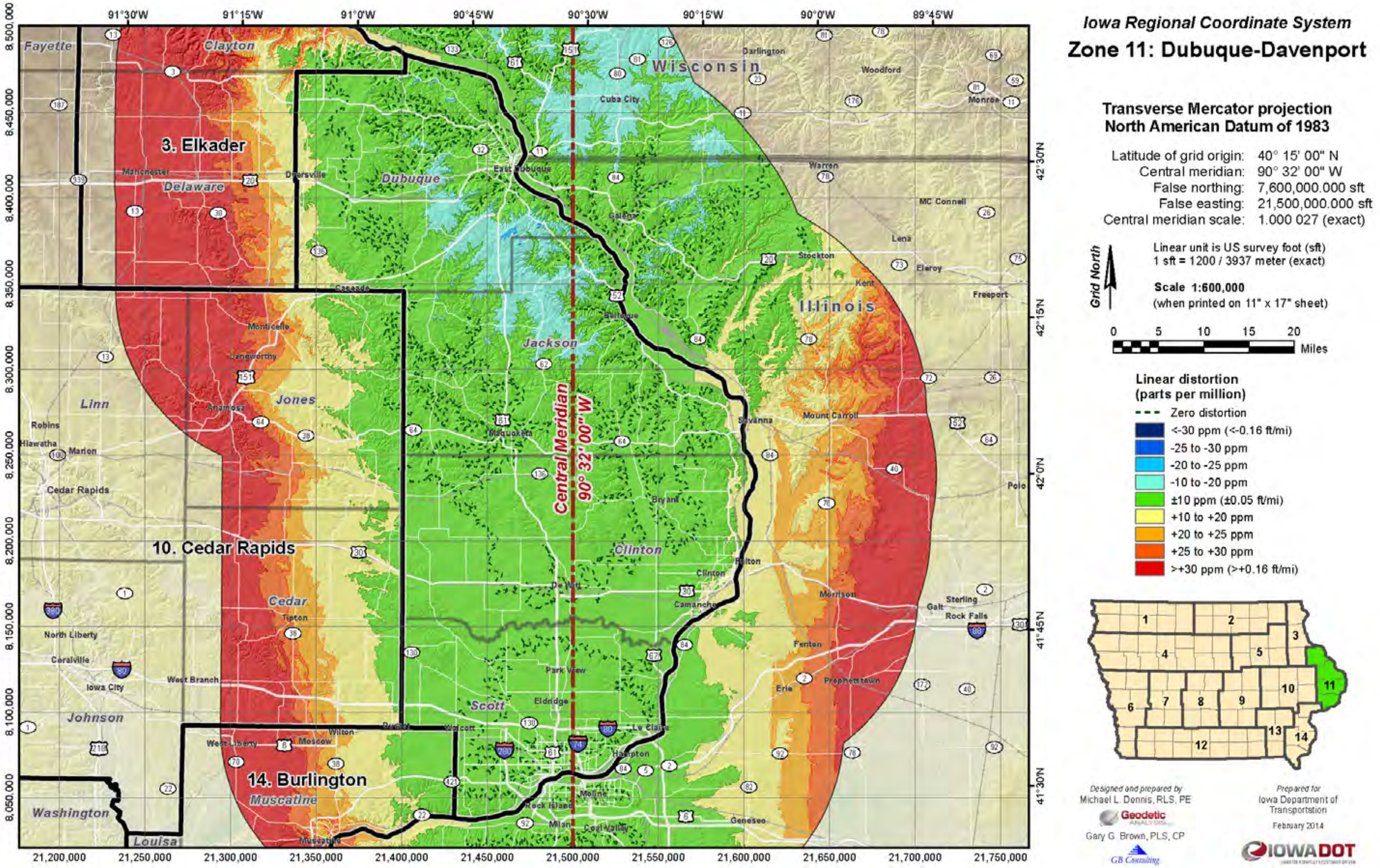
February 2014



Iowa Regional Coordinate System

Zone 11: Dubuque-Davenport

Transverse Mercator projection
North American Datum of 1983

Latitude of grid origin:	40° 15' 00" N
Central meridian:	90° 32' 00" W
False northing:	7,600,000.000 sft
False easting:	21,500,000.000 sft
Central meridian scale:	1.000 027 (exact)

Grid North

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:600,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 Miles

Linear distortion (parts per million)

- - -	Zero distortion
■	<-30 ppm (<-0.16 ft/mi)
■	-25 to -30 ppm
■	-20 to -25 ppm
■	-10 to -20 ppm
🟩	±10 ppm (±0.05 ft/mi)
🟨	+10 to +20 ppm
🟧	+20 to +25 ppm
🟧	+25 to +30 ppm
🟥	>+30 ppm (>+0.16 ft/mi)

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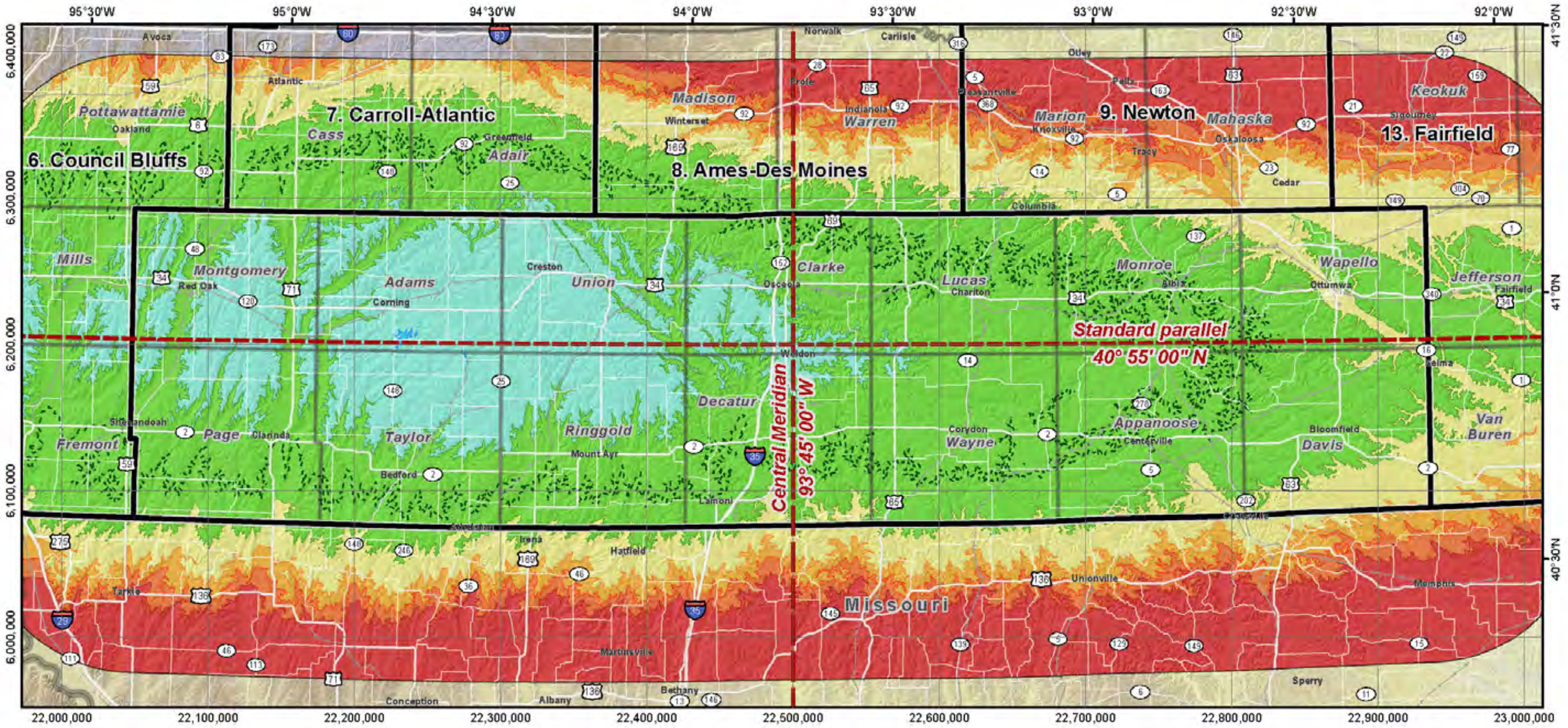
February 2014

IOWADOT



Iowa Regional Coordinate System

Zone 12: Red Oak-Ottumwa

Lambert Conformal Conic projection
(single parallel)
North American Datum of 1983

Standard parallel & grid origin:	40° 55' 00" N
Central meridian:	93° 45' 00" W
False northing:	6,200,000.000 sft
False easting:	22,500,000.000 sft
Standard parallel scale:	1.000 037 (exact)

Grid North

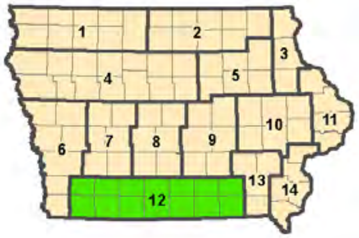
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:800,000
(when printed on 11" x 17" sheet)

0 5 10 15 20 25 Miles

Linear distortion
(parts per million)

- - -	Zero distortion
🟦	<-30 ppm (<-0.16 ft/mi)
🟦	-25 to -30 ppm
🟦	-20 to -25 ppm
🟦	-10 to -20 ppm
🟩	±10 ppm (±0.05 ft/mi)
🟨	+10 to +20 ppm
🟧	+20 to +25 ppm
🟧	+25 to +30 ppm
🟥	>+30 ppm (>+0.16 ft/mi)



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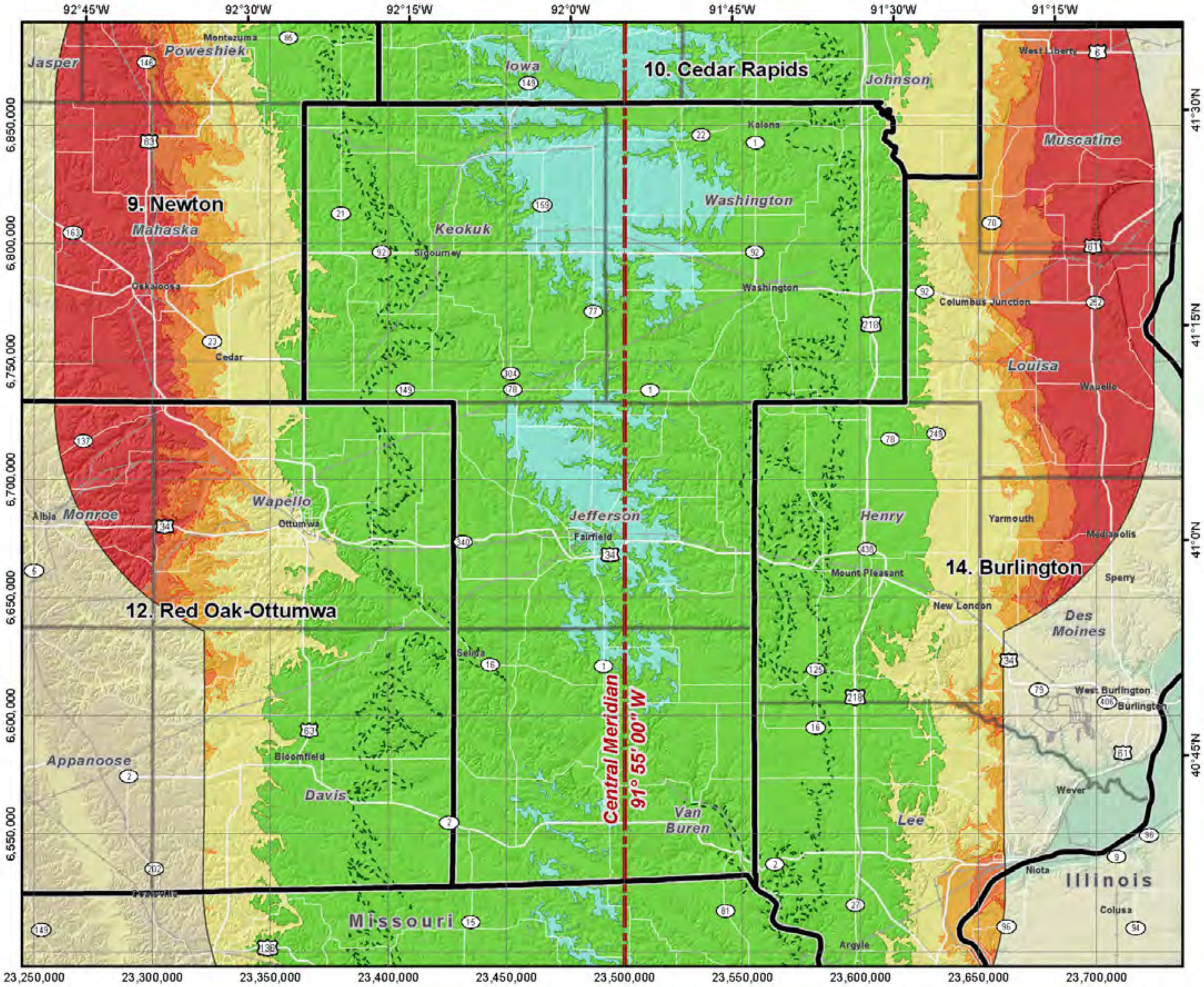


Iowa Regional Coordinate System

Zone 13: Fairfield

Transverse Mercator projection
North American Datum of 1983

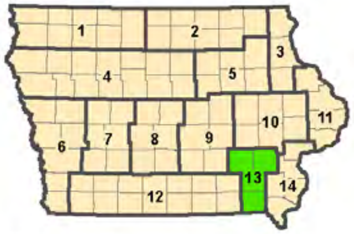
Latitude of grid origin:	40° 15' 00" N
Central meridian:	91° 55' 00" W
False northing:	6,400,000.000 sft
False easting:	23,500,000.000 sft
Central meridian scale:	1.000 020 (exact)

Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)

Scale 1:500,000
(when printed on 11" x 17" sheet)

Linear distortion
(parts per million)

- --- Zero distortion
- ■ <-30 ppm (<-0.16 ft/mi)
- ■ -25 to -30 ppm
- ■ -20 to -25 ppm
- ■ -10 to -20 ppm
- 🟩 ±10 ppm (±0.05 ft/mi)
- 🟨 +10 to +20 ppm
- 🟧 +20 to +25 ppm
- ■ +25 to +30 ppm
- 🟥 >+30 ppm (>+0.16 ft/mi)



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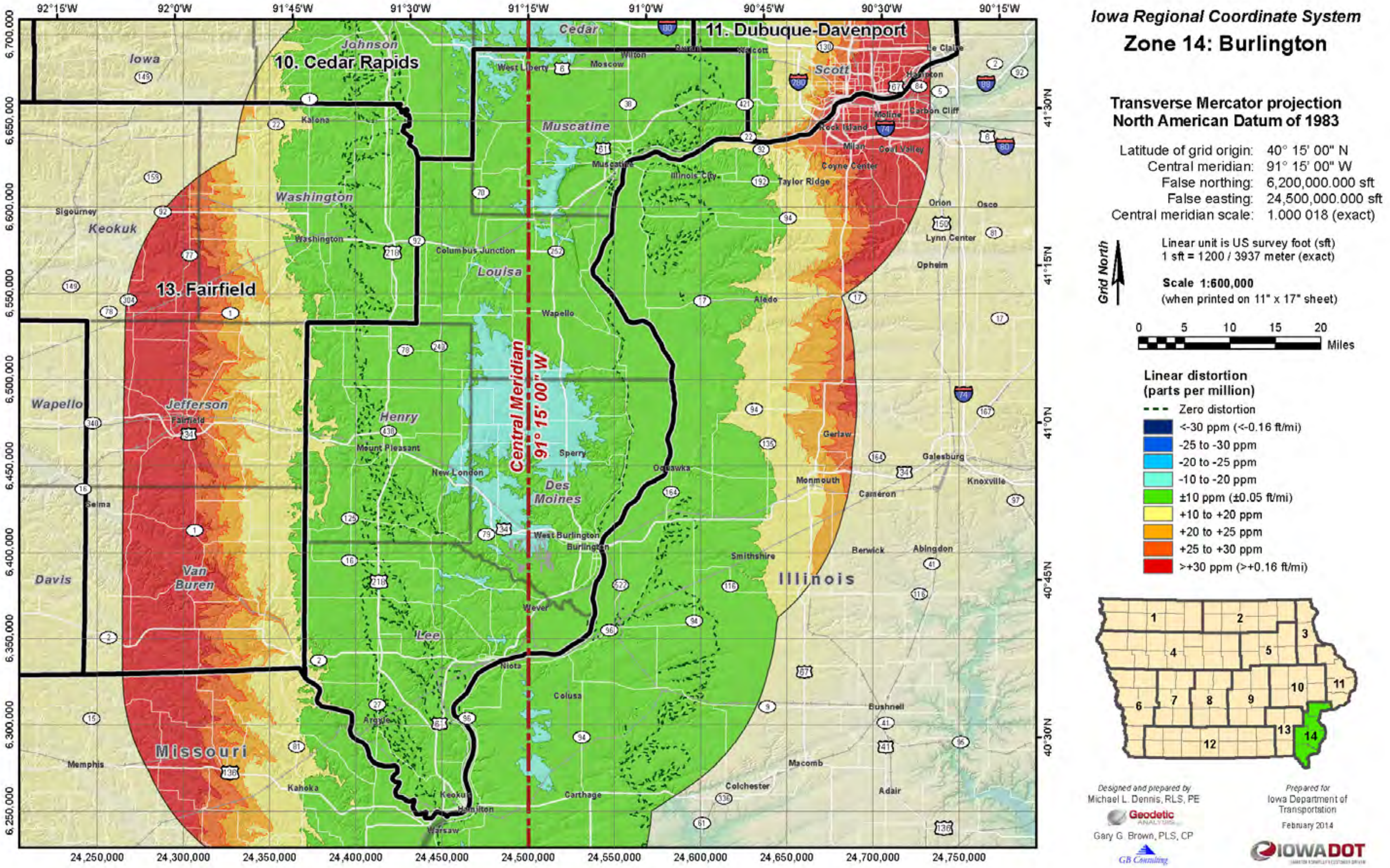
Iowa Regional Coordinate System
Zone 14: Burlington
Transverse Mercator projection
North American Datum of 1983
Latitude of grid origin: 40° 15' 00" N
Central meridian: 91° 15' 00" W
False northing: 6,200,000.000 sft
False easting: 24,500,000.000 sft
Central meridian scale: 1.000 018 (exact)
Linear unit is US survey foot (sft)
1 sft = 1200 / 3937 meter (exact)
Grid North
Scale 1:600,000
(when printed on 11" x 17" sheet)
0 5 10 15 20 Miles
Linear distortion (parts per million)
Zero distortion
<-30 ppm (<-0.16 ft/mi)
-25 to -30 ppm
-20 to -25 ppm
-10 to -20 ppm
±10 ppm (±0.05 ft/mi)
+10 to +20 ppm
+20 to +25 ppm
+25 to +30 ppm
>+30 ppm (>+0.16 ft/mi)
1 2 3 4 5 6 7 8 9 10 11 12 13 14
Designed and prepared by
Michael L. Dennis, RLS, PE
Geodetic Analysis
Gary G. Brown, PLS, CP
GB Consulting
Prepared for
Iowa Department of Transportation
February 2014
IOWADOT
Central Meridian 91° 15' 00" W
10. Cedar Rapids
11. Dubuque-Davenport
13. Fairfield
92°15'W 92°0'W 91°45'W 91°30'W 91°15'W 91°0'W 90°45'W 90°30'W 90°15'W
41°30'N 41°15'N 41°0'N 40°45'N 40°30'N
6,700,000 6,650,000 6,600,000 6,550,000 6,500,000 6,450,000 6,400,000 6,350,000 6,300,000 6,250,000
24,250,000 24,300,000 24,350,000 24,400,000 24,450,000 24,500,000 24,550,000 24,600,000 24,650,000 24,700,000 24,750,000
Iowa
Johnson
Cedar
Scott
Muscatine
Washington
Keokuk
Louisa
Jefferson
Wapello
Henry
Des Moines
Davis
Van Buren
Lee
Missouri
Illinois
Sigourney
Kalona
Washington
Columbus Junction
West Liberty
Moscow
Wilton
Durant
Walcott
Le Claire
Hampton
Moline
Rock Island
Carbon Cliff
Milan
Coal Valley
Coyne Center
Muscatine
Illinois City
Taylor Ridge
Orion
Osco
Lynn Center
Ophiem
Aledo
Wapello
Fairfield
Mount Pleasant
New London
Sperry
Oquawka
Gerlaw
Galesburg
Knoxville
Monmouth
Cameron
West Burlington
Burlington
Smithshire
Berwick
Abingdon
Selma
Wever
Niota
Colusa
Bushnell
Argyle
Keokuk
Hamilton
Warsaw
Kahoka
Memphis
Carthage
Macomb
Colchester
Adair

Appendix B.

IaRCS coordinates on NAD 83(2011) epoch 2010.00 NGS control

IaRCS coordinates for NGS NAD 83(2011) epoch 2010.00 control

Tables B-1 and B-2 give IaRCS coordinates for 312 NGS-published NAD 83(2011) epoch 2010.00 control stations in Iowa, sorted by designation (or CORS ID) within each zone. Table B-1 lists 35 NGS Continually Operating Reference Station (CORS) Antenna Reference Points (ARPs), and Table B-2 lists 277 NGS passive control stations (i.e., monuments that can be occupied with survey equipment, such as brass disks). The northing and easting values are given to the nearest 0.0001 US survey foot (sft) to facilitate checking of projected coordinate computations. The stations given here were obtained from the NGS Integrated Data Base (NGSIDB) on August 11, 2014 and represent the status of NGS published NAD 83(2011) epoch 2010.00 control in Iowa on that date. IaRCS coordinates were computed directly from the NGS published latitude and longitude values, and the ellipsoid heights (published in meters) were converted to US survey feet. The stations were not occupied or recovered to create these tables, and so some stations may presently be obstructed, removed, damaged, destroyed, or otherwise unavailable or unsuitable for use.

Table B-1. *IaRCS coordinates for NGS NAD 83(2011) epoch 2010.00 CORS in Iowa.*

Zone number and name	NGS PID	CORS ID (and station designation)	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
1. Spencer	DP1310	IAAS (IOWA DOT ASHTON CORS ARP)	43°18'20.16923''N	95°46'44.57524''W	1412.678	**9,638,938.5122**	**11,359,164.4935**
1. Spencer	DP2488	IASW (IADT SWEA CITY CORS ARP)	43°23'00.12333''N	94°17'47.25784''W	1108.669	**9,668,284.3093**	**11,753,510.4306**
2. Mason City	DO2871	IADE (IOWA DOT DECORAH CORS ARP)	43°16'15.80601''N	91°49'53.48333''W	1041.770	**9,839,392.5007**	**12,744,636.2323**
2. Mason City	DP1957	IAHT (IADT HANLONTOWN CORS ARP)	43°17'02.35597''N	93°22'06.64350''W	1133.439	**9,843,372.5719**	**12,335,292.3623**
3. Elkader	DP1235	IAEL (IOWA DOT ELKADER CORS ARP)	42°52'40.45052''N	91°21'41.48774''W	984.296	**9,257,644.1304**	**13,456,701.6428**
3. Elkader	DL3589	IANA (NEW ALBIN CORS ARP)	43°29'49.45244''N	91°17'26.49752''W	568.463	**9,483,303.0854**	**13,475,933.0492**
4. Sioux City-Iowa Falls	DP1229	IACL (IOWA DOT CLARION CORS ARP)	42°43'51.59391''N	93°45'04.85678''W	1096.012	**8,673,898.7371**	**14,790,721.3526**
4. Sioux City-Iowa Falls	DP1245	IAPS (IADT POCHAHONTAS CORS ARP)	42°44'16.91863''N	94°40'45.28490''W	1159.499	**8,674,644.6357**	**14,541,398.6469**
4. Sioux City-Iowa Falls	DP1247	IASX (IADT SIOUX CITY CORS ARP)	42°33'00.13910''N	96°20'54.47505''W	1079.748	**8,609,737.8629**	**14,091,726.6190**
5. Waterloo	DP1223	IAAL (IOWA DOT ALLISON CORS ARP)	42°44'49.37888''N	92°47'14.20394''W	958.354	**8,935,830.1085**	**15,355,673.8529**
6. Council Bluffs	DP1227	IACB (COUNCIL BLUFFS CORS ARP)	41°13'26.38362''N	95°51'11.59336''W	911.760	**6,954,894.9804**	**16,467,018.1555**
6. Council Bluffs	DP1233	IADN (IOWA DOT DENISON CORS ARP)	41°59'50.56299''N	95°22'32.52887''W	1152.140	**7,236,897.9079**	**16,597,218.9069**
6. Council Bluffs	AH5054	OMH1 (OMAHA 1 CORS ARP)	41°46'41.76551''N	95°54'40.67031''W	1308.268	**7,156,896.9070**	**16,451,456.4413**
6. Council Bluffs	AH5056	OMH2 (OMAHA 2 CORS ARP)	41°46'42.57678''N	95°54'41.34064''W	1306.211	**7,156,979.1337**	**16,451,405.8205**
6. Council Bluffs	DI8412	OMH5 (OMAHA 5 CORS ARP)	41°46'41.76531''N	95°54'40.67014''W	1308.767	**7,156,896.8867**	**16,451,456.4541**

Zone number and name	NGS PID	CORS ID (and station designation)	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
6. Council Bluffs	DI8414	OMH6 (OMAHA 6 CORS ARP)	41°46'42.57631''N	95°54'41.34080''W	1306.917	**7,156,979.0861**	**16,451,405.8083**
7. Carroll-Atlantic	DP1225	IAAT (IOWA DOT ATLANTIC CORS ARP)	41°24'19.52348''N	94°59'16.80591''W	1127.662	**7,221,183.2314**	**17,402,697.5455**
8. Ames-Des Moines	DM2686	IAAM (IADT AMES CORS ARP)	42°00'34.52729''N	93°33'35.03154''W	874.493	**7,641,180.6403**	**18,542,653.1922**
8. Ames-Des Moines	DP1239	IAMD (IADT MARTENSDALE CORS ARP)	41°22'16.79994''N	93°44'38.84682''W	764.306	**7,408,558.3181**	**18,492,463.2709**
8. Ames-Des Moines	AI2153	SLAI (SLATER CORS ARP)	41°54'02.07288''N	93°41'55.90356''W	953.095	**7,601,414.5327**	**18,504,847.3154**
9. Newton	DP1243	IAOK (IADT OSKALOOSA CORS ARP)	41°17'35.36919''N	92°41'04.79068''W	684.694	**7,580,096.7447**	**19,536,276.2000**
9. Newton	DP1249	IATA (IOWA DOT TAMA CORS ARP)	41°58'01.64688''N	92°33'05.03261''W	814.887	**7,825,773.5478**	**19,572,144.2997**
10. Cedar Rapids	DP1318	IAMN (IOWA DOT MARION CORS ARP)	42°01'49.08336''N	91°32'55.55595''W	754.451	**8,071,800.2439**	**20,532,033.4405**
10. Cedar Rapids	AF9523	NLIB (NORTH LIBERTY CORS ARP)	41°46'17.70040''N	91°34'29.59182''W	682.827	**7,977,511.2391**	**20,525,037.1410**
11. Dubuque-Davenport	DP1314	IADA (IADT DAVENPORT CORS ARP)	41°36'36.18278''N	90°37'49.54785''W	661.705	**8,095,555.9536**	**21,473,446.0006**
11. Dubuque-Davenport	DP1241	IAMQ (IADT MAQUOKETA CORS ARP)	42°04'25.20090''N	90°38'42.15312''W	618.906	**8,264,508.4365**	**21,469,669.4831**
11. Dubuque-Davenport	AF9642	RIS1 (ROCK ISLAND 1 CORS ARP)	42°00'44.18171''N	90°13'32.20280''W	712.971	**8,242,265.3143**	**21,583,630.9279**
11. Dubuque-Davenport	AF9644	RIS2 (ROCK ISLAND 2 CORS ARP)	42°00'44.28366''N	90°13'30.08134''W	712.669	**8,242,276.2108**	**21,583,791.0463**
11. Dubuque-Davenport	DI8416	RIS5 (ROCK ISLAND 5 CORS ARP)	42°00'44.18164''N	90°13'32.20241''W	713.460	**8,242,265.3073**	**21,583,630.9574**
11. Dubuque-Davenport	DI8418	RIS6 (ROCK ISLAND 6 CORS ARP)	42°00'44.28368''N	90°13'30.08075''W	713.233	**8,242,276.2130**	**21,583,791.0908**
12. Red Oak-Ottumwa	DP1312	IACE (IADT CENTERVILLE CORS ARP)	40°42'07.27176''N	92°52'12.62543''W	940.891	**6,123,019.9334**	**22,743,958.6148**
12. Red Oak-Ottumwa	DP1231	IACN (IOWA DOT CLARINDA CORS ARP)	40°44'33.94334''N	95°01'20.26096''W	926.310	**6,139,201.2365**	**22,147,439.9384**
12. Red Oak-Ottumwa	DP1237	IALN (IADT LEON CORS ARP)	40°43'44.48410''N	93°45'42.85995''W	1045.159	**6,131,631.9616**	**22,496,700.1095**
13. Fairfield	DP1251	IAWN (IADT WASHINGTON CORS ARP)	41°18'34.12005''N	91°40'44.74803''W	677.430	**6,786,102.3329**	**23,565,270.9189**
14. Burlington	DP1316	IADO (IADT DONNELLSON CORS ARP)	40°38'48.98303''N	91°33'57.38924''W	618.995	**6,344,770.9431**	**24,412,324.2231**

Table B-2. *IaRCS coordinates for NGS NAD 83(2011) epoch 2010.00 passive control in Iowa.*

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
1. Spencer	DH3926	15 WL	43°30'01.34011"N	94°29'32.28774"W	1146.418	**9,710,401.6902**	**11,701,058.9774**
1. Spencer	DH3928	31 DWB	43°30'02.76910"N	94°43'32.05318"W	1216.474	**9,710,072.2895**	**11,639,160.1638**
1. Spencer	AJ8322	963073 3 7089	43°09'24.21959"N	95°12'09.72542"W	1241.946	**9,584,230.4907**	**11,512,621.8543**
1. Spencer	OP0140	A 19	43°06'09.49177"N	94°38'22.46680"W	1129.033	**9,565,105.0309**	**11,663,037.7462**
1. Spencer	OP1149	ALGOPORT	43°04'43.81368"N	94°16'25.81776"W	1116.008	**9,557,356.4996**	**11,760,819.1636**
1. Spencer	OP0566	B 17	43°29'56.39118"N	95°41'42.40870"W	1560.952	**9,709,304.5753**	**11,381,883.1405**
1. Spencer	OP0792	BEACON	43°10'02.07601"N	95°11'50.99946"W	1240.204	**9,588,064.3446**	**11,514,007.5392**
1. Spencer	AI5700	BIGELOW	43°29'29.67104"N	95°41'55.88410"W	1563.960	**9,706,604.2655**	**11,380,875.3407**
1. Spencer	NM0034	D 154	42°59'09.58979"N	96°29'07.64620"W	1091.353	**9,524,435.3913**	**11,169,405.0720**
1. Spencer	OP0490	D 18	43°09'08.96506"N	95°13'49.15519"W	1242.484	**9,582,682.9964**	**11,505,251.8394**
1. Spencer	NL0717	DALE 2	42°58'55.28013"N	94°13'38.92787"W	1026.514	**9,522,218.0706**	**11,773,636.0680**
1. Spencer	OQ0592	GARFIELD	43°19'13.69590"N	96°10'35.47487"W	1322.776	**9,645,278.0338**	**11,253,418.7398**
1. Spencer	CO3187	GROTEWOLD AZ MK	43°28'31.41674"N	96°24'36.34396"W	1419.184	**9,702,520.3323**	**11,192,042.1981**
1. Spencer	OP0124	K 1	43°13'35.22725"N	94°13'16.86601"W	1057.882	**9,611,326.8536**	**11,774,181.0310**
1. Spencer	OP0806	LAKE PARK	43°26'36.32781"N	95°22'06.59834"W	1440.260	**9,688,754.7001**	**11,468,525.7352**
1. Spencer	OP0152	M 19	43°18'38.10357"N	94°47'33.28320"W	1178.518	**9,640,642.0522**	**11,621,758.2158**
1. Spencer	OP1162	MILPORT	43°20'04.68373"N	95°09'09.71235"W	1342.783	**9,649,091.0449**	**11,525,890.1953**
1. Spencer	AE2141	ORC A	42°59'21.41063"N	96°03'43.74176"W	1316.310	**9,524,246.6255**	**11,282,684.4955**
1. Spencer	AJ8293	ORC B	42°58'56.49785"N	96°03'32.54829"W	1302.081	**9,521,716.2853**	**11,283,492.0750**
1. Spencer	AJ8292	ORC C	42°59'36.84976"N	96°03'48.91209"W	1324.243	**9,525,813.4854**	**11,282,315.4027**
1. Spencer	AJ8320	SPW A 2001	43°10'04.37230"N	95°12'31.76870"W	1243.980	**9,588,295.1572**	**11,510,985.8638**
1. Spencer	OQ1239	STALIN	43°30'00.14519"N	96°01'42.49927"W	1366.890	**9,710,331.2862**	**11,293,427.5225**
1. Spencer	OQ1237	STALIN RM 3	43°30'00.13377"N	96°01'04.51153"W	1344.686	**9,710,304.2631**	**11,296,227.5126**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
1. Spencer	OP0559	U 16	43°19'27.50927''N	95°46'58.89817''W	1364.922	**9,645,763.5829**	**11,358,148.8086**
1. Spencer	OP0782	WHYNOT	43°15'56.19534''N	95°01'58.98582''W	1369.987	**9,623,990.3757**	**11,557,790.8928**
1. Spencer	OP0485	Y 17	43°10'00.10254''N	95°23'18.37663''W	1285.457	**9,587,890.6809**	**11,463,063.1217**
2. Mason City	OO0687	41 1	43°07'33.22896''N	93°30'06.64422''W	1171.300	**9,786,040.3612**	**12,299,269.6674**
2. Mason City	OO1164	AIR	43°09'01.20328''N	93°20'10.35289''W	1101.602	**9,794,594.3128**	**12,343,553.3879**
2. Mason City	OO0967	AIRPORT	43°04'02.30143''N	92°36'38.58477''W	1018.961	**9,763,813.9624**	**12,537,221.9895**
2. Mason City	OO1148	BEANS	43°04'00.49179''N	93°11'40.16252''W	1121.563	**9,763,915.0053**	**12,381,213.2853**
2. Mason City	AB2419	BRUA RESET	43°28'08.55682''N	93°28'06.76142''W	1256.851	**9,911,039.0971**	**12,309,233.3315**
2. Mason City	OO0226	C 37	43°03'51.13831''N	92°13'28.24890''W	1053.325	**9,763,093.3391**	**12,640,438.2268**
2. Mason City	ON0867	CANOE	43°23'04.50792''N	91°44'17.99343''W	1084.069	**9,881,058.2624**	**12,768,956.7940**
2. Mason City	DL5322	CCY A	43°04'41.15268''N	92°37'02.32957''W	1012.564	**9,767,744.7582**	**12,535,453.0906**
2. Mason City	OO1315	CHARLPORT	43°04'21.35598''N	92°36'34.46716''W	1014.155	**9,765,743.7296**	**12,537,524.4205**
2. Mason City	OO1209	CLOVER	43°13'38.05246''N	93°50'59.62251''W	1209.207	**9,824,003.2048**	**12,206,835.8048**
2. Mason City	AE2134	DEH A	43°16'25.16222''N	91°43'56.19993''W	1059.735	**9,840,645.3320**	**12,771,057.4839**
2. Mason City	ON0899	HESPER	43°29'11.04750''N	91°45'17.61359''W	1235.024	**9,918,117.5032**	**12,764,113.1652**
2. Mason City	OO1179	JOICE RESET	43°21'34.26150''N	93°24'30.73388''W	1247.399	**9,870,984.5022**	**12,324,850.5074**
2. Mason City	OO1635	LOUISE	43°30'00.59649''N	92°29'57.20175''W	1180.673	**9,921,665.2943**	**12,566,545.6796**
2. Mason City	OO0292	M 36	43°04'28.99125''N	92°40'51.42860''W	911.835	**9,766,492.9423**	**12,518,450.1937**
2. Mason City	OO0945	MAPLE	43°18'56.87200''N	92°26'08.32335''W	1255.522	**9,854,516.5453**	**12,583,668.5966**
2. Mason City	OO0274	N 40	43°20'04.83000''N	92°52'41.22725''W	1094.666	**9,861,266.6198**	**12,465,910.4039**
2. Mason City	NK0179	T 39	42°58'48.74442''N	92°32'21.95084''W	879.290	**9,732,106.6323**	**12,556,352.7041**
2. Mason City	DF4650	TT 10 WM	43°29'58.44287''N	93°39'35.99384''W	1167.396	**9,922,659.4746**	**12,258,526.9889**
2. Mason City	OO0257	V 39	43°01'16.93048''N	92°35'28.41169''W	911.274	**9,747,079.6325**	**12,542,462.9449**
3. Elkader	NJ0606	997	42°34'45.84174''N	91°32'48.92159''W	897.232	**9,148,998.1827**	**13,406,556.6020**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
3. Elkader	ON0828	EGAN	43°09'12.22060''N	91°16'17.44969''W	1057.321	**9,358,024.8540**	**13,480,915.4535**
3. Elkader	NJ0754	ET 2 JS	42°22'26.88426''N	91°08'43.43266''W	924.440	**9,074,001.0773**	**13,514,755.1604**
3. Elkader	NJ0700	GUTTEN	42°45'24.86908''N	91°07'45.27124''W	850.802	**9,213,510.6290**	**13,519,004.4593**
3. Elkader	ON0786	MINNOWA	43°30'00.52514''N	91°27'54.01362''W	1050.549	**9,484,523.0919**	**13,429,680.8216**
4. Sioux City-Iowa Falls	NK0300	42 105	42°19'55.66105''N	93°18'35.33261''W	1014.129	**8,530,371.9238**	**14,911,960.6023**
4. Sioux City-Iowa Falls	NK0284	42 140	42°29'06.37127''N	93°15'45.48268''W	1029.634	**8,586,347.9599**	**14,923,683.6487**
4. Sioux City-Iowa Falls	NK0285	42 141	42°28'14.50826''N	93°15'45.11350''W	1036.140	**8,581,098.8211**	**14,923,808.6132**
4. Sioux City-Iowa Falls	NM0820	A 146	42°46'56.59477''N	96°35'33.84741''W	1054.745	**8,695,676.0113**	**14,027,671.2681**
4. Sioux City-Iowa Falls	NK0186	A 29	42°44'22.94202''N	93°18'03.04720''W	1117.084	**8,678,938.9982**	**14,911,699.5294**
4. Sioux City-Iowa Falls	NM1659	AITKEN	42°24'53.20417''N	96°07'32.44822''W	1319.840	**8,559,452.5095**	**14,151,002.4918**
4. Sioux City-Iowa Falls	NL0062	B 28	42°41'26.24341''N	94°01'48.21925''W	1041.753	**8,658,350.7157**	**14,715,975.6041**
4. Sioux City-Iowa Falls	NL0066	D 3	42°13'29.73770''N	94°02'52.48497''W	1045.762	**8,488,585.5198**	**14,712,748.8326**
4. Sioux City-Iowa Falls	NL0581	DIVIDE	42°50'32.39450''N	95°19'44.18634''W	1449.515	**8,713,010.8726**	**14,367,068.3204**
4. Sioux City-Iowa Falls	NL0584	EARLY	42°25'19.87286''N	95°07'06.56646''W	1317.947	**8,559,621.1044**	**14,422,999.6627**
4. Sioux City-Iowa Falls	DI3115	EBS A	42°26'29.82509''N	93°52'26.01143''W	1014.509	**8,568,039.3355**	**14,758,990.3538**
4. Sioux City-Iowa Falls	DI3116	EBS B	42°26'20.53260''N	93°52'10.94507''W	1019.060	**8,567,111.4570**	**14,760,130.7215**
4. Sioux City-Iowa Falls	DI3117	EBS C	42°25'55.52606''N	93°51'49.18307''W	1028.955	**8,564,598.6165**	**14,761,791.4603**
4. Sioux City-Iowa Falls	NL0804	ET 1 HK	42°15'09.40621''N	94°22'44.60851''W	1031.287	**8,498,019.4040**	**14,622,997.7649**
4. Sioux City-Iowa Falls	NK0735	ET 7 JA	42°16'02.69586''N	93°45'25.44542''W	1024.407	**8,504,934.3804**	**14,791,330.2398**
4. Sioux City-Iowa Falls	NL0374	F 14	42°28'23.03111''N	95°43'40.10908''W	1116.162	**8,579,307.7103**	**14,258,666.9041**
4. Sioux City-Iowa Falls	NL0119	F 32	42°28'19.60412''N	94°03'01.16130''W	1022.819	**8,578,663.1695**	**14,711,263.7572**
4. Sioux City-Iowa Falls	AE2135	FOD A	42°33'09.88062''N	94°11'14.86704''W	1042.554	**8,607,737.8450**	**14,674,038.7972**
4. Sioux City-Iowa Falls	AE2149	GPS 048	42°41'28.41533''N	96°19'51.60841''W	1356.595	**8,661,104.8449**	**14,097,341.0223**
4. Sioux City-Iowa Falls	NK0673	HILL ET	42°52'37.33196''N	93°07'26.08330''W	1013.814	**8,729,892.8401**	**14,958,217.0016**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
4. Sioux City-Iowa Falls	NM1615	HOMAN RESET	42°54'36.71920''N	96°01'27.73466''W	1335.693	**8,739,601.7068**	**14,180,896.5332**
4. Sioux City-Iowa Falls	DL5969	HPT A	42°43'32.39644''N	93°13'31.02504''W	1068.981	**8,674,198.5764**	**14,932,093.7402**
4. Sioux City-Iowa Falls	DL5971	HPT B	42°43'49.81302''N	93°13'30.96078''W	1081.422	**8,675,961.6717**	**14,932,065.0822**
4. Sioux City-Iowa Falls	DL5970	HPT C	42°43'04.53480''N	93°13'31.66944''W	1059.286	**8,671,377.3557**	**14,932,099.1575**
4. Sioux City-Iowa Falls	NL0235	K 22 RESET	42°51'05.75091''N	94°58'33.15936''W	1288.009	**8,716,031.5886**	**14,461,772.2900**
4. Sioux City-Iowa Falls	NK0459	L 28	42°43'40.77582''N	93°44'53.60534''W	1069.834	**8,672,814.2974**	**14,791,575.1014**
4. Sioux City-Iowa Falls	NL0869	POCAHONTAS 3	42°44'07.91862''N	94°37'10.33277''W	1133.115	**8,673,768.2567**	**14,557,442.8940**
4. Sioux City-Iowa Falls	NK0427	R 31	42°29'00.05609''N	93°37'03.16962''W	1133.538	**8,584,134.9226**	**14,827,965.3715**
4. Sioux City-Iowa Falls	NM1700	SIOUX CITY ARP 2	42°24'14.60456''N	96°23'00.48191''W	1007.495	**8,556,712.7808**	**14,081,322.8702**
4. Sioux City-Iowa Falls	AI1965	SLB A	42°36'13.67394''N	95°14'37.61142''W	1383.235	**8,625,949.6596**	**14,389,488.6087**
4. Sioux City-Iowa Falls	NM0113	SLOAN	42°12'52.42674''N	96°12'54.40838''W	981.602	**8,486,874.0636**	**14,125,663.5446**
4. Sioux City-Iowa Falls	NL0936	STORMPORT	42°36'06.09868''N	95°14'27.24833''W	1379.646	**8,625,179.0003**	**14,390,259.9760**
4. Sioux City-Iowa Falls	NL0937	STORMPORT AZ MK	42°35'52.81878''N	95°14'08.62031''W	1373.137	**8,623,827.8869**	**14,391,646.8293**
4. Sioux City-Iowa Falls	DG6506	SUX A	42°24'27.46769''N	96°23'37.52724''W	1001.136	**8,558,065.7970**	**14,078,567.8217**
4. Sioux City-Iowa Falls	DG6507	SUX B	42°23'42.11408''N	96°22'37.78217''W	1005.733	**8,553,392.9794**	**14,082,965.8240**
4. Sioux City-Iowa Falls	NL0870	TJEBBEN	42°30'09.71242''N	94°36'27.65867''W	1145.736	**8,588,915.5433**	**14,560,853.7344**
4. Sioux City-Iowa Falls	NM1911	U 181	42°19'43.85536''N	96°18'02.44361''W	995.195	**8,528,908.9279**	**14,103,206.4551**
4. Sioux City-Iowa Falls	NM1912	Y 181	42°22'39.85332''N	96°20'17.14902''W	1004.837	**8,546,901.0604**	**14,093,405.3588**
5. Waterloo	NK0164	B 30	42°43'47.79285''N	92°32'07.17554''W	833.000	**8,929,265.8618**	**15,423,332.9584**
5. Waterloo	NK0663	BEST	42°48'54.93534''N	92°46'17.56108''W	950.303	**8,960,664.0902**	**15,360,053.6890**
5. Waterloo	NJ0599	C 12	42°56'07.47970''N	91°50'59.32202''W	1079.493	**9,004,279.2504**	**15,607,175.7380**
5. Waterloo	NK0514	DETTMER	42°48'56.09825''N	92°22'36.70359''W	957.925	**8,960,375.8192**	**15,465,959.0131**
5. Waterloo	NJ1003	G 75 RESET	42°20'33.18488''N	91°49'15.46542''W	839.647	**8,788,242.1369**	**15,615,998.0633**
5. Waterloo	NK0584	HUDSON	42°25'46.22191''N	92°27'56.61686''W	853.309	**8,819,713.0981**	**15,441,754.9608**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
5. Waterloo	AE2138	IIB A	42°27'11.28040''N	91°57'11.41553''W	863.647	**8,828,390.5157**	**15,580,111.8469**
5. Waterloo	NK0036	L 11	42°26'34.99137''N	92°25'14.38582''W	768.479	**8,824,622.5895**	**15,453,931.9780**
5. Waterloo	DL3989	OLZ A	42°40'31.58163''N	91°58'09.79770''W	955.329	**8,909,397.0038**	**15,575,466.1011**
5. Waterloo	DL3988	OLZ B	42°40'40.71952''N	91°58'25.65739''W	959.627	**8,910,318.2280**	**15,574,278.3023**
5. Waterloo	DL3990	OLZ C	42°40'56.01316''N	91°58'46.88238''W	971.852	**8,911,861.4421**	**15,572,687.8325**
5. Waterloo	NK0006	S 11	42°36'31.43522''N	92°05'47.56311''W	898.499	**8,884,996.7534**	**15,541,313.3876**
5. Waterloo	NK0652	SALEM	42°30'48.92023''N	92°45'47.64122''W	989.250	**8,850,703.2736**	**15,361,616.5029**
5. Waterloo	NJ1008	T 74 RESET	42°38'29.69121''N	91°54'29.56383''W	903.482	**8,897,117.3734**	**15,591,968.2338**
5. Waterloo	NJ0626	X 74	42°32'28.14278''N	91°54'34.79039''W	903.669	**8,860,513.0772**	**15,591,724.8862**
5. Waterloo	NJ0596	Z 11	42°49'04.77081''N	91°53'20.83775''W	964.578	**8,961,434.9365**	**15,596,830.7175**
6. Council Bluffs	MJ0984	43 58	41°33'03.52653''N	95°59'06.30261''W	910.681	**7,074,121.8139**	**16,431,087.5546**
6. Council Bluffs	AI8383	743816 3	41°12'11.37191''N	95°13'55.68780''W	1084.017	**6,947,677.2591**	**16,637,927.3455**
6. Council Bluffs	AI8381	744006 1	41°14'44.53018''N	95°28'49.54774''W	1097.225	**6,962,883.1450**	**16,569,552.6748**
6. Council Bluffs	AI8382	744224 3	41°11'21.59274''N	95°37'54.96241''W	1107.481	**6,942,257.7032**	**16,527,910.4579**
6. Council Bluffs	AI8380	753913 3	41°17'20.49358''N	95°17'20.33490''W	1153.620	**6,978,880.5450**	**16,622,123.4442**
6. Council Bluffs	AI8379	764033 3	41°19'57.03449''N	95°27'38.63256''W	1085.552	**6,994,530.3828**	**16,574,870.8368**
6. Council Bluffs	AI8375	764204 1	41°25'03.70941''N	95°40'10.64658''W	999.191	**7,025,460.4228**	**16,517,475.0908**
6. Council Bluffs	AI8378	764235 3	41°19'57.92520''N	95°38'45.29759''W	1181.910	**6,994,515.0055**	**16,524,009.2878**
6. Council Bluffs	AI8374	764306 1	41°24'47.20054''N	95°49'31.46697''W	916.317	**7,023,796.4013**	**16,474,742.8097**
6. Council Bluffs	AI8377	773936 3	41°25'07.17812''N	95°17'20.85777''W	1203.420	**7,026,117.5596**	**16,621,841.5552**
6. Council Bluffs	AI8376	774035 2	41°25'07.65202''N	95°24'11.74775''W	1223.610	**7,026,025.5845**	**16,590,534.8659**
6. Council Bluffs	MJ0283	83 99 RESET 2	41°44'41.20898''N	95°12'32.67146''W	1319.367	**7,145,079.1138**	**16,643,077.3674**
6. Council Bluffs	MJ0639	A 140	41°28'25.76047''N	95°52'53.99522''W	912.551	**7,045,940.4465**	**16,459,348.4236**
6. Council Bluffs	MJ1160	ASPIN	41°56'30.64649''N	95°09'01.76601''W	1408.629	**7,216,996.6060**	**16,658,578.7029**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
6. Council Bluffs	AH9100	BLENCOE RESET	41°55'24.17156''N	96°05'21.89848''W	945.015	**7,209,929.5437**	**16,403,089.8363**
6. Council Bluffs	LF1169	C 133	40°44'37.45693''N	95°48'35.31707''W	832.580	**6,779,893.6549**	**16,478,807.4172**
6. Council Bluffs	MJ0513	C 147	41°27'36.70391''N	95°20'13.58682''W	1037.193	**7,041,188.7281**	**16,608,611.7148**
6. Council Bluffs	MJ1403	COUNPORT	41°15'30.43575''N	95°45'38.48670''W	1156.448	**6,967,429.5296**	**16,492,477.7180**
6. Council Bluffs	MJ1411	COUNPORT AZ MK	41°15'47.38390''N	95°45'56.27288''W	1139.689	**6,969,145.4318**	**16,491,119.8712**
6. Council Bluffs	MJ1382	E 180	41°24'05.44242''N	95°53'38.81346''W	893.748	**7,019,597.1821**	**16,455,887.5997**
6. Council Bluffs	LF1531	EE 158 RESET	40°55'36.18607''N	95°33'23.75361''W	891.179	**6,846,603.2208**	**16,548,840.7224**
6. Council Bluffs	LF1445	G 182	40°35'33.98821''N	95°39'40.95293''W	811.645	**6,724,890.1504**	**16,519,985.2126**
6. Council Bluffs	MJ1199	HANCOCK	41°23'07.71512''N	95°20'49.27959''W	1159.971	**7,013,949.4343**	**16,606,015.4039**
6. Council Bluffs	AE2137	HNR A	41°35'04.93879''N	95°20'30.15668''W	1113.748	**7,086,554.0411**	**16,607,144.4462**
6. Council Bluffs	NL0444	J 159	42°00'24.60964''N	95°50'57.75893''W	1264.860	**7,240,162.8053**	**16,468,459.0772**
6. Council Bluffs	MJ1402	J 180	41°08'56.89992''N	95°48'44.50262''W	887.324	**6,927,606.2202**	**16,478,233.8793**
6. Council Bluffs	NL0901	MAPPORT	42°10'46.99521''N	95°47'34.94325''W	1023.269	**7,303,152.0629**	**16,483,815.7336**
6. Council Bluffs	AE9294	OMA 1	41°46'40.93335''N	95°54'41.72468''W	1285.522	**7,156,812.8363**	**16,451,376.3771**
6. Council Bluffs	AE9293	OMA 2	41°46'43.56508''N	95°54'38.52216''W	1283.275	**7,157,078.7338**	**16,451,619.5823**
6. Council Bluffs	AE2142	SDA A	40°45'16.47341''N	95°24'17.56996''W	872.154	**6,784,003.4749**	**16,591,003.0675**
6. Council Bluffs	LF1495	SHENPORT	40°45'14.13759''N	95°24'59.52460''W	851.393	**6,783,755.2016**	**16,587,774.9713**
6. Council Bluffs	LF1496	SHENPORT AZ MK	40°45'04.69655''N	95°24'41.72124''W	864.562	**6,782,804.6774**	**16,589,148.6850**
6. Council Bluffs	MJ0955	T 150	41°37'51.51632''N	95°31'34.52126''W	1089.798	**7,103,240.4150**	**16,556,613.9515**
6. Council Bluffs	LF0985	V 134	40°36'03.78407''N	95°44'06.84728''W	812.620	**6,727,897.4806**	**16,499,471.8046**
7. Carroll-Atlantic	DL6007	CIN A	42°02'49.84834''N	94°47'14.96223''W	1104.069	**7,454,885.6347**	**17,458,126.4171**
7. Carroll-Atlantic	DL6008	CIN B	42°03'10.25797''N	94°47'43.18829''W	1110.054	**7,456,955.6633**	**17,456,000.5873**
7. Carroll-Atlantic	DL6009	CIN C	42°02'24.96416''N	94°46'58.41910''W	1099.742	**7,452,364.3641**	**17,459,370.2430**
7. Carroll-Atlantic	MJ0181	P 163	41°29'47.96394''N	94°39'36.29416''W	1339.144	**7,254,230.1450**	**17,492,671.9227**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
7. Carroll-Atlantic	MJ1121	TURK	41°19'53.01921''N	94°59'13.29124''W	1216.438	**7,194,206.7194**	**17,402,855.3356**
7. Carroll-Atlantic	MJ1465	W 100 RESET	41°40'27.79661''N	94°50'42.42306''W	1303.820	**7,319,065.9235**	**17,442,137.7591**
7. Carroll-Atlantic	NL0186	W 89	42°03'19.86471''N	94°47'01.27346''W	1107.383	**7,457,922.3931**	**17,459,164.6173**
7. Carroll-Atlantic	MJ0136	X 103	41°16'56.95998''N	94°27'46.16706''W	1267.819	**7,176,234.3245**	**17,546,866.8351**
7. Carroll-Atlantic	NL0140	X 93	42°04'46.95111''N	94°53'56.08372''W	1154.676	**7,466,814.3842**	**17,427,897.3795**
7. Carroll-Atlantic	NL0192	Y 89	42°03'55.25628''N	94°52'19.40928''W	1163.738	**7,461,559.7239**	**17,435,173.4328**
8. Ames-Des Moines	AE2154	20 ADP	41°23'18.58562''N	93°47'10.01418''W	911.245	**7,414,818.5959**	**18,480,942.2915**
8. Ames-Des Moines	MJ0089	A 162	41°29'22.49250''N	94°06'39.76435''W	996.314	**7,451,891.7076**	**18,391,944.0132**
8. Ames-Des Moines	AJ8301	AMW D	41°59'37.60879''N	93°37'05.65419''W	824.073	**7,635,395.1104**	**18,526,758.5217**
8. Ames-Des Moines	AJ8302	AMW E	41°59'13.14215''N	93°37'26.76799''W	843.798	**7,632,916.5990**	**18,525,166.7840**
8. Ames-Des Moines	AJ8303	AMW F	41°59'55.26242''N	93°37'31.13374''W	824.864	**7,637,180.0395**	**18,524,832.5199**
8. Ames-Des Moines	DI3066	BNW A	42°03'10.32014''N	93°51'04.39467''W	1045.490	**7,656,941.1536**	**18,463,454.6528**
8. Ames-Des Moines	DI3067	BNW B	42°02'32.33000''N	93°50'32.17803''W	1041.802	**7,653,091.7147**	**18,465,879.6038**
8. Ames-Des Moines	NK0751	BOONEPORT AZ MK	42°02'49.32724''N	93°50'43.56839''W	1044.329	**7,654,813.6225**	**18,465,022.7010**
8. Ames-Des Moines	AB5750	DSM ARP	41°32'09.04470''N	93°39'32.25129''W	828.191	**7,468,509.1167**	**18,515,800.1518**
8. Ames-Des Moines	AJ6051	DSM C	41°32'31.03055''N	93°40'13.73564''W	809.847	**7,470,732.6498**	**18,512,643.9052**
8. Ames-Des Moines	AJ6052	DSM D	41°31'56.74683''N	93°39'51.49852''W	817.213	**7,467,263.3826**	**18,514,337.0743**
8. Ames-Des Moines	MH0688	ET 9 JA	41°59'39.87934''N	93°45'25.34031''W	965.221	**7,635,612.1654**	**18,489,024.6952**
8. Ames-Des Moines	AE2151	GPS 15	41°34'06.49552''N	93°30'12.40316''W	788.401	**7,480,464.3968**	**18,558,349.5956**
8. Ames-Des Moines	AE2150	GPS 9	41°31'09.30621''N	93°46'41.06873''W	836.829	**7,462,463.0367**	**18,483,182.5087**
8. Ames-Des Moines	NK0704	HUBBARD WEST BASE	42°11'17.95886''N	93°21'58.33308''W	1051.130	**7,706,471.7976**	**18,594,984.4947**
8. Ames-Des Moines	AE1868	IADOT BASE STATION	42°01'20.05440''N	93°37'20.02686''W	863.922	**7,645,764.3868**	**18,525,661.7262**
8. Ames-Des Moines	AE2139	IKV A	41°41'29.93728''N	93°34'00.67413''W	785.356	**7,525,314.2731**	**18,540,919.3891**
8. Ames-Des Moines	DG6295	IKV B	41°40'57.97043''N	93°34'00.26039''W	781.508	**7,522,078.5261**	**18,540,956.4114**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
8. Ames-Des Moines	DG6296	IKV C	41°41'51.69365''N	93°34'00.24960''W	798.565	**7,527,516.5915**	**18,540,947.7655**
8. Ames-Des Moines	DF6532	IOWA DOT RCE OFFICE	41°39'26.19307''N	93°35'52.25757''W	839.050	**7,512,775.2604**	**18,532,470.6708**
8. Ames-Des Moines	MJ1441	PERRYPORT	41°49'40.57682''N	94°09'33.55209''W	913.131	**7,575,254.4458**	**18,379,350.4585**
8. Ames-Des Moines	AE2153	STORY 11	41°51'47.92524''N	93°37'11.80899''W	917.980	**7,587,849.4986**	**18,526,347.3701**
8. Ames-Des Moines	AE2152	STORY 5	41°58'31.84243''N	93°20'51.89025''W	912.423	**7,628,938.2905**	**18,600,321.3184**
8. Ames-Des Moines	MH0406	U 33	41°58'39.48642''N	93°30'42.62559''W	856.343	**7,629,562.6559**	**18,555,697.1122**
8. Ames-Des Moines	NL0104	U 88	42°02'15.50886''N	94°05'12.13108''W	954.358	**7,651,581.2405**	**18,399,472.7815**
8. Ames-Des Moines	MJ0074	X 3	41°46'37.16494''N	94°02'54.25403''W	930.041	**7,556,552.1741**	**18,409,510.1347**
9. Newton	MH0207	A 5	41°34'01.05315''N	93°09'34.68517''W	818.030	**7,680,024.9786**	**19,406,142.5791**
9. Newton	NK0611	BROOK	42°10'00.41828''N	92°41'20.72751''W	936.550	**7,898,448.7548**	**19,534,587.8023**
9. Newton	MH0163	D 88	41°50'54.83231''N	92°46'58.85515''W	925.838	**7,782,458.5424**	**19,509,168.9968**
9. Newton	MH0650	DYER	41°24'39.03504''N	93°16'17.27450''W	826.294	**7,623,278.9223**	**19,375,239.6092**
9. Newton	AE2136	GGI A	41°42'35.52408''N	92°44'03.24680''W	896.740	**7,731,925.2224**	**19,522,508.5787**
9. Newton	MH0783	KNOXPORT	41°17'52.99963''N	93°06'45.97485''W	821.153	**7,581,992.4157**	**19,418,632.3981**
9. Newton	MH0784	KNOXPORT AZ MK	41°18'14.34440''N	93°06'58.77991''W	818.335	**7,584,156.2098**	**19,417,662.4235**
9. Newton	MH0109	L 87	41°27'46.90688''N	92°38'49.22097''W	758.568	**7,642,013.1085**	**19,546,504.0708**
9. Newton	MH0578	LARSON	41°42'09.62127''N	92°37'11.72868''W	882.485	**7,729,353.8478**	**19,553,728.0182**
9. Newton	DK3690	OOA A 2007	41°13'18.84814''N	92°29'16.53151''W	727.751	**7,554,276.2582**	**19,590,441.0920**
9. Newton	MH0795	OSKAPORT	41°13'26.25901''N	92°29'30.06489''W	728.306	**7,555,022.4617**	**19,589,404.0610**
9. Newton	MH0796	OSKAPORT AZ MK	41°13'36.86442''N	92°29'44.30735''W	729.641	**7,556,091.8455**	**19,588,311.7160**
9. Newton	AJ8304	OXV A	41°17'42.23322''N	93°06'36.28153''W	822.636	**7,580,900.1674**	**19,419,368.6230**
9. Newton	MH0124	T 5	41°12'55.84164''N	92°39'16.68709''W	582.440	**7,551,818.2183**	**19,544,581.2990**
9. Newton	AE2147	TT 10 FHJ	42°00'27.85152''N	92°57'34.95203''W	858.433	**7,840,494.3980**	**19,461,121.9827**
9. Newton	NK0107	Y 10	42°11'29.24695''N	92°43'41.28660''W	852.649	**7,907,427.6338**	**19,523,992.9694**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
10. Cedar Rapids	MG0566	57 27	41°52'59.87116"N	91°38'48.29225"W	704.418	**8,018,208.1491**	**20,505,424.3165**
10. Cedar Rapids	AE2145	95 03	41°51'07.34269"N	90°59'54.93790"W	721.373	**8,007,524.5331**	**20,682,017.1284**
10. Cedar Rapids	AB5732	CID ARP 2	41°53'05.60187"N	91°42'32.27653"W	750.635	**8,018,790.4519**	**20,488,481.3624**
10. Cedar Rapids	DM6119	CID C	41°53'11.82688"N	91°42'49.82823"W	755.914	**8,019,421.2752**	**20,487,154.0472**
10. Cedar Rapids	AJ8568	CID GP 1	41°53'00.03262"N	91°44'00.13338"W	760.799	**8,018,230.9164**	**20,481,835.1793**
10. Cedar Rapids	AJ8598	CID GP 2	41°52'58.76392"N	91°41'53.98694"W	745.412	**8,018,097.0280**	**20,491,377.4426**
10. Cedar Rapids	NJ0755	ET 4 JS	42°15'14.48012"N	91°13'35.21997"W	836.767	**8,153,615.4816**	**20,619,187.4784**
10. Cedar Rapids	AE2155	GPS CONTROL POINT 96 102	41°30'40.23844"N	91°53'12.95977"W	641.741	**7,882,683.2965**	**20,439,669.1118**
10. Cedar Rapids	MH0487	HARTWICK	41°49'50.45505"N	92°17'18.64311"W	831.002	**7,999,647.2242**	**20,330,521.0347**
10. Cedar Rapids	AE9184	NLIB A	41°45'49.79225"N	91°34'43.23410"W	713.457	**7,974,685.1901**	**20,524,006.2721**
10. Cedar Rapids	MG0916	NORTH LIBERTY	41°46'19.24958"N	91°34'28.67582"W	674.812	**7,977,668.1273**	**20,525,106.3842**
10. Cedar Rapids	NK0557	PRATT	42°12'38.34995"N	92°12'42.60032"W	876.055	**8,137,973.0231**	**20,352,297.6098**
10. Cedar Rapids	AE9186	X 183	41°45'25.31506"N	91°36'25.00767"W	676.790	**7,972,200.8883**	**20,516,295.0320**
11. Dubuque-Davenport	NJ0271	52 JDF	42°24'20.03547"N	90°35'41.00665"W	981.143	**8,385,451.0515**	**21,483,418.7307**
11. Dubuque-Davenport	NJ0367	A 178	42°35'09.83207"N	90°54'18.60395"W	1016.448	**8,451,448.6262**	**21,399,858.0925**
11. Dubuque-Davenport	AE9312	A 185	42°01'22.32407"N	90°13'40.79841"W	694.050	**8,246,124.1041**	**21,582,968.2460**
11. Dubuque-Davenport	NJ0104	C 175	42°07'00.05692"N	90°13'12.13315"W	518.775	**8,280,320.5997**	**21,585,006.6541**
11. Dubuque-Davenport	AJ8298	CWI A	41°49'38.72354"N	90°19'52.01407"W	581.380	**8,174,817.4482**	**21,555,116.6592**
11. Dubuque-Davenport	AJ8299	CWI B	41°50'01.57667"N	90°20'02.74576"W	592.794	**8,177,128.8721**	**21,554,298.7852**
11. Dubuque-Davenport	AJ8300	CWI C	41°50'21.47832"N	90°19'26.16935"W	596.498	**8,179,150.0170**	**21,557,062.8445**
11. Dubuque-Davenport	DF9357	DBQ A	42°23'49.43922"N	90°42'40.06578"W	924.076	**8,382,397.8749**	**21,451,971.8665**
11. Dubuque-Davenport	DF9358	DBQ B	42°24'00.43415"N	90°41'57.41636"W	962.485	**8,383,504.4808**	**21,455,174.2935**
11. Dubuque-Davenport	NJ0939	DUBUQUE	42°31'38.67891"N	90°43'47.61186"W	878.663	**8,429,913.3586**	**21,447,013.4814**
11. Dubuque-Davenport	NJ0258	DUBUQUE APT ARP	42°24'10.24788"N	90°42'32.32734"W	950.336	**8,384,503.2460**	**21,452,556.8848**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
11. Dubuque-Davenport	AB5747	DVN A 1975	41°37'01.21365''N	90°35'38.92464''W	644.146	**8,098,080.5409**	**21,483,370.8023**
11. Dubuque-Davenport	NJ0232	E 79	42°03'03.88819''N	90°32'03.50578''W	777.580	**8,256,257.3679**	**21,499,735.4992**
11. Dubuque-Davenport	MG0328	G 70	41°38'44.62278''N	90°34'51.08682''W	672.377	**8,108,545.5417**	**21,487,010.2616**
11. Dubuque-Davenport	NJ0893	HANTEN	42°23'46.08165''N	90°39'56.54371''W	1070.024	**8,382,035.5756**	**21,464,241.4217**
11. Dubuque-Davenport	NJ0119	Q 175	42°11'48.34150''N	90°22'40.68449''W	493.815	**8,309,386.5050**	**21,542,102.1489**
11. Dubuque-Davenport	AE9310	RISL A	42°00'42.87571''N	90°13'28.52294''W	688.962	**8,242,134.1096**	**21,583,909.2087**
11. Dubuque-Davenport	AE9311	RISL B	42°00'41.99975''N	90°13'49.96187''W	683.798	**8,242,039.6562**	**21,582,291.0225**
11. Dubuque-Davenport	NJ0153	X 175	42°18'18.24428''N	90°27'23.09433''W	628.955	**8,348,828.5889**	**21,520,808.2823**
12. Red Oak-Ottumwa	AB5782	AP 1963 STA B	41°06'32.03477''N	92°27'14.39383''W	735.254	**6,272,688.0767**	**22,857,152.6224**
12. Red Oak-Ottumwa	MH0780	CHARIPORT AZ MK	41°01'12.50909''N	93°21'50.60071''W	940.854	**6,237,937.1065**	**22,606,504.8801**
12. Red Oak-Ottumwa	MJ1425	CRESTPORT	41°01'09.89436''N	94°21'46.58932''W	1193.046	**6,238,030.1071**	**22,330,852.1183**
12. Red Oak-Ottumwa	MJ1426	CRESTPORT AZ MK	41°00'52.65093''N	94°21'40.39883''W	1191.691	**6,236,281.5813**	**22,331,314.4536**
12. Red Oak-Ottumwa	AE2133	CSQ A	41°01'43.91084''N	94°22'03.36175''W	1196.579	**6,241,481.9572**	**22,329,590.7418**
12. Red Oak-Ottumwa	MH0054	D 6	41°05'23.11039''N	92°21'45.31057''W	694.923	**6,266,099.1983**	**22,882,452.5720**
12. Red Oak-Ottumwa	MH0055	E 6	41°06'12.14688''N	92°18'54.14191''W	643.949	**6,271,273.1464**	**22,895,476.7064**
12. Red Oak-Ottumwa	LE0588	ET 2 MES	40°37'19.56759''N	93°44'51.66327''W	983.331	**6,092,675.4631**	**22,500,642.8961**
12. Red Oak-Ottumwa	LE0532	FAIRALL	40°46'05.13317''N	93°29'13.95798''W	1006.153	**6,145,975.8740**	**22,572,795.1766**
12. Red Oak-Ottumwa	MH0272	H 110	41°02'14.04864''N	93°45'55.72237''W	1036.737	**6,243,931.1219**	**22,495,729.6708**
12. Red Oak-Ottumwa	DL2463	I75 A	41°03'19.57015''N	93°41'17.11149''W	1005.733	**6,250,568.4141**	**22,517,076.5476**
12. Red Oak-Ottumwa	DL2464	I75 B	41°03'01.87774''N	93°41'25.54283''W	1007.170	**6,248,777.2619**	**22,516,431.8021**
12. Red Oak-Ottumwa	DL2465	I75 C	41°02'44.64091''N	93°41'19.01388''W	1009.030	**6,247,033.0167**	**22,516,933.2772**
12. Red Oak-Ottumwa	LF0049	K 105	40°39'12.97540''N	94°20'41.97741''W	1042.085	**6,104,714.5589**	**22,334,898.3911**
12. Red Oak-Ottumwa	MH0561	LOVILIA	41°08'14.50196''N	92°54'24.87029''W	832.006	**6,281,532.7744**	**22,732,244.4360**
12. Red Oak-Ottumwa	LE0593	OSCEOLA	40°59'58.50662''N	93°46'10.73190''W	1047.242	**6,230,212.8219**	**22,494,576.3221**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
12. Red Oak-Ottumwa	LE0502	PARKER	40°58'18.35168''N	92°30'49.36503''W	744.392	**6,222,487.8050**	**22,841,403.8024**
12. Red Oak-Ottumwa	LF1299	PRESCOTT 2	40°58'44.57939''N	94°37'20.98510''W	1198.065	**6,223,931.3432**	**22,259,080.5921**
12. Red Oak-Ottumwa	LF0026	R 104 RESET	40°54'50.46776''N	94°20'14.54737''W	1139.525	**6,199,580.2829**	**22,337,649.7132**
12. Red Oak-Ottumwa	MH0280	R 110	41°00'23.27409''N	93°34'42.95187''W	844.460	**6,232,765.3278**	**22,547,309.9234**
12. Red Oak-Ottumwa	MJ1447	REDPORT	41°00'37.94930''N	95°15'35.49482''W	941.937	**6,237,800.4102**	**22,083,299.2423**
12. Red Oak-Ottumwa	LF1488	S 106 RESET	40°44'42.42070''N	94°47'23.77564''W	1133.771	**6,139,208.2135**	**22,211,834.2140**
12. Red Oak-Ottumwa	LF0231	S 8	40°36'37.37483''N	95°13'13.46415''W	872.426	**6,091,836.5127**	**22,091,736.1316**
12. Red Oak-Ottumwa	LF1489	SCHEPORT	40°43'21.96242''N	95°01'34.79898''W	883.669	**6,131,933.2885**	**22,146,214.6861**
12. Red Oak-Ottumwa	MJ0521	U 148	41°08'46.35705''N	95°17'20.47409''W	1181.628	**6,287,366.5658**	**22,076,121.6842**
12. Red Oak-Ottumwa	MH0053	WAPELLO	41°06'23.14446''N	92°26'41.86367''W	734.726	**6,271,825.3702**	**22,859,656.0486**
12. Red Oak-Ottumwa	LE0188	X 7	40°37'46.22566''N	92°55'06.25734''W	926.596	**6,096,470.6194**	**22,730,836.6383**
13. Fairfield	DK3513	AWG A 2007	41°16'43.43812''N	91°40'26.17734''W	642.689	**6,774,903.5292**	**23,566,719.5133**
13. Fairfield	DK3514	AWG B 2007	41°16'13.03085''N	91°40'33.63242''W	639.867	**6,771,824.2691**	**23,566,158.8182**
13. Fairfield	MG0476	B 8	41°19'34.28699''N	91°33'39.59402''W	645.422	**6,792,303.0791**	**23,597,692.8087**
13. Fairfield	LE0437	COPELAND	40°55'18.05727''N	92°07'51.64979''W	671.291	**6,644,786.9768**	**23,440,761.8139**
13. Fairfield	MG0416	D 8	41°21'14.80923''N	91°29'04.50801''W	575.704	**6,802,572.8726**	**23,618,630.7705**
13. Fairfield	AE2156	GPS CONTROL PT 96 150	41°13'19.01730''N	91°56'39.19923''W	532.348	**6,754,121.1242**	**23,492,419.2228**
13. Fairfield	LD0592	T 124	40°59'49.50548''N	91°48'40.46871''W	649.530	**6,672,205.0881**	**23,529,102.7992**
13. Fairfield	MG0914	WASHPORT AZ MK	41°16'26.59887''N	91°40'12.51668''W	644.195	**6,773,202.0795**	**23,567,767.3926**
13. Fairfield	MG0472	X 6	41°17'35.48418''N	91°43'30.61684''W	597.601	**6,780,136.1812**	**23,552,625.2671**
14. Burlington	AE2146	39 RWM	40°54'21.33634''N	91°04'34.60297''W	599.185	**6,439,020.9396**	**24,548,021.9189**
14. Burlington	AE2148	ARDON AZ MK RESET	41°26'37.28228''N	91°10'26.06727''W	633.962	**6,634,925.4496**	**24,520,862.9541**
14. Burlington	AJ8295	EOK A 2000	40°27'47.51270''N	91°26'04.65947''W	557.673	**6,277,724.9777**	**24,448,624.4248**
14. Burlington	AJ8296	EOK B 2000	40°27'29.34040''N	91°25'54.28927''W	559.103	**6,275,884.2674**	**24,449,422.2155**

Zone number and name	NGS PID	Station designation	Latitude	Longitude	Ellipsoid ht (sft)	Northing (sft)	Easting (sft)
14. Burlington	AJ8297	EOK C	40°27'41.64464''N	91°25'24.00163''W	557.479	**6,277,124.7556**	**24,451,765.9524**
14. Burlington	MG0794	HASCHAR	41°16'19.80877''N	91°09'01.12346''W	589.533	**6,572,433.6286**	**24,527,404.2001**
14. Burlington	LD0867	JACKSON	40°52'20.17802''N	91°35'51.85822''W	608.188	**6,426,902.0538**	**24,403,825.6685**
14. Burlington	LD0882	KEOPORT AZ MK	40°27'22.38075''N	91°25'40.72022''W	552.893	**6,275,177.8107**	**24,450,469.7093**
14. Burlington	DF6531	LEE CO GPS CONTROL PT 2001 013	40°43'34.22349''N	91°36'11.31037''W	605.448	**6,373,677.8979**	**24,402,116.8736**
14. Burlington	LD0800	MADISON	40°38'53.65283''N	91°17'12.95765''W	600.639	**6,345,088.2323**	**24,489,751.1510**
14. Burlington	AE2140	MPZ A	40°56'41.10628''N	91°30'39.12964''W	617.820	**6,453,226.7161**	**24,427,929.8889**
14. Burlington	MG0791	MUSCATINE	41°25'25.60277''N	91°04'18.06294''W	616.616	**6,627,711.4010**	**24,548,905.4332**
14. Burlington	AJ8263	MUT A 2001	41°21'39.34386''N	91°09'10.27275''W	436.515	**6,604,774.7657**	**24,526,669.3462**
14. Burlington	AJ8264	MUT B 2001	41°22'10.60326''N	91°08'07.43353''W	433.595	**6,607,944.5824**	**24,531,457.1302**
14. Burlington	AJ8265	MUT C	41°22'06.88342''N	91°09'05.29859''W	428.775	**6,607,562.6497**	**24,527,045.4958**
14. Burlington	LD0612	R 122=56 34	40°43'17.43849''N	91°33'49.84701''W	591.314	**6,371,937.8029**	**24,413,002.6342**
14. Burlington	LD0616	T 122 RESET	40°45'18.51968''N	91°33'49.44352''W	601.649	**6,384,191.7863**	**24,413,077.4927**
14. Burlington	LD0531	ZZ 125	40°46'49.39212''N	91°07'02.40624''W	580.655	**6,393,261.0347**	**24,536,741.9136**

Appendix C.

IaRCS distortion values on NAD 83(2011) epoch 2010.00 NGS control

IaRCS distortion values for NAD 83(2011) epoch 2010.00 NGS control

Tables C-1 and C-2 give IaRCS distortion values for 312 NGS-published NAD 83(2011) epoch 2010.00 control stations in Iowa, sorted by designation (or CORS ID) within each zone. Table C-1 lists 35 NGS Continually Operating Reference Station (CORS) Antenna Reference Points (ARPs), and Table C-2 lists 277 NGS passive control stations (i.e., monuments that can be occupied with survey equipment, such as brass disks). The values given are linear distortion, grid point scale factor, height scale factor, combined scale factor, and convergence angle. Linear distortion is given in parts per million (ppm), feet per mile, and as a dimensionless ratio. These values can be used as checks for distortion computations. The stations given here were obtained from the NGS Integrated Data Base (NGSIDB) on August 11, 2014 and represent the status of NGS published NAD 83(2011) epoch 2010.00 control in Iowa on that date. IaRCS distortion values were computed directly from the NGS published latitude, longitude, and the ellipsoid heights (as given in tables B-1 and B-2). The stations were not occupied or recovered to create these tables, and so some stations may presently be obstructed, removed, damaged, destroyed, or otherwise unavailable or unsuitable for use.

Table C-1. *IaRCS distortion values for NGS NAD 83(2011) epoch 2010.00 CORS in Iowa.*

Zone number and name	NGS PID	CORS ID (and station designation)	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
1. Spencer	DP1310	IAAS (IOWA DOT ASHTON CORS ARP)	**-13.829**	**-0.07302**	**1 : 72,313**	1.000053694	0.999932481	0.999986171	–0°21'43.77''
1. Spencer	DP2488	IASW (IADT SWEA CITY CORS ARP)	**4.116**	**0.02173**	**1 : 242,932**	1.000057108	0.999947011	1.000004116	+0°39'09.87''
2. Mason City	DO2871	IADE (IOWA DOT DECORAH CORS ARP)	**-5.140**	**-0.02714**	**1 : 194,564**	1.000044655	0.999950208	0.999994860	+0°37'42.06''
2. Mason City	DP1957	IAHT (IADT HANLONTOWN CORS ARP)	**-9.086**	**-0.04797**	**1 : 110,065**	1.000045090	0.999945827	0.999990914	–0°25'23.30''
3. Elkader	DP1235	IAEL (IOWA DOT ELKADER CORS ARP)	**-9.908**	**-0.05231**	**1 : 100,932**	1.000037142	0.999952952	0.999990092	–0°06'35.67''
3. Elkader	DL3589	IANA (NEW ALBIN CORS ARP)	**8.491**	**0.04483**	**1 : 117,779**	1.000035662	0.999972830	1.000008491	–0°03'44.73''
4. Sioux City-Iowa Falls	DP1229	IACL (IOWA DOT CLARION CORS ARP)	**-1.455**	**-0.00768**	**1 : 687,363**	1.000050936	0.999947612	0.999998545	+0°43'53.19''
4. Sioux City-Iowa Falls	DP1245	IAPS (IADT POCHAHONTAS CORS ARP)	**-4.059**	**-0.02143**	**1 : 246,357**	1.000051366	0.999944578	0.999995941	+0°06'15.00''
4. Sioux City-Iowa Falls	DP1247	IASX (IADT SIOUX CITY CORS ARP)	**-6.572**	**-0.03470**	**1 : 152,165**	1.000045042	0.999948388	0.999993428	–1°01'27.33''
5. Waterloo	DP1223	IAAL (IOWA DOT ALLISON CORS ARP)	**-12.380**	**-0.06537**	**1 : 80,777**	1.000033430	0.999954192	0.999987620	–0°21'50.46''
6. Council Bluffs	DP1227	IACB (COUNCIL BLUFFS CORS ARP)	**-3.348**	**-0.01768**	**1 : 298,717**	1.000040243	0.999956411	0.999996652	–0°04'44.42''
6. Council Bluffs	DP1233	IADN (IOWA DOT DENISON CORS ARP)	**-5.279**	**-0.02787**	**1 : 189,444**	1.000049800	0.999944925	0.999994721	+0°14'21.45''
6. Council Bluffs	AH5054	OMH1 (OMAHA 1 CORS ARP)	**-20.850**	**-0.11009**	**1 : 47,962**	1.000041693	0.999937460	0.999979150	–0°07'06.85''
6. Council Bluffs	AH5056	OMH2 (OMAHA 2 CORS ARP)	**-20.746**	**-0.10954**	**1 : 48,202**	1.000041698	0.999937558	0.999979254	–0°07'07.30''

Zone number and name	NGS PID	CORS ID (and station designation)	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
6. Council Bluffs	DI8412	OMH5 (OMAHA 5 CORS ARP)	**-20.874**	**-0.11021**	**1 : 47,907**	1.000041693	0.999937436	0.999979126	–0°07'06.85''
6. Council Bluffs	DI8414	OMH6 (OMAHA 6 CORS ARP)	**-20.780**	**-0.10972**	**1 : 48,124**	1.000041698	0.999937525	0.999979220	–0°07'07.30''
7. Carroll-Atlantic	DP1225	IAAT (IOWA DOT ATLANTIC CORS ARP)	**1.907**	**0.01007**	**1 : 524,249**	1.000055820	0.999946091	1.000001907	–0°14'04.46''
8. Ames-Des Moines	DM2686	IAAM (IADT AMES CORS ARP)	**-6.726**	**-0.03552**	**1 : 148,669**	1.000035079	0.999958196	0.999993274	+0°06'18.11''
8. Ames-Des Moines	DP1239	IAMD (IADT MARTENSDALE CORS ARP)	**-3.476**	**-0.01835**	**1 : 287,721**	1.000033065	0.999963461	0.999996524	–0°01'05.33''
8. Ames-Des Moines	AI2153	SLAI (SLATER CORS ARP)	**-12.536**	**-0.06619**	**1 : 79,769**	1.000033027	0.999954438	0.999987464	+0°00'42.81''
9. Newton	DP1243	IAOK (IADT OSKALOOSA CORS ARP)	**-4.231**	**-0.02234**	**1 : 236,369**	1.000028504	0.999967266	0.999995769	+0°05'13.60''
9. Newton	DP1249	IATA (IOWA DOT TAMA CORS ARP)	**-6.009**	**-0.03173**	**1 : 166,428**	1.000032947	0.999961045	0.999993991	+0°10'38.59''
10. Cedar Rapids	DP1318	IAMN (IOWA DOT MARION CORS ARP)	**-10.173**	**-0.05371**	**1 : 98,299**	1.000025893	0.999963935	0.999989827	+0°04'43.09''
10. Cedar Rapids	AF9523	NLIB (NORTH LIBERTY CORS ARP)	**-12.065**	**-0.06370**	**1 : 82,885**	1.000020578	0.999967357	0.999987935	+0°03'40.37''
11. Dubuque-Davenport	DP1314	IADA (IADT DAVENPORT CORS ARP)	**-3.829**	**-0.02021**	**1 : 261,192**	1.000027806	0.999968367	0.999996171	–0°03'52.12''
11. Dubuque-Davenport	DP1241	IAMQ (IADT MAQUOKETA CORS ARP)	**-1.536**	**-0.00811**	**1 : 651,209**	1.000028051	0.999970414	0.999998464	–0°04'29.48''
11. Dubuque-Davenport	AF9642	RIS1 (ROCK ISLAND 1 CORS ARP)	**0.908**	**0.00479**	**1 : 1,101,358**	1.000034992	0.999965917	1.000000908	+0°12'21.44''
11. Dubuque-Davenport	AF9644	RIS2 (ROCK ISLAND 2 CORS ARP)	**0.953**	**0.00503**	**1 : 1,049,286**	1.000035022	0.999965932	1.000000953	+0°12'22.86''
11. Dubuque-Davenport	DI8416	RIS5 (ROCK ISLAND 5 CORS ARP)	**0.885**	**0.00467**	**1 : 1,130,445**	1.000034992	0.999965894	1.000000885	+0°12'21.44''
11. Dubuque-Davenport	DI8418	RIS6 (ROCK ISLAND 6 CORS ARP)	**0.926**	**0.00489**	**1 : 1,079,841**	1.000035022	0.999965905	1.000000926	+0°12'22.86''
12. Red Oak-Ottumwa	DP1312	IACE (IADT CENTERVILLE CORS ARP)	**-1.003**	**-0.00530**	**1 : 996,718**	1.000043983	0.999955016	0.999998997	+0°34'34.51''
12. Red Oak-Ottumwa	DP1231	IACN (IOWA DOT CLARINDA CORS ARP)	**-2.704**	**-0.01428**	**1 : 369,783**	1.000041585	0.999955713	0.999997296	–0°49'59.89''
12. Red Oak-Ottumwa	DP1237	IALN (IADT LEON CORS ARP)	**-7.634**	**-0.04031**	**1 : 130,995**	1.000042337	0.999950031	0.999992366	–0°00'28.07''
13. Fairfield	DP1251	IAWN (IADT WASHINGTON CORS ARP)	**-7.518**	**-0.03970**	**1 : 133,008**	1.000024869	0.999967614	0.999992482	+0°09'24.58''
14. Burlington	DP1316	IADO (IADT DONNELLSON CORS ARP)	**-2.809**	**-0.01483**	**1 : 355,944**	1.000026786	0.999970405	0.999997191	–0°12'20.90''

Table C-2. *IaRCS distortion values for NGS NAD 83(2011) epoch 2010.00 passive control in Iowa.*

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
1. Spencer	DH3926	15 WL	**10.921**	**0.05766**	**1 : 91,570**	1.000065717	0.999945208	1.000010921	+0°31'07.25''
1. Spencer	DH3928	31 DWB	**7.609**	**0.04017**	**1 : 131,431**	1.000065753	0.999941860	1.000007609	+0°21'32.39''
1. Spencer	AJ8322	963073 3 7089	**-7.079**	**-0.03738**	**1 : 141,260**	1.000052284	0.999940640	0.999992921	+0°01'56.56''
1. Spencer	OP0140	A 19	**-0.529**	**-0.00279**	**1 : 1,890,661**	1.000053438	0.999946036	0.999999471	+0°25'04.31''
1. Spencer	OP1149	ALGOPORT	**0.882**	**0.00466**	**1 : 1,133,700**	1.000054227	0.999946658	1.000000882	+0°40'05.62''
1. Spencer	OP0566	B 17	**-9.017**	**-0.04761**	**1 : 110,902**	1.000065591	0.999925397	0.999990983	–0°18'16.92''
1. Spencer	OP0792	BEACON	**-7.117**	**-0.03758**	**1 : 140,506**	1.000052163	0.999940723	0.999992883	+0°02'09.38''
1. Spencer	AI5700	BIGELOW	**-9.828**	**-0.05189**	**1 : 101,753**	1.000064924	0.999925253	0.999990172	–0°18'26.15''
1. Spencer	NM0034	D 154	**6.776**	**0.03578**	**1 : 147,586**	1.000058943	0.999947836	1.000006776	–0°50'44.62''
1. Spencer	OP0490	D 18	**-7.047**	**-0.03721**	**1 : 141,913**	1.000052342	0.999940614	0.999992953	+0°00'48.50''
1. Spencer	NL0717	DALE 2	**10.135**	**0.05351**	**1 : 98,668**	1.000059203	0.999950935	1.000010135	+0°41'59.87''
1. Spencer	OQ0592	GARFIELD	**-9.021**	**-0.04763**	**1 : 110,849**	1.000054204	0.999936778	0.999990979	–0°38'03.29''
1. Spencer	CO3187	GROTEWOLD AZ MK	**-4.304**	**-0.02273**	**1 : 232,332**	1.000063528	0.999932172	0.999995696	–0°47'38.90''
1. Spencer	OP0124	K 1	**1.541**	**0.00814**	**1 : 648,960**	1.000052106	0.999949437	1.000001541	+0°42'14.97''
1. Spencer	OP0806	LAKE PARK	**-7.834**	**-0.04137**	**1 : 127,642**	1.000061006	0.999931164	0.999992166	–0°04'52.03''
1. Spencer	OP0152	M 19	**-2.474**	**-0.01306**	**1 : 404,271**	1.000053857	0.999943672	0.999997526	+0°18'47.26''
1. Spencer	OP1162	MILPORT	**-9.428**	**-0.04978**	**1 : 106,062**	1.000054753	0.999935822	0.999990572	+0°03'59.79''
1. Spencer	AE2141	ORC A	**-4.188**	**-0.02211**	**1 : 238,786**	1.000058731	0.999937085	0.999995812	–0°33'21.44''
1. Spencer	AJ8293	ORC B	**-3.059**	**-0.01615**	**1 : 326,934**	1.000059180	0.999937765	0.999996941	–0°33'13.78''
1. Spencer	AJ8292	ORC C	**-4.838**	**-0.02554**	**1 : 206,695**	1.000058460	0.999936705	0.999995162	–0°33'24.98''
1. Spencer	AJ8320	SPW A 2001	**-7.304**	**-0.03856**	**1 : 136,913**	1.000052157	0.999940543	0.999992696	+0°01'41.47''
1. Spencer	OQ1239	STALIN	**0.353**	**0.00186**	**1 : 2,833,595**	1.000065686	0.999934671	1.000000353	–0°31'58.44''
1. Spencer	OQ1237	STALIN RM 3	**1.414**	**0.00747**	**1 : 707,279**	1.000065686	0.999935732	1.000001414	–0°31'32.44''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
1. Spencer	OP0559	U 16	**-10.893**	**-0.05751**	**1 : 91,803**	1.000054347	0.999934764	0.999989107	–0°21'53.58''
1. Spencer	OP0782	WHYNOT	**-12.829**	**-0.06774**	**1 : 77,950**	1.000052654	0.999934521	0.999987171	+0°08'54.64''
1. Spencer	OP0485	Y 17	**-9.275**	**-0.04897**	**1 : 107,822**	1.000052168	0.999938560	0.999990725	–0°05'41.16''
2. Mason City	OO0687	41 1	**-12.734**	**-0.06724**	**1 : 78,529**	1.000043252	0.999944016	0.999987266	–0°30'51.68''
2. Mason City	OO1164	AIR	**-9.614**	**-0.05076**	**1 : 104,010**	1.000043040	0.999947347	0.999990386	–0°24'03.74''
2. Mason City	OO0967	AIRPORT	**-4.208**	**-0.02222**	**1 : 237,642**	1.000044498	0.999951297	0.999995792	+0°05'43.03''
2. Mason City	OO1148	BEANS	**-9.097**	**-0.04803**	**1 : 109,928**	1.000044513	0.999946393	0.999990903	–0°18'14.71''
2. Mason City	AB2419	BRUA RESET	**-3.174**	**-0.01676**	**1 : 315,101**	1.000056900	0.999939930	0.999996826	–0°29'29.66''
2. Mason City	OO0226	C 37	**-5.756**	**-0.03039**	**1 : 173,744**	1.000044592	0.999949654	0.999994244	+0°21'34.19''
2. Mason City	ON0867	CANOE	**-1.600**	**-0.00845**	**1 : 625,105**	1.000050216	0.999948187	0.999998400	+0°41'31.58''
2. Mason City	DL5322	CCY A	**-4.210**	**-0.02223**	**1 : 237,545**	1.000044190	0.999951602	0.999995790	+0°05'26.79''
2. Mason City	OO1315	CHARLPORT	**-4.134**	**-0.02182**	**1 : 241,925**	1.000044342	0.999951526	0.999995866	+0°05'45.85''
2. Mason City	OO1209	CLOVER	**-14.241**	**-0.07519**	**1 : 70,222**	1.000043557	0.999942205	0.999985759	–0°45'08.87''
2. Mason City	AE2134	DEH A	**-5.915**	**-0.03123**	**1 : 169,064**	1.000044738	0.999949349	0.999994085	+0°41'46.49''
2. Mason City	ON0899	HESPER	**-0.487**	**-0.00257**	**1 : 2,053,081**	1.000058543	0.999940973	0.999999513	+0°40'50.79''
2. Mason City	OO1179	JOICE RESET	**-10.972**	**-0.05793**	**1 : 91,144**	1.000048651	0.999940381	0.999989028	–0°27'01.87''
2. Mason City	OO1635	LOUISE	**3.479**	**0.01837**	**1 : 287,448**	1.000059912	0.999943571	1.000003479	+0°10'17.62''
2. Mason City	OO0292	M 36	**0.697**	**0.00368**	**1 : 1,434,213**	1.000044282	0.999956417	1.000000697	+0°02'50.05''
2. Mason City	OO0945	MAPLE	**-13.632**	**-0.07198**	**1 : 73,354**	1.000046378	0.999939992	0.999986368	+0°12'54.21''
2. Mason City	OO0274	N 40	**-5.035**	**-0.02658**	**1 : 198,629**	1.000047288	0.999947680	0.999994965	–0°05'15.54''
2. Mason City	NK0179	T 39	**6.241**	**0.03295**	**1 : 160,230**	1.000048271	0.999957972	1.000006241	+0°08'38.60''
2. Mason City	DF4650	TT 10 WM	**4.053**	**0.02140**	**1 : 246,743**	1.000059851	0.999944205	1.000004053	–0°37'21.18''
2. Mason City	OO0257	V 39	**2.643**	**0.01395**	**1 : 378,392**	1.000046202	0.999956443	1.000002643	+0°06'31.04''
3. Elkader	NJ0606	997	**2.086**	**0.01101**	**1 : 479,372**	1.000044976	0.999957112	1.000002086	–0°14'05.04''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
3. Elkader	ON0828	EGAN	**-15.122**	**-0.07984**	**1 : 66,129**	1.000035416	0.999949464	0.999984878	–0°02'56.08''
3. Elkader	NJ0754	ET 2 JS	**-8.942**	**-0.04721**	**1 : 111,830**	1.000035249	0.999955811	0.999991058	+0°02'12.48''
3. Elkader	NJ0700	GUTTEN	**-5.257**	**-0.02775**	**1 : 190,240**	1.000035413	0.999959332	0.999994743	+0°02'52.93''
3. Elkader	ON0786	MINNOWA	**-9.565**	**-0.05050**	**1 : 104,553**	1.000040648	0.999949789	0.999990435	–0°10'56.70''
4. Sioux City-Iowa Falls	NK0300	42 105	**2.658**	**0.01403**	**1 : 376,211**	1.000051137	0.999951523	1.000002658	+1°01'47.74''
4. Sioux City-Iowa Falls	NK0284	42 140	**-3.866**	**-0.02041**	**1 : 258,656**	1.000045353	0.999950783	0.999996134	+1°03'42.56''
4. Sioux City-Iowa Falls	NK0285	42 141	**-3.935**	**-0.02078**	**1 : 254,133**	1.000045595	0.999950472	0.999996065	+1°03'42.81''
4. Sioux City-Iowa Falls	NM0820	A 146	**4.008**	**0.02116**	**1 : 249,496**	1.000054426	0.999949585	1.000004008	–1°11'21.80''
4. Sioux City-Iowa Falls	NK0186	A 29	**-1.927**	**-0.01018**	**1 : 518,876**	1.000051471	0.999946605	0.999998073	+1°02'09.57''
4. Sioux City-Iowa Falls	NM1659	AITKEN	**-15.960**	**-0.08427**	**1 : 62,658**	1.000047132	0.999936912	0.999984040	–0°52'25.14''
4. Sioux City-Iowa Falls	NL0062	B 28	**-1.040**	**-0.00549**	**1 : 961,932**	1.000048758	0.999950205	0.999998960	+0°32'34.90''
4. Sioux City-Iowa Falls	NL0066	D 3	**9.418**	**0.04973**	**1 : 106,174**	1.000059411	0.999950011	1.000009418	+0°31'51.45''
4. Sioux City-Iowa Falls	NL0581	DIVIDE	**-9.773**	**-0.05160**	**1 : 102,327**	1.000059515	0.999930717	0.999990227	–0°20'06.14''
4. Sioux City-Iowa Falls	NL0584	EARLY	**-16.127**	**-0.08515**	**1 : 62,007**	1.000046874	0.999937002	0.999983873	–0°11'33.98''
4. Sioux City-Iowa Falls	DI3115	EBS A	**-2.220**	**-0.01172**	**1 : 450,355**	1.000046276	0.999951506	0.999997780	+0°38'54.96''
4. Sioux City-Iowa Falls	DI3116	EBS B	**-2.365**	**-0.01249**	**1 : 422,798**	1.000046349	0.999951288	0.999997635	+0°39'05.15''
4. Sioux City-Iowa Falls	DI3117	EBS C	**-2.632**	**-0.01390**	**1 : 379,901**	1.000046555	0.999950815	0.999997368	+0°39'19.86''
4. Sioux City-Iowa Falls	NL0804	ET 1 HK	**7.641**	**0.04035**	**1 : 130,868**	1.000056941	0.999950703	1.000007641	+0°18'25.56''
4. Sioux City-Iowa Falls	NK0735	ET 7 JA	**6.745**	**0.03561**	**1 : 148,258**	1.000055716	0.999951032	1.000006745	+0°43'39.27''
4. Sioux City-Iowa Falls	NL0374	F 14	**-7.804**	**-0.04121**	**1 : 128,137**	1.000045551	0.999946647	0.999992196	–0°36'16.85''
4. Sioux City-Iowa Falls	NL0119	F 32	**-3.325**	**-0.01756**	**1 : 300,768**	1.000045569	0.999951109	0.999996675	+0°31'45.59''
4. Sioux City-Iowa Falls	AE2135	FOD A	**-4.779**	**-0.02523**	**1 : 209,247**	1.000045057	0.999950166	0.999995221	+0°26'11.83''
4. Sioux City-Iowa Falls	AE2149	GPS 048	**-16.060**	**-0.08479**	**1 : 62,268**	1.000048787	0.999935157	0.999983940	–1°00'44.83''
4. Sioux City-Iowa Falls	NK0673	HILL ET	**14.500**	**0.07656**	**1 : 68,965**	1.000062962	0.999951542	1.000014500	+1°09'20.16''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	**(ft/mile)**	**(ratio)**				
4. Sioux City-Iowa Falls	NM1615	HOMAN RESET	**2.752**	**0.01453**	**1 : 363,358**	1.000066599	0.999936158	1.000002752	–0°48'18.59''
4. Sioux City-Iowa Falls	DL5969	HPT A	**-0.479**	**-0.00253**	**1 : 2,087,970**	1.000050620	0.999948904	0.999999521	+1°05'13.46''
4. Sioux City-Iowa Falls	DL5971	HPT B	**-0.787**	**-0.00416**	**1 : 1,270,407**	1.000050906	0.999948309	0.999999213	+1°05'13.50''
4. Sioux City-Iowa Falls	DL5970	HPT C	**-0.459**	**-0.00242**	**1 : 2,178,908**	1.000050176	0.999949367	0.999999541	+1°05'13.02''
4. Sioux City-Iowa Falls	NL0235	K 22 RESET	**-1.169**	**-0.00617**	**1 : 855,653**	1.000060399	0.999938436	0.999998831	–0°05'46.91''
4. Sioux City-Iowa Falls	NK0459	L 28	**-0.383**	**-0.00202**	**1 : 2,612,445**	1.000050757	0.999948863	0.999999617	+0°44'00.80''
4. Sioux City-Iowa Falls	NL0869	POCAHONTAS 3	**-2.953**	**-0.01559**	**1 : 338,677**	1.000051212	0.999945839	0.999997047	+0°08'40.31''
4. Sioux City-Iowa Falls	NK0427	R 31	**-8.807**	**-0.04650**	**1 : 113,551**	1.000045379	0.999945817	0.999991193	+0°49'18.82''
4. Sioux City-Iowa Falls	NM1700	SIOUX CITY ARP 2	**-0.627**	**-0.00331**	**1 : 1,595,238**	1.000047535	0.999951841	0.999999373	–1°02'52.51''
4. Sioux City-Iowa Falls	AI1965	SLB A	**-20.366**	**-0.10753**	**1 : 49,101**	1.000045754	0.999933883	0.999979634	–0°16'38.89''
4. Sioux City-Iowa Falls	NM0113	SLOAN	**13.469**	**0.07112**	**1 : 74,242**	1.000060395	0.999953077	1.000013469	–0°56'02.79''
4. Sioux City-Iowa Falls	NL0936	STORMPORT	**-20.239**	**-0.10686**	**1 : 49,409**	1.000045709	0.999934054	0.999979761	–0°16'31.89''
4. Sioux City-Iowa Falls	NL0937	STORMPORT AZ MK	**-20.003**	**-0.10561**	**1 : 49,994**	1.000045635	0.999934366	0.999979997	–0°16'19.29''
4. Sioux City-Iowa Falls	DG6506	SUX A	**-0.461**	**-0.00243**	**1 : 2,169,053**	1.000047396	0.999952145	0.999999539	–1°03'17.56''
4. Sioux City-Iowa Falls	DG6507	SUX B	**-0.177**	**-0.00093**	**1 : 5,661,744**	1.000047901	0.999951925	0.999999823	–1°02'37.17''
4. Sioux City-Iowa Falls	NL0870	TJEBBEN	**-9.626**	**-0.05083**	**1 : 103,883**	1.000045142	0.999945234	0.999990374	+0°09'09.16''
4. Sioux City-Iowa Falls	NM1911	U 181	**3.765**	**0.01988**	**1 : 265,626**	1.000051339	0.999952428	1.000003765	–0°59'31.03''
4. Sioux City-Iowa Falls	NM1912	Y 181	**0.637**	**0.00336**	**1 : 1,571,051**	1.000048671	0.999951968	1.000000637	–1°01'02.10''
5. Waterloo	NK0164	B 30	**-6.848**	**-0.03616**	**1 : 146,029**	1.000032970	0.999960183	0.999993152	–0°11'35.93''
5. Waterloo	NK0663	BEST	**-9.276**	**-0.04898**	**1 : 107,800**	1.000036148	0.999954577	0.999990724	–0°21'12.08''
5. Waterloo	NJ0599	C 12	**-7.218**	**-0.03811**	**1 : 138,545**	1.000044382	0.999948403	0.999992782	+0°16'16.09''
5. Waterloo	NK0514	DETTMER	**-9.624**	**-0.05082**	**1 : 103,902**	1.000036165	0.999954212	0.999990376	–0°05'09.42''
5. Waterloo	NJ1003	G 75 RESET	**6.183**	**0.03265**	**1 : 161,732**	1.000046321	0.999959864	1.000006183	+0°17'26.45''
5. Waterloo	NK0584	HUDSON	**-1.421**	**-0.00750**	**1 : 703,624**	1.000039369	0.999959211	0.999998579	–0°08'46.17''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
5. Waterloo	AE2138	IIB A	**-3.409**	**-0.01800**	**1 : 293,324**	1.000037875	0.999958717	0.999996591	+0°12'03.99''
5. Waterloo	NK0036	L 11	**1.757**	**0.00927**	**1 : 569,297**	1.000038492	0.999963266	1.000001757	–0°06'56.26''
5. Waterloo	DL3989	OLZ A	**-13.567**	**-0.07164**	**1 : 73,706**	1.000032098	0.999954336	0.999986433	+0°11'24.43''
5. Waterloo	DL3988	OLZ B	**-13.752**	**-0.07261**	**1 : 72,715**	1.000032119	0.999954130	0.999986248	+0°11'13.69''
5. Waterloo	DL3990	OLZ C	**-14.298**	**-0.07549**	**1 : 69,941**	1.000032158	0.999953546	0.999985702	+0°10'59.30''
5. Waterloo	NK0006	S 11	**-10.691**	**-0.05645**	**1 : 93,535**	1.000032258	0.999957052	0.999989309	+0°06'14.29''
5. Waterloo	NK0652	SALEM	**-12.466**	**-0.06582**	**1 : 80,217**	1.000034822	0.999952714	0.999987534	–0°20'51.81''
5. Waterloo	NJ1008	T 74 RESET	**-11.177**	**-0.05901**	**1 : 89,471**	1.000032011	0.999956814	0.999988823	+0°13'53.64''
5. Waterloo	NJ0626	X 74	**-9.400**	**-0.04963**	**1 : 106,382**	1.000033797	0.999956804	0.999990600	+0°13'50.10''
5. Waterloo	NJ0596	Z 11	**-9.820**	**-0.05185**	**1 : 101,829**	1.000036287	0.999953894	0.999990180	+0°14'40.21''
6. Council Bluffs	MJ0984	43 58	**0.889**	**0.00469**	**1 : 1,124,739**	1.000044427	0.999956464	1.000000889	–0°10'01.14''
6. Council Bluffs	AI8383	743816 3	**8.914**	**0.04707**	**1 : 112,178**	1.000060742	0.999948176	1.000008914	+0°19'48.57''
6. Council Bluffs	AI8381	744006 1	**-7.929**	**-0.04186**	**1 : 126,120**	1.000044529	0.999947545	0.999992071	+0°10'00.25''
6. Council Bluffs	AI8382	744224 3	**-13.058**	**-0.06894**	**1 : 76,584**	1.000039890	0.999947054	0.999986942	+0°04'00.40''
6. Council Bluffs	AI8380	753913 3	**0.890**	**0.00470**	**1 : 1,123,095**	1.000056044	0.999944849	1.000000890	+0°17'35.56''
6. Council Bluffs	AI8379	764033 3	**-6.493**	**-0.03428**	**1 : 154,018**	1.000045406	0.999948103	0.999993507	+0°10'48.13''
6. Council Bluffs	AI8375	764204 1	**-8.421**	**-0.04446**	**1 : 118,757**	1.000039349	0.999952232	0.999991579	+0°02'31.73''
6. Council Bluffs	AI8378	764235 3	**-16.846**	**-0.08895**	**1 : 59,360**	1.000039659	0.999943497	0.999983154	+0°03'27.84''
6. Council Bluffs	AI8374	764306 1	**-4.079**	**-0.02154**	**1 : 245,176**	1.000039729	0.999956194	0.999995921	–0°03'39.26''
6. Council Bluffs	AI8377	773936 3	**-1.569**	**-0.00828**	**1 : 637,513**	1.000055965	0.999942469	0.999998431	+0°17'37.93''
6. Council Bluffs	AI8376	774035 2	**-10.132**	**-0.05349**	**1 : 98,701**	1.000048367	0.999941504	0.999989868	+0°13'06.10''
6. Council Bluffs	MJ0283	83 99 RESET 2	**-0.682**	**-0.00360**	**1 : 1,465,768**	1.000062392	0.999936929	0.999999318	+0°20'56.63''
6. Council Bluffs	MJ0639	A 140	**-2.739**	**-0.01446**	**1 : 365,110**	1.000040888	0.999956374	0.999997261	–0°05'53.65''
6. Council Bluffs	MJ1160	ASPIN	**0.394**	**0.00208**	**1 : 2,538,054**	1.000067735	0.999932664	1.000000394	+0°23'22.44''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
6. Council Bluffs	AH9100	BLENCOE RESET	**4.554**	**0.02404**	**1 : 219,590**	1.000049731	0.999954825	1.000004554	–0°14'16.49''
6. Council Bluffs	LF1169	C 133	**-0.294**	**-0.00155**	**1 : 3,397,963**	1.000039513	0.999960194	0.999999706	–0°02'59.69''
6. Council Bluffs	MJ0513	C 147	**2.894**	**0.01528**	**1 : 345,527**	1.000052481	0.999950416	1.000002894	+0°15'44.44''
6. Council Bluffs	MJ1403	COUNPORT	**-16.224**	**-0.08566**	**1 : 61,638**	1.000039065	0.999944714	0.999983776	–0°01'04.95''
6. Council Bluffs	MJ1411	COUNPORT AZ MK	**-15.397**	**-0.08130**	**1 : 64,948**	1.000039090	0.999945515	0.999984603	–0°01'16.68''
6. Council Bluffs	MJ1382	E 180	**-1.505**	**-0.00795**	**1 : 664,394**	1.000041224	0.999957273	0.999998495	–0°06'22.79''
6. Council Bluffs	LF1531	EE 158 RESET	**-0.882**	**-0.00466**	**1 : 1,133,635**	1.000041726	0.999957393	0.999999118	+0°06'56.80''
6. Council Bluffs	LF1445	G 182	**0.649**	**0.00343**	**1 : 1,540,515**	1.000039457	0.999961194	1.000000649	+0°02'48.56''
6. Council Bluffs	MJ1199	HANCOCK	**-3.612**	**-0.01907**	**1 : 276,822**	1.000051844	0.999944546	0.999996388	+0°15'19.44''
6. Council Bluffs	AE2137	HNR A	**-1.127**	**-0.00595**	**1 : 887,299**	1.000052119	0.999946757	0.999998873	+0°15'35.76''
6. Council Bluffs	NL0444	J 159	**-20.329**	**-0.10734**	**1 : 49,191**	1.000040137	0.999939537	0.999979671	–0°04'39.57''
6. Council Bluffs	MJ1402	J 180	**-2.882**	**-0.01521**	**1 : 347,039**	1.000039541	0.999957579	0.999997118	–0°03'07.21''
6. Council Bluffs	NL0901	MAPPORT	**-9.617**	**-0.05078**	**1 : 103,983**	1.000039299	0.999951086	0.999990383	–0°02'24.33''
6. Council Bluffs	AE9294	OMA 1	**-19.754**	**-0.10430**	**1 : 50,624**	1.000041702	0.999938547	0.999980246	–0°07'07.55''
6. Council Bluffs	AE9293	OMA 2	**-19.673**	**-0.10387**	**1 : 50,831**	1.000041675	0.999938655	0.999980327	–0°07'05.42''
6. Council Bluffs	AE2142	SDA A	**6.766**	**0.03572**	**1 : 147,807**	1.000048466	0.999958302	1.000006766	+0°12'51.92''
6. Council Bluffs	LF1495	SHENPORT	**7.099**	**0.03748**	**1 : 140,873**	1.000047806	0.999959295	1.000007099	+0°12'24.52''
6. Council Bluffs	LF1496	SHENPORT AZ MK	**6.747**	**0.03562**	**1 : 148,220**	1.000048084	0.999958665	1.000006747	+0°12'36.10''
6. Council Bluffs	MJ0955	T 150	**-9.437**	**-0.04983**	**1 : 105,962**	1.000042663	0.999947902	0.999990563	+0°08'15.25''
6. Council Bluffs	LF0985	V 134	**0.146**	**0.00077**	**1 : 6,830,936**	1.000039000	0.999961148	1.000000146	–0°00'04.46''
7. Carroll-Atlantic	DL6007	CIN A	**-5.776**	**-0.03050**	**1 : 173,118**	1.000047003	0.999947223	0.999994224	–0°06'11.68''
7. Carroll-Atlantic	DL6008	CIN B	**-5.854**	**-0.03091**	**1 : 170,827**	1.000047212	0.999946937	0.999994146	–0°06'30.63''
7. Carroll-Atlantic	DL6009	CIN C	**-5.687**	**-0.03003**	**1 : 175,845**	1.000046886	0.999947429	0.999994313	–0°06'00.55''
7. Carroll-Atlantic	MJ0181	P 163	**-18.959**	**-0.10011**	**1 : 52,744**	1.000045061	0.999935982	0.999981041	–0°01'03.80''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
7. Carroll-Atlantic	MJ1121	TURK	**-2.372**	**-0.01252**	**1 : 421,600**	1.000055785	0.999941847	0.999997628	–0°14'00.90''
7. Carroll-Atlantic	MJ1465	W 100 RESET	**-13.505**	**-0.07131**	**1 : 74,045**	1.000048826	0.999937672	0.999986495	–0°08'26.93''
7. Carroll-Atlantic	NL0186	W 89	**-6.033**	**-0.03185**	**1 : 165,758**	1.000046905	0.999947064	0.999993967	–0°06'02.57''
7. Carroll-Atlantic	MJ0136	X 103	**-13.103**	**-0.06918**	**1 : 76,320**	1.000047510	0.999939390	0.999986897	+0°06'44.99''
7. Carroll-Atlantic	NL0140	X 93	**-4.259**	**-0.02249**	**1 : 234,806**	1.000050940	0.999944804	0.999995741	–0°10'40.74''
7. Carroll-Atlantic	NL0192	Y 89	**-5.830**	**-0.03078**	**1 : 171,515**	1.000049802	0.999944371	0.999994170	–0°09'35.79''
8. Ames-Des Moines	AE2154	20 ADP	**-10.150**	**-0.05359**	**1 : 98,522**	1.000033415	0.999956436	0.999989850	–0°02'45.30''
8. Ames-Des Moines	MJ0089	A 162	**-1.289**	**-0.00680**	**1 : 775,950**	1.000046343	0.999952370	0.999998711	–0°15'40.58''
8. Ames-Des Moines	AJ8301	AMW D	**-5.577**	**-0.02945**	**1 : 179,314**	1.000033818	0.999960606	0.999994423	+0°03'57.08''
8. Ames-Des Moines	AJ8302	AMW E	**-6.614**	**-0.03492**	**1 : 151,191**	1.000033724	0.999959663	0.999993386	+0°03'42.92''
8. Ames-Des Moines	AJ8303	AMW F	**-5.728**	**-0.03024**	**1 : 174,578**	1.000033705	0.999960569	0.999994272	+0°03'40.05''
8. Ames-Des Moines	DI3066	BNW A	**-15.453**	**-0.08159**	**1 : 64,713**	1.000034526	0.999950023	0.999984547	–0°05'24.46''
8. Ames-Des Moines	DI3067	BNW B	**-15.473**	**-0.08169**	**1 : 64,631**	1.000034330	0.999950199	0.999984527	–0°05'02.81''
8. Ames-Des Moines	NK0751	BOONEPORT AZ MK	**-15.526**	**-0.08198**	**1 : 64,410**	1.000034398	0.999950078	0.999984474	–0°05'10.47''
8. Ames-Des Moines	AB5750	DSM ARP	**-6.309**	**-0.03331**	**1 : 158,514**	1.000033285	0.999960407	0.999993691	+0°02'17.76''
8. Ames-Des Moines	AJ6051	DSM C	**-5.534**	**-0.02922**	**1 : 180,693**	1.000033183	0.999961284	0.999994466	+0°01'50.26''
8. Ames-Des Moines	AJ6052	DSM D	**-5.834**	**-0.03080**	**1 : 171,404**	1.000033235	0.999960932	0.999994166	+0°02'04.98''
8. Ames-Des Moines	MH0688	ET 9 JA	**-13.005**	**-0.06866**	**1 : 76,896**	1.000033138	0.999953859	0.999986995	–0°01'37.24''
8. Ames-Des Moines	AE2151	GPS 15	**-0.801**	**-0.00423**	**1 : 1,248,512**	1.000036891	0.999962310	0.999999199	+0°08'29.31''
8. Ames-Des Moines	AE2150	GPS 9	**-6.684**	**-0.03529**	**1 : 149,618**	1.000033323	0.999959994	0.999993316	–0°02'26.54''
8. Ames-Des Moines	NK0704	HUBBARD WEST BASE	**-6.940**	**-0.03664**	**1 : 144,099**	1.000043309	0.999949754	0.999993060	+0°14'07.30''
8. Ames-Des Moines	AE1868	IADOT BASE STATION	**-7.547**	**-0.03985**	**1 : 132,498**	1.000033752	0.999958702	0.999992453	+0°03'47.58''
8. Ames-Des Moines	AE2139	IKV A	**-2.632**	**-0.01390**	**1 : 379,920**	1.000034913	0.999962456	0.999997368	+0°05'58.72''
8. Ames-Des Moines	DG6295	IKV B	**-2.445**	**-0.01291**	**1 : 409,043**	1.000034917	0.999962640	0.999997555	+0°05'58.93''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	**(ft/mile)**	**(ratio)**				
8. Ames-Des Moines	DG6296	IKV C	**-3.261**	**-0.01722**	**1 : 306,664**	1.000034916	0.999961824	0.999996739	+0°05'59.04''
8. Ames-Des Moines	DF6532	IOWA DOT RCE OFFICE	**-5.908**	**-0.03119**	**1 : 169,272**	1.000034205	0.999959889	0.999994092	+0°04'44.31''
8. Ames-Des Moines	MJ1441	PERRYPORT	**5.980**	**0.03157**	**1 : 167,235**	1.000049633	0.999956348	1.000005980	–0°17'42.75''
8. Ames-Des Moines	AE2153	STORY 11	**-10.091**	**-0.05328**	**1 : 99,094**	1.000033793	0.999956117	0.999989909	+0°03'52.37''
8. Ames-Des Moines	AE2152	STORY 5	**0.881**	**0.00465**	**1 : 1,134,884**	1.000044500	0.999956383	1.000000881	+0°14'48.26''
8. Ames-Des Moines	MH0406	U 33	**-4.393**	**-0.02320**	**1 : 227,631**	1.000036545	0.999959064	0.999995607	+0°08'13.19''
8. Ames-Des Moines	NL0104	U 88	**-1.076**	**-0.00568**	**1 : 929,280**	1.000044547	0.999954379	0.999998924	–0°14'52.03''
8. Ames-Des Moines	MJ0074	X 3	**-2.105**	**-0.01111**	**1 : 475,034**	1.000042357	0.999955540	0.999997895	–0°13'15.66''
9. Newton	MH0207	A 5	**-2.041**	**-0.01078**	**1 : 489,890**	1.000037067	0.999960893	0.999997959	–0°13'39.21''
9. Newton	NK0611	BROOK	**-16.404**	**-0.08661**	**1 : 60,962**	1.000028367	0.999955231	0.999983596	+0°05'08.31''
9. Newton	MH0163	D 88	**-17.164**	**-0.09063**	**1 : 58,261**	1.000027096	0.999955741	0.999982836	+0°01'20.82''
9. Newton	MH0650	DYER	**5.284**	**0.02790**	**1 : 189,260**	1.000044788	0.999960498	1.000005284	–0°18'02.99''
9. Newton	AE2136	GGI A	**-15.291**	**-0.08074**	**1 : 65,399**	1.000027579	0.999957131	0.999984709	+0°03'17.45''
9. Newton	MH0783	KNOXPORT	**-4.692**	**-0.02477**	**1 : 213,119**	1.000034566	0.999960743	0.999995308	–0°11'43.52''
9. Newton	MH0784	KNOXPORT AZ MK	**-4.376**	**-0.02311**	**1 : 228,519**	1.000034748	0.999960878	0.999995624	–0°11'52.06''
9. Newton	MH0109	L 87	**-6.794**	**-0.03587**	**1 : 147,184**	1.000029471	0.999963735	0.999993206	+0°06'44.42''
9. Newton	MH0578	LARSON	**-11.890**	**-0.06278**	**1 : 84,106**	1.000030299	0.999957813	0.999988110	+0°07'51.19''
9. Newton	DK3690	OOA A 2007	**1.554**	**0.00821**	**1 : 643,311**	1.000036348	0.999965208	1.000001554	+0°12'59.88''
9. Newton	MH0795	OSKAPORT	**1.315**	**0.00694**	**1 : 760,565**	1.000036135	0.999965181	1.000001315	+0°12'51.00''
9. Newton	MH0796	OSKAPORT AZ MK	**1.029**	**0.00543**	**1 : 971,696**	1.000035913	0.999965117	1.000001029	+0°12'41.66''
9. Newton	AJ8304	OXV A	**-4.899**	**-0.02587**	**1 : 204,106**	1.000034430	0.999960672	0.999995101	–0°11'37.08''
9. Newton	MH0124	T 5	**1.425**	**0.00752**	**1 : 701,718**	1.000029271	0.999972154	1.000001425	+0°06'24.34''
9. Newton	AE2147	TT 10 FHJ	**-12.310**	**-0.06500**	**1 : 81,234**	1.000028727	0.999958964	0.999987690	–0°05'44.62''
9. Newton	NK0107	Y 10	**-13.102**	**-0.06918**	**1 : 76,324**	1.000027658	0.999959241	0.999986898	+0°03'34.05''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
10. Cedar Rapids	MG0566	57 27	**-13.296**	**-0.07020**	**1 : 75,210**	1.000020379	0.999966326	0.999986704	+0°00'47.83''
10. Cedar Rapids	AE2145	95 03	**-14.433**	**-0.07620**	**1 : 69,288**	1.000020053	0.999965515	0.999985567	+0°26'44.09''
10. Cedar Rapids	AB5732	CID ARP 2	**-15.481**	**-0.08174**	**1 : 64,596**	1.000020403	0.999964116	0.999984519	–0°01'41.56''
10. Cedar Rapids	DM6119	CID C	**-15.706**	**-0.08293**	**1 : 63,671**	1.000020431	0.999963864	0.999984294	–0°01'53.27''
10. Cedar Rapids	AJ8568	CID GP 1	**-15.991**	**-0.08443**	**1 : 62,537**	1.000020380	0.999963631	0.999984009	–0°02'40.16''
10. Cedar Rapids	AJ8598	CID GP 2	**-15.260**	**-0.08057**	**1 : 65,529**	1.000020374	0.999964366	0.999984740	–0°01'16.03''
10. Cedar Rapids	NJ0755	ET 4 JS	**6.915**	**0.03651**	**1 : 144,611**	1.000046916	0.999960001	1.000006915	+0°17'36.99''
10. Cedar Rapids	AE2155	GPS CONTROL POINT 96 102	**5.042**	**0.02662**	**1 : 198,350**	1.000035722	0.999969321	1.000005042	–0°08'48.88''
10. Cedar Rapids	MH0487	HARTWICK	**-19.725**	**-0.10415**	**1 : 50,696**	1.000020001	0.999960274	0.999980275	–0°24'53.10''
10. Cedar Rapids	AE9184	NLIB A	**-13.375**	**-0.07062**	**1 : 74,767**	1.000020733	0.999965893	0.999986625	+0°03'31.27''
10. Cedar Rapids	MG0916	NORTH LIBERTY	**-11.690**	**-0.06172**	**1 : 85,545**	1.000020570	0.999967741	0.999988310	+0°03'40.98''
10. Cedar Rapids	NK0557	PRATT	**-0.232**	**-0.00122**	**1 : 4,316,967**	1.000041647	0.999958123	0.999999768	–0°21'48.99''
10. Cedar Rapids	AE9186	X 183	**-11.472**	**-0.06057**	**1 : 87,171**	1.000020883	0.999967646	0.999988528	+0°02'23.39''
11. Dubuque-Davenport	NJ0271	52 JDF	**-19.587**	**-0.10342**	**1 : 51,055**	1.000027314	0.999953100	0.999980413	–0°02'29.04''
11. Dubuque-Davenport	NJ0367	A 178	**-10.131**	**-0.05349**	**1 : 98,712**	1.000038457	0.999951414	0.999989869	–0°15'05.84''
11. Dubuque-Davenport	AE9312	A 185	**1.686**	**0.00890**	**1 : 593,007**	1.000034866	0.999966822	1.000001686	+0°12'15.84''
11. Dubuque-Davenport	NJ0104	C 175	**10.457**	**0.05521**	**1 : 95,634**	1.000035257	0.999975201	1.000010457	+0°12'36.40''
11. Dubuque-Davenport	AJ8298	CWI A	**2.678**	**0.01414**	**1 : 373,470**	1.000030471	0.999972207	1.000002678	+0°08'05.49''
11. Dubuque-Davenport	AJ8299	CWI B	**2.030**	**0.01072**	**1 : 492,682**	1.000030369	0.999971662	1.000002030	+0°07'58.39''
11. Dubuque-Davenport	AJ8300	CWI C	**2.204**	**0.01164**	**1 : 453,645**	1.000030721	0.999971484	1.000002204	+0°08'22.84''
11. Dubuque-Davenport	DF9357	DBQ A	**-14.538**	**-0.07676**	**1 : 68,787**	1.000029636	0.999955828	0.999985462	–0°07'11.57''
11. Dubuque-Davenport	DF9358	DBQ B	**-16.713**	**-0.08825**	**1 : 59,833**	1.000029296	0.999953992	0.999983287	–0°06'42.84''
11. Dubuque-Davenport	NJ0939	DUBUQUE	**-11.794**	**-0.06227**	**1 : 84,788**	1.000030208	0.999958000	0.999988206	–0°07'58.31''
11. Dubuque-Davenport	NJ0258	DUBUQUE APT ARP	**-15.857**	**-0.08372**	**1 : 63,065**	1.000029572	0.999954573	0.999984143	–0°07'06.40''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	**(ft/mile)**	**(ratio)**				
11. Dubuque-Davenport	AB5747	DVN A 1975	**-3.479**	**-0.01837**	**1 : 287,447**	1.000027316	0.999969206	0.999996521	–0°02'25.40"
11. Dubuque-Davenport	NJ0232	E 79	**-10.172**	**-0.05371**	**1 : 98,310**	1.000027000	0.999962829	0.999989828	–0°00'02.35"
11. Dubuque-Davenport	MG0328	G 70	**-4.952**	**-0.02614**	**1 : 201,955**	1.000027193	0.999967856	0.999995048	–0°01'53.69"
11. Dubuque-Davenport	NJ0893	HANTEN	**-22.688**	**-0.11980**	**1 : 44,075**	1.000028461	0.999948852	0.999977312	–0°05'21.31"
11. Dubuque-Davenport	NJ0119	Q 175	**5.419**	**0.02861**	**1 : 184,544**	1.000029025	0.999976394	1.000005419	+0°06'15.68"
11. Dubuque-Davenport	AE9310	RISL A	**2.109**	**0.01114**	**1 : 474,165**	1.000035045	0.999967065	1.000002109	+0°12'23.90"
11. Dubuque-Davenport	AE9311	RISL B	**2.049**	**0.01082**	**1 : 488,154**	1.000034738	0.999967312	1.000002049	+0°12'09.55"
11. Dubuque-Davenport	NJ0153	X 175	**-2.572**	**-0.01358**	**1 : 388,863**	1.000027495	0.999969935	0.999997428	+0°03'06.38"
12. Red Oak-Ottumwa	AB5782	AP 1963 STA B	**7.459**	**0.03939**	**1 : 134,058**	1.000042612	0.999964848	1.000007459	+0°50'55.79"
12. Red Oak-Ottumwa	MH0780	CHARIPORT AZ MK	**-6.357**	**-0.03357**	**1 : 157,299**	1.000038625	0.999955019	0.999993643	+0°15'10.00"
12. Red Oak-Ottumwa	MJ1425	CRESTPORT	**-18.437**	**-0.09735**	**1 : 54,239**	1.000038603	0.999942963	0.999981563	–0°24'05.23"
12. Red Oak-Ottumwa	MJ1426	CRESTPORT AZ MK	**-18.518**	**-0.09777**	**1 : 54,002**	1.000038457	0.999943027	0.999981482	–0°24'01.17"
12. Red Oak-Ottumwa	AE2133	CSQ A	**-18.297**	**-0.09661**	**1 : 54,653**	1.000038911	0.999942794	0.999981703	–0°24'16.21"
12. Red Oak-Ottumwa	MH0054	D 6	**8.325**	**0.04396**	**1 : 120,122**	1.000041550	0.999966777	1.000008325	+0°54'31.33"
12. Red Oak-Ottumwa	MH0055	E 6	**11.507**	**0.06075**	**1 : 86,907**	1.000042294	0.999969214	1.000011507	+0°56'23.43"
12. Red Oak-Ottumwa	LE0588	ET 2 MES	**3.130**	**0.01652**	**1 : 319,537**	1.000050146	0.999952986	1.000003130	+0°00'05.46"
12. Red Oak-Ottumwa	LE0532	FAIRALL	**-7.759**	**-0.04097**	**1 : 128,879**	1.000040347	0.999951896	0.999992241	+0°10'19.62"
12. Red Oak-Ottumwa	MH0272	H 110	**-10.360**	**-0.05470**	**1 : 96,529**	1.000039207	0.999950435	0.999989640	–0°00'36.50"
12. Red Oak-Ottumwa	DL2463	I75 A	**-8.160**	**-0.04309**	**1 : 122,543**	1.000039924	0.999951918	0.999991840	+0°02'25.98"
12. Red Oak-Ottumwa	DL2464	I75 B	**-8.433**	**-0.04452**	**1 : 118,587**	1.000039720	0.999951849	0.999991567	+0°02'20.46"
12. Red Oak-Ottumwa	DL2465	I75 C	**-8.713**	**-0.04600**	**1 : 114,774**	1.000039529	0.999951760	0.999991287	+0°02'24.74"
12. Red Oak-Ottumwa	LF0049	K 105	**-2.339**	**-0.01235**	**1 : 427,547**	1.000047486	0.999950177	0.999997661	–0°23'22.91"
12. Red Oak-Ottumwa	MH0561	LOVILIA	**4.620**	**0.02439**	**1 : 216,446**	1.000044399	0.999960223	1.000004620	+0°33'07.89"
12. Red Oak-Ottumwa	LE0593	OSCEOLA	**-12.025**	**-0.06349**	**1 : 83,158**	1.000038044	0.999949933	0.999987975	–0°00'46.33"

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	(ft/mile)	(ratio)				
12. Red Oak-Ottumwa	LE0502	PARKER	**1.870**	**0.00988**	**1 : 534,618**	1.000037461	0.999964411	1.000001870	+0°48'34.99''
12. Red Oak-Ottumwa	LF1299	PRESCOTT 2	**-19.689**	**-0.10396**	**1 : 50,790**	1.000037591	0.999942723	0.999980311	–0°34'17.22''
12. Red Oak-Ottumwa	LF0026	R 104 RESET	**-17.480**	**-0.09230**	**1 : 57,207**	1.000037001	0.999945521	0.999982520	–0°23'04.95''
12. Red Oak-Ottumwa	MH0280	R 110	**-2.150**	**-0.01135**	**1 : 465,062**	1.000038224	0.999959627	0.999997850	+0°06'44.14''
12. Red Oak-Ottumwa	MJ1447	REDPORT	**-6.697**	**-0.03536**	**1 : 149,325**	1.000038338	0.999954967	0.999993303	–0°59'20.04''
12. Red Oak-Ottumwa	LF1488	S 106 RESET	**-12.746**	**-0.06730**	**1 : 78,455**	1.000041461	0.999945795	0.999987254	–0°40'52.03''
12. Red Oak-Ottumwa	LF0231	S 8	**9.498**	**0.05015**	**1 : 105,285**	1.000051212	0.999958288	1.000009498	–0°57'47.01''
12. Red Oak-Ottumwa	LF1489	SCHEPORT	**0.449**	**0.00237**	**1 : 2,229,547**	1.000042699	0.999957751	1.000000449	–0°50'09.41''
12. Red Oak-Ottumwa	MJ0521	U 148	**-11.489**	**-0.06066**	**1 : 87,040**	1.000045004	0.999943509	0.999988511	–1°00'28.79''
12. Red Oak-Ottumwa	MH0053	WAPELLO	**7.341**	**0.03876**	**1 : 136,215**	1.000042469	0.999964874	1.000007341	+0°51'17.09''
12. Red Oak-Ottumwa	LE0188	X 7	**5.190**	**0.02740**	**1 : 192,678**	1.000049494	0.999955699	1.000005190	+0°32'40.78''
13. Fairfield	DK3513	AWG A 2007	**-5.639**	**-0.02977**	**1 : 177,336**	1.000025087	0.999969274	0.999994361	+0°09'36.48''
13. Fairfield	DK3514	AWG B 2007	**-5.589**	**-0.02951**	**1 : 178,913**	1.000025002	0.999969409	0.999994411	+0°09'31.47''
13. Fairfield	MG0476	B 8	**0.050**	**0.00026**	**1 : 19,989,475**	1.000030907	0.999969144	1.000000050	+0°14'05.52''
13. Fairfield	LE0437	COPELAND	**-8.084**	**-0.04269**	**1 : 123,696**	1.000024011	0.999967906	0.999991916	–0°08'25.45''
13. Fairfield	MG0416	D 8	**8.559**	**0.04519**	**1 : 116,832**	1.000036083	0.999972477	1.000008559	+0°17'07.74''
13. Fairfield	AE2156	GPS CONTROL PT 96 150	**-5.386**	**-0.02844**	**1 : 185,681**	1.000020066	0.999974549	0.999994614	–0°01'05.37''
13. Fairfield	LD0592	T 124	**-10.086**	**-0.05326**	**1 : 99,144**	1.000020968	0.999968946	0.999989914	+0°04'08.98''
13. Fairfield	MG0914	WASHPORT AZ MK	**-5.550**	**-0.02930**	**1 : 180,181**	1.000025248	0.999969202	0.999994450	+0°09'45.44''
13. Fairfield	MG0472	X 6	**-5.406**	**-0.02854**	**1 : 184,990**	1.000023165	0.999971430	0.999994594	+0°07'34.93''
14. Burlington	AE2146	39 RWM	**-8.012**	**-0.04230**	**1 : 124,814**	1.000020636	0.999971353	0.999991988	+0°06'49.52''
14. Burlington	AE2148	ARDON AZ MK RESET	**-11.811**	**-0.06236**	**1 : 84,667**	1.000018497	0.999969692	0.999988189	+0°03'01.31''
14. Burlington	AJ8295	EOK A 2000	**-5.647**	**-0.02982**	**1 : 177,075**	1.000021017	0.999973336	0.999994353	–0°07'11.34''
14. Burlington	AJ8296	EOK B 2000	**-5.809**	**-0.03067**	**1 : 172,156**	1.000020924	0.999973268	0.999994191	–0°07'04.56''

Zone number and name	NGS PID	Station designation	Linear distortion at ground surface			Grid point scale factor	Height scale factor	Combined scale factor	Convergence angle
			(ppm)	**(ft/mile)**	**(ratio)**				
14. Burlington	AJ8297	EOK C	**-5.996**	**-0.03166**	**1 : 166,785**	1.000020659	0.999973345	0.999994004	–0°06'44.94''
14. Burlington	MG0794	HASCHAR	**-9.327**	**-0.04925**	**1 : 107,219**	1.000018858	0.999971816	0.999990673	+0°03'56.73''
14. Burlington	LD0867	JACKSON	**-0.507**	**-0.00268**	**1 : 1,973,740**	1.000028572	0.999970922	0.999999493	–0°13'39.19''
14. Burlington	LD0882	KEOPORT AZ MK	**-5.632**	**-0.02973**	**1 : 177,569**	1.000020804	0.999973565	0.999994368	–0°06'55.74''
14. Burlington	DF6531	LEE CO GPS CONTROL PT 2001 013	**0.003**	**0.00002**	**1 : 312,086,746**	1.000028951	0.999971053	1.000000003	–0°13'49.47''
14. Burlington	LD0800	MADISON	**-10.598**	**-0.05596**	**1 : 94,358**	1.000018120	0.999971283	0.999989402	–0°01'26.61''
14. Burlington	AE2140	MPZ A	**-5.602**	**-0.02958**	**1 : 178,506**	1.000023937	0.999970462	0.999994398	–0°10'15.44''
14. Burlington	MG0791	MUSCATINE	**-8.746**	**-0.04618**	**1 : 114,338**	1.000020733	0.999970521	0.999991254	+0°07'04.72''
14. Burlington	AJ8263	MUT A 2001	**-2.056**	**-0.01086**	**1 : 486,279**	1.000018813	0.999979131	0.999997944	+0°03'51.10''
14. Burlington	AJ8264	MUT B 2001	**-1.599**	**-0.00844**	**1 : 625,477**	1.000019131	0.999979271	0.999998401	+0°04'32.67''
14. Burlington	AJ8265	MUT C	**-1.663**	**-0.00878**	**1 : 601,208**	1.000018836	0.999979501	0.999998337	+0°03'54.42''
14. Burlington	LD0612	R 122=56 34	**-1.621**	**-0.00856**	**1 : 616,773**	1.000026651	0.999971729	0.999998379	–0°12'17.10''
14. Burlington	LD0616	T 122 RESET	**-2.130**	**-0.01125**	**1 : 469,420**	1.000026636	0.999971235	0.999997870	–0°12'17.34''
14. Burlington	LD0531	ZZ 125	**-8.219**	**-0.04340**	**1 : 121,667**	1.000019543	0.999972238	0.999991781	+0°05'11.95''