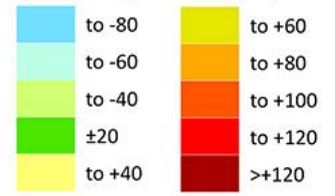


North Dakota Counties Topographic surface linear distortion

State Plane Coordinate System 1983
using NDDOT county coordinate
conversion factors (3 arc-sec resolution)

**Linear Distortion
at the Topographic Surface
in parts per million (ppm)**



**Distortion Values for All Zones
in parts per million (ppm)**

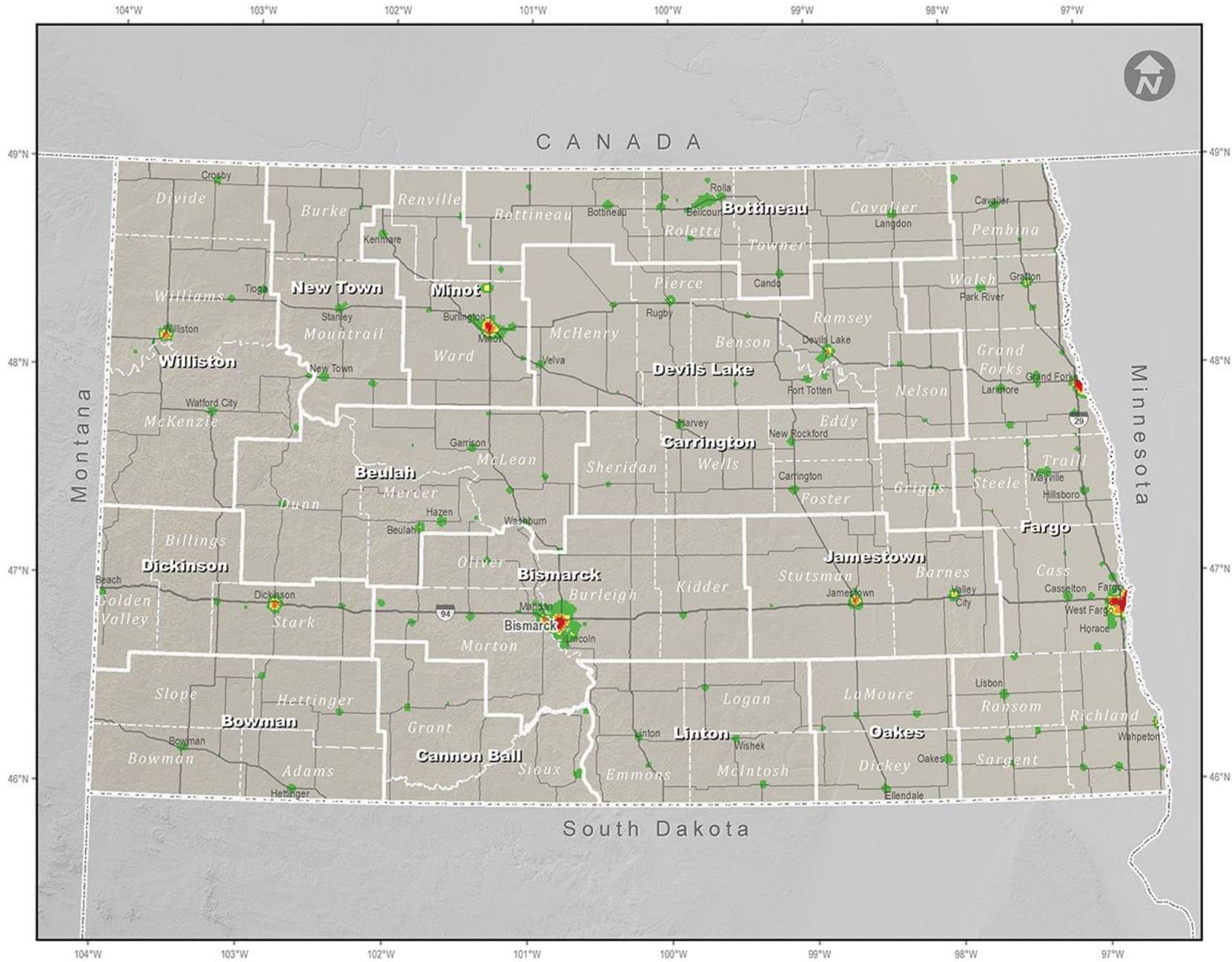
Min: -63 Range: 194
Max: +131 Mean: +5.7

Area of the state that is within:

± 10ppm: 38% ± 25ppm: 75%
± 20ppm: 66% ± 30ppm: 82%









- Interstate
- US Route
- State Route
- State
- - - County



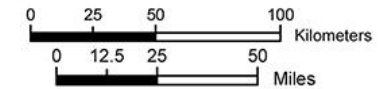


North Dakota Population Density

**- 8/1/2019 DRAFT -
FOR REVIEW PURPOSES**

-  County
 -  LDP Zone
 -  State
- Persons per km²**
-  Less than 25
 -  25 to 249
 -  250 to 499
 -  500 to 999
 -  1,000 or more

Source: U.S. Census Bureau, 2010 Decennial Census
Kernel density raster created from population by census block



NDDOT
North Dakota
Department of Transportation



North Dakota 2017 Annual Average Daily Traffic (AADT)

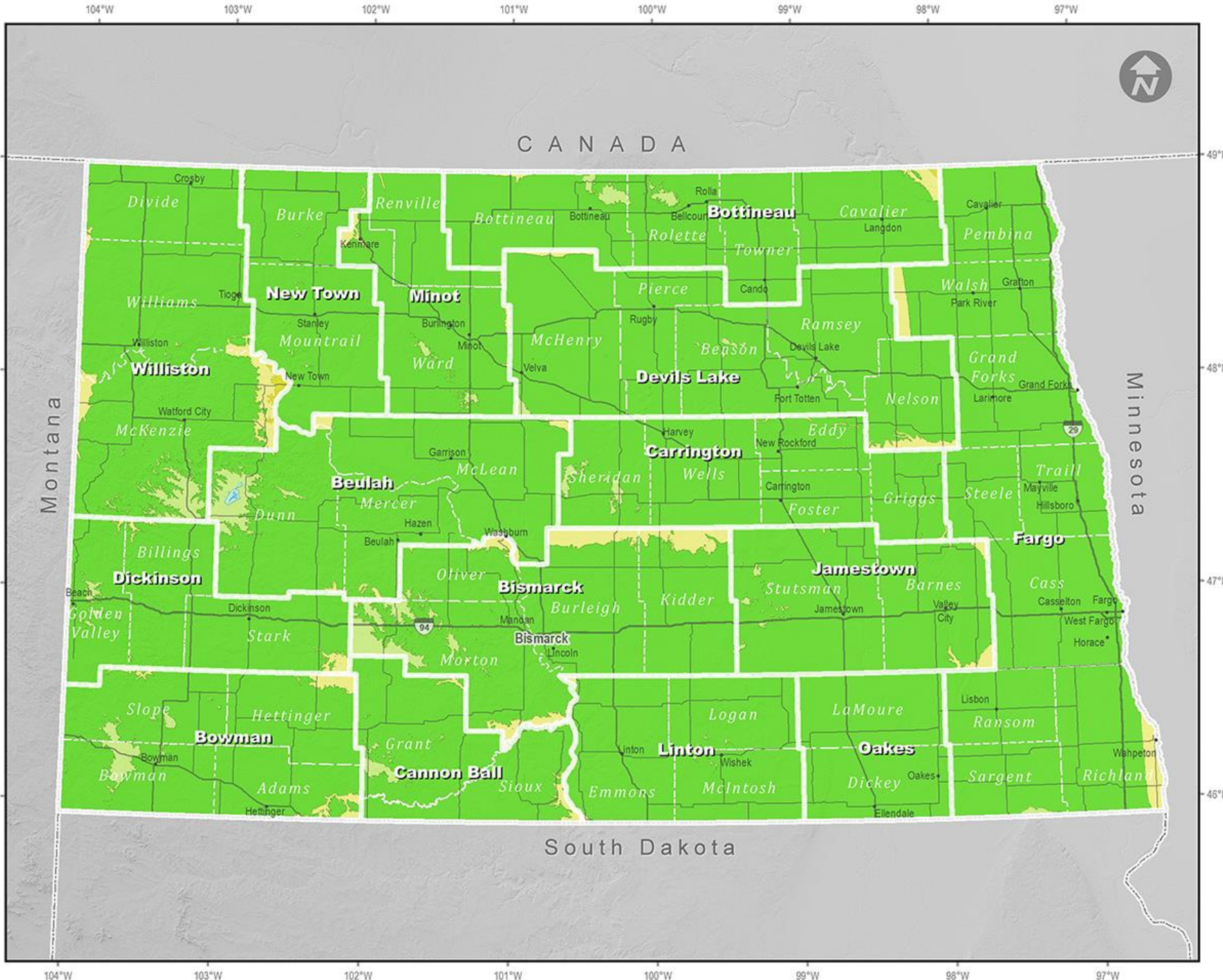
**- 8/1/2019 DRAFT -
FOR REVIEW PURPOSES**

- County
- LDP Zone
- State

- 2017 AADT**
- Less than 2,500
 - 2,500 to 7,499
 - 7,500 to 14,999
 - 15,000 to 24,999
 - More than 25,000

Source: Annual Average Daily Traffic (AADT) data from the 2017 Highway Performance Monitoring System (HPMS) submittal for North Dakota DOT to the Federal Highway Administration (FHWA)

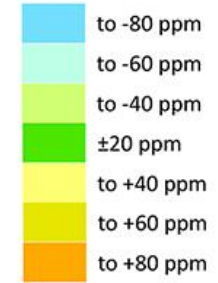




North Dakota Preliminary LDP Zones

**- 8/1/2019 DRAFT -
FOR REVIEW PURPOSES**

**Linear Distortion
at the Topographic Surface
in parts per million (ppm)**



**Distortion Values for All Zones
in parts per million (ppm)**

Min: -65 Range: 127
Max: +62 Mean: -0.9

Area of the state that is within:

± 10ppm: 64% ± 25ppm: 98%
± 20ppm: 95% ± 30ppm: 99%



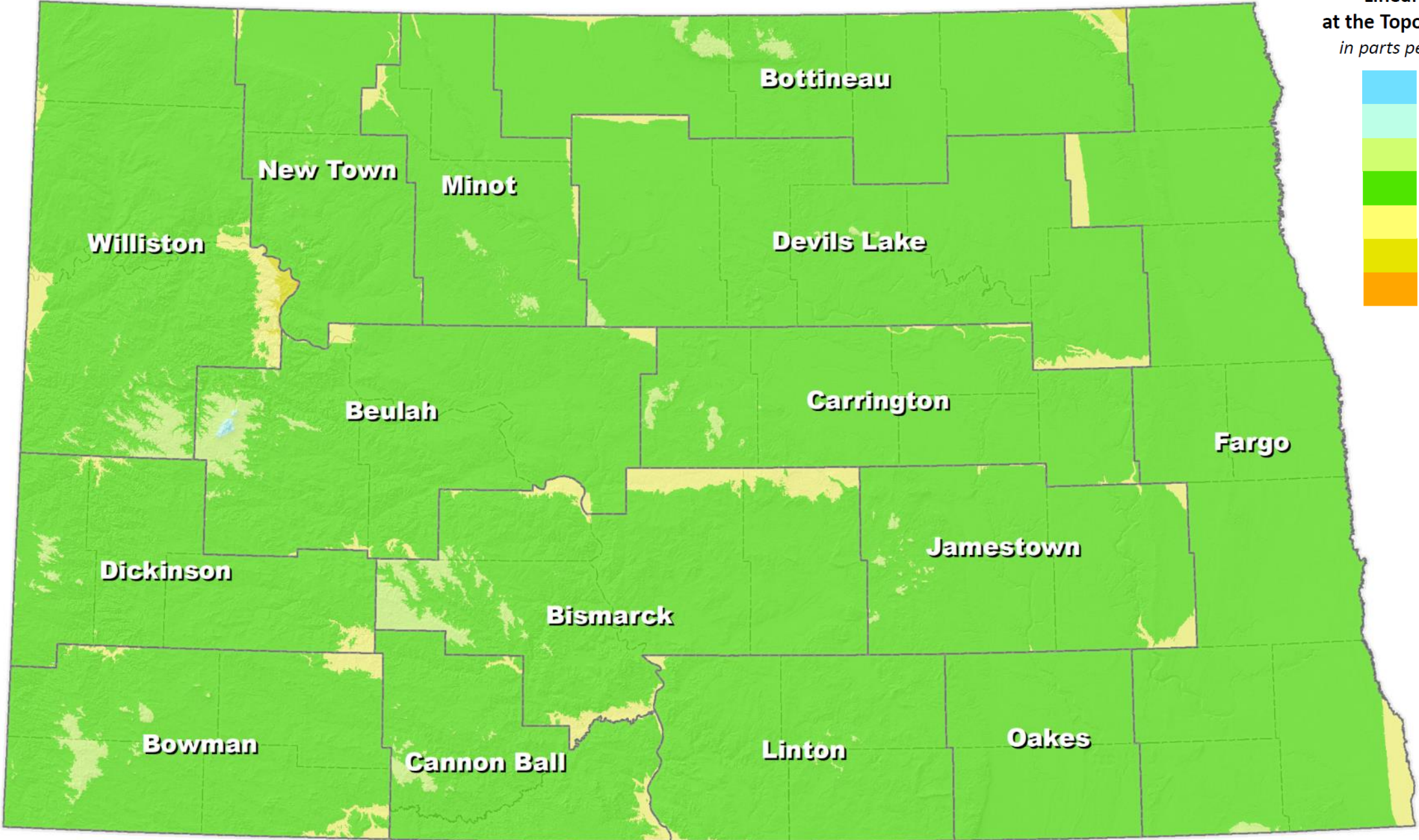
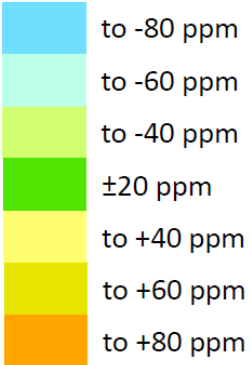
Distortion Values by Preliminary Zone

(Zone names based on the most populous city in the zone)

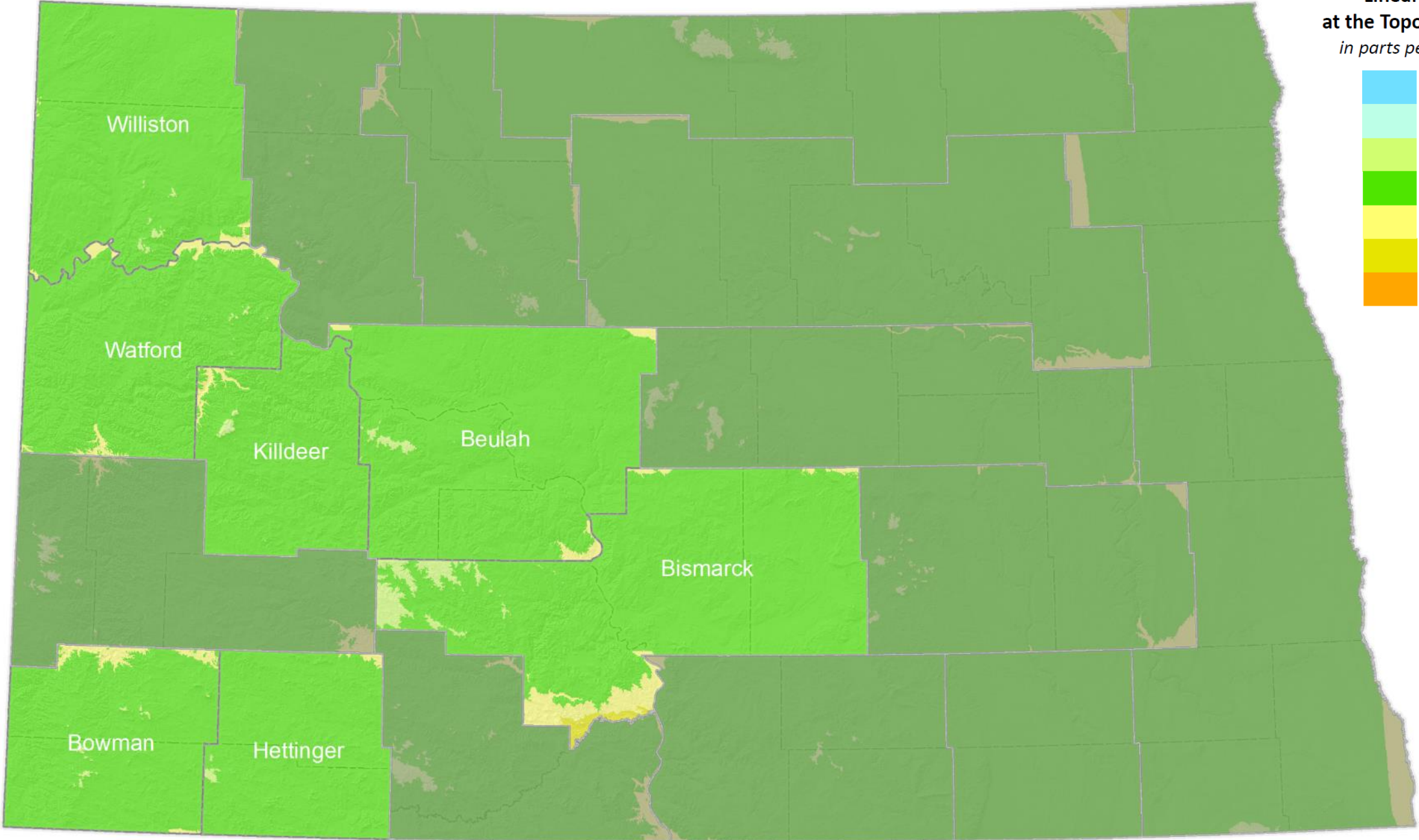
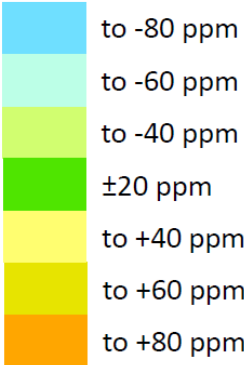
Zone Name	Raster File	Distortion in parts per million (ppm)				Percent of Zone within...			
		Minimum	Maximum	Mean	Range	±10ppm	±20ppm	±25ppm	±30ppm
Beulah	Beulah1_LCC_k1000089_cp4727_09s.img	-65	39	0.8	104	63	93	97	99
Bismarck	Bismarck1_LCC_k1000081_cp4649_09s.img	-37	43	0.4	80	58	86	93	98
Bottineau	Bottineau1_LCC_k1000066_cp4836_09s.img	-30	49	-0.1	79	75	96	99	99
Bowman	Bowman1_LCC_k1000123_cp4617_09s.img	-37	39	0.4	75	54	93	98	100
Cannon Ball	CannonBall1_LCC_k1000093_cp4617_09s.img	-34	37	0.3	71	55	95	99	100
Carrington	Carrington1_LCC_k1000072_cp473130_09s.img	-31	28	1.1	58	63	98	100	100
Devils Lake	DevilsLake1_LCC_k1000056_cp4810_09s.img	-32	34	-6.0	66	54	98	100	100
Dickinson	Dickinson1_LCC_k1000112_cp4700_09s.img	-46	32	-1.0	77	68	96	99	100
Fargo	Fargo1_TM_k1000035_cp9718_09s.img	-40	35	-1.8	76	73	97	99	100
Jamestown	Jamestown1_LCC_k1000067_cp4657_09s.img	-25	31	1.9	56	55	97	100	100
Linton	Linton1_LCC_k1000081_cp4618_09s.img	-23	27	-3.1	50	70	99	100	100
Minot	Minot1_TM_k1000080_cp10127_09s.img	-24	29	0.4	52	58	96	100	100
New Town	NewTown1_LCC_k1000094_cp10227_09s.img	-23	23	-1.1	45	60	99	100	100
Oakes	Oakes1_TM_k1000061_cp9820_09s.img	-16	11	-0.1	27	98	100	100	100
Williston	Williston1_TM_k1000092_cp10327_09s.img	-34	62	-1.4	96	62	91	95	98
All Combined	allZones_Prelim1_Mosaic_ppm09s.img	-65	62	-0.9	127	64	95	98	99

Note: Linear distortion is derived at the topographic surface.

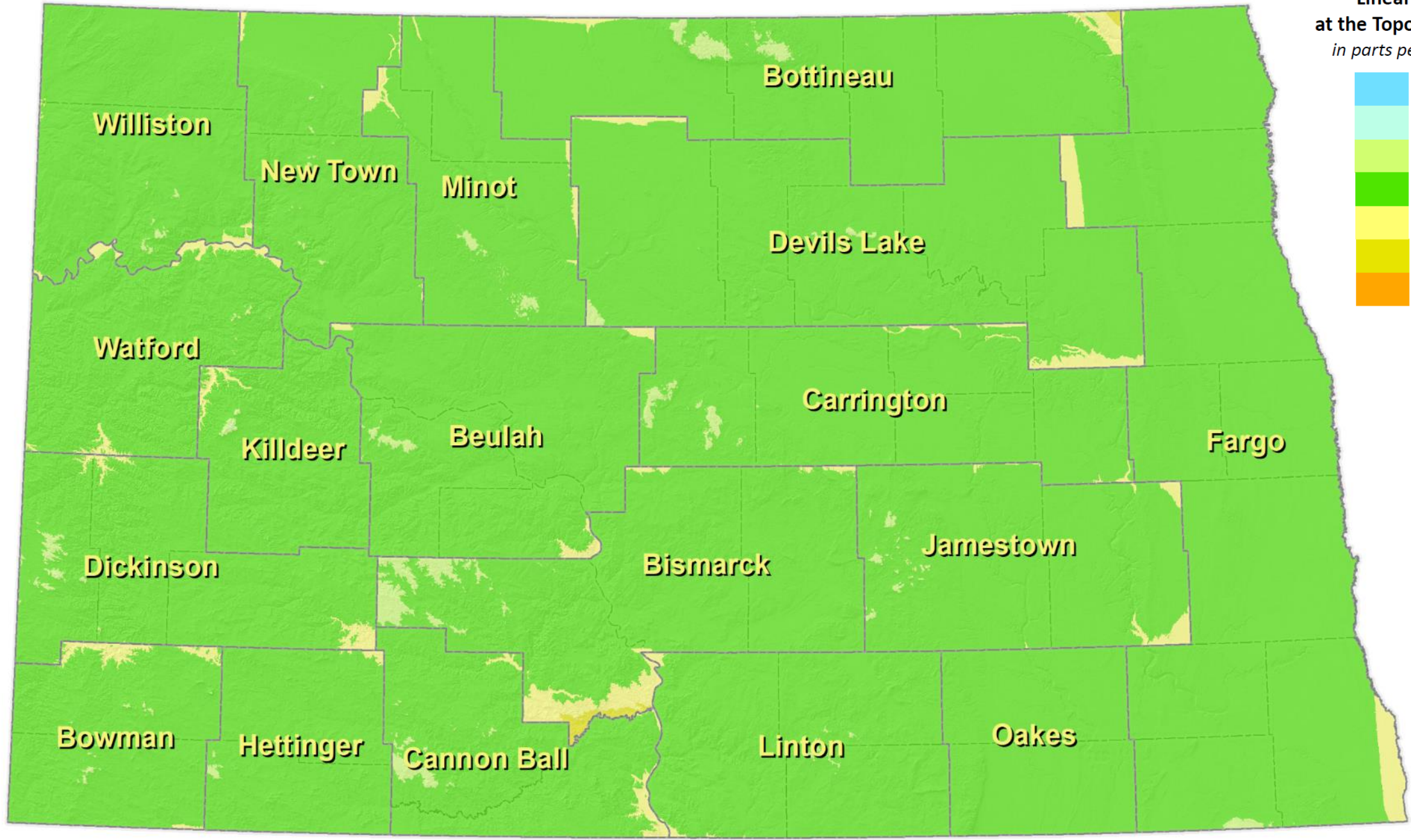
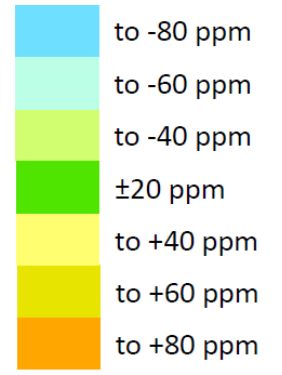
**Linear Distortion
at the Topographic Surface**
in parts per million (ppm)



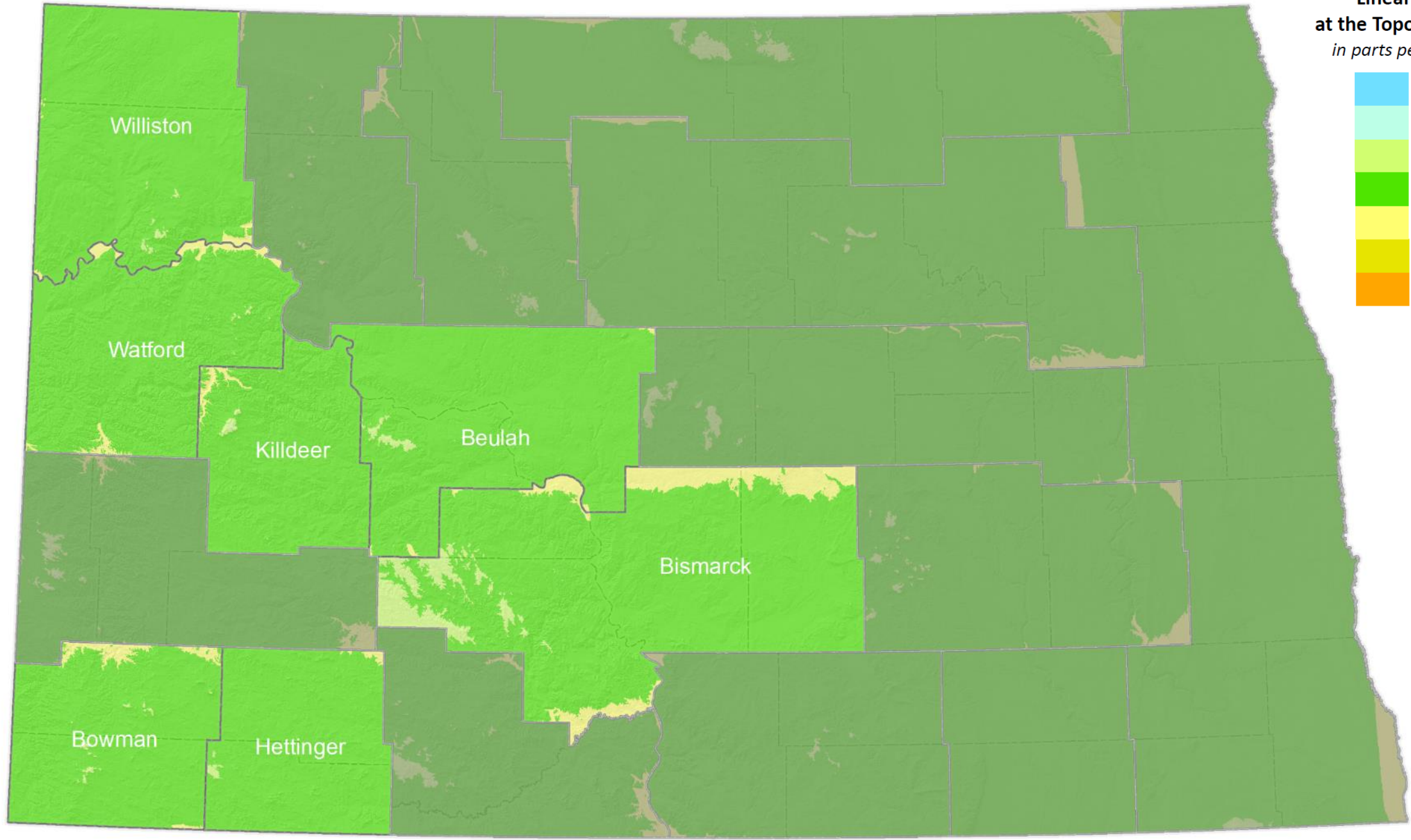
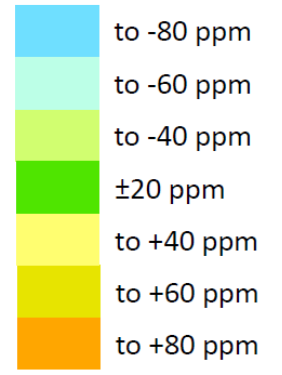
**Linear Distortion
at the Topographic Surface**
in parts per million (ppm)



**Linear Distortion
at the Topographic Surface**
in parts per million (ppm)



**Linear Distortion
at the Topographic Surface**
in parts per million (ppm)



Distortion Values by Preliminary Zone

(Zone names based on the most populous city in the zone)

Zone Name	Raster File	Distortion in parts per million (ppm)				Percent of Zone within...			
		Minimum	Maximum	Mean	Range	±10ppm	±20ppm	±25ppm	±30ppm
Beulah	Beulah1_LCC_k1000089_cp4727_09s.img	-65	39	0.8	104	63	93	97	99
Bismarck	Bismarck1_LCC_k1000081_cp4649_09s.img	-37	43	0.4	80	58	86	93	98
Bottineau	Bottineau1_LCC_k1000066_cp4836_09s.img	-30	49	-0.1	79	75	96	99	99
Bowman	Bowman1_LCC_k1000123_cp4617_09s.img	-37	39	0.4	75	54	93	98	100
Cannon Ball	CannonBall1_LCC_k1000093_cp4617_09s.img	-34	37	0.3	71	55	95	99	100
Carrington	Carrington1_LCC_k1000072_cp473130_09s.img	-31	28	1.1	58	63	98	100	100
Devils Lake	DevilsLake1_LCC_k1000056_cp4810_09s.img	-32	34	-6.0	66	54	98	100	100
Dickinson	Dickinson1_LCC_k1000112_cp4700_09s.img	-46	32	-1.0	77	68	96	99	100
Fargo	Fargo1_TM_k1000035_cp9718_09s.img	-40	35	-1.8	76	73	97	99	100
Jamestown	Jamestown1_LCC_k1000067_cp4657_09s.img	-25	31	1.9	56	55	97	100	100
Linton	Linton1_LCC_k1000081_cp4618_09s.img	-23	27	-3.1	50	70	99	100	100
Minot	Minot1_TM_k1000080_cp10127_09s.img	-24	29	0.4	52	58	96	100	100
New Town	NewTown1_LCC_k1000094_cp10227_09s.img	-23	23	-1.1	45	60	99	100	100
Oakes	Oakes1_TM_k1000061_cp9820_09s.img	-16	11	-0.1	27	98	100	100	100
Williston	Williston1_TM_k1000092_cp10327_09s.img	-34	62	-1.4	96	62	91	95	98
All Combined	allZones_Prelim1_Mosaic_ppm09s.img	-65	62	-0.9	127	64	95	98	99

Note: Linear distortion is derived at the topographic surface.

Distortion Values by Preliminary Zone - 2

(Zone names based on the most populous city in the zone)

Zone Name	Raster File	Distortion in parts per million (ppm)				Percent of Zone within...			
		Minimum	Maximum	Mean	Range	±10ppm	±20ppm	±25ppm	±30ppm
xBeulah2	xBeulah2_LCC_k1000082_cp4726_09s.img	-26	37	0	63	82	98	99	100
xBismarck2	xBismarck2_LCC_k1000083_cp4655_09s.img	-34	63	2	96	64	90	95	97
Bottineau1	Bottineau1_LCC_k1000066_cp4836_09s.img	-30	49	0	79	75	96	99	99
xBowman2	xBowman2_LCC_k100013_cp4617_09s.img	-30	36	1	66	70	95	99	100
CannonBall1	CannonBall1_LCC_k1000093_cp4617_09s.img	-34	37	0	71	55	95	99	100
Carrington1	Carrington1_LCC_k1000072_cp473130_09s.img	-31	28	1	59	63	98	100	100
DevilsLake1	DevilsLake1_LCC_k1000056_cp4810_09s.img	-32	34	-6	66	54	98	100	100
Dickinson1	Dickinson1_LCC_k1000112_cp4700_09s.img	-46	32	-1	77	68	96	99	100
Fargo1	Fargo1_TM_k1000035_cp9718_09s.img	-40	35	-2	76	73	97	99	100
xHettinger2	xHettinger2_LCC_k1000115_cp4618_09s.img	-28	29	0	57	77	99	100	100
Jamestown1	Jamestown1_LCC_k1000067_cp4657_09s.img	-25	31	2	56	55	97	100	100
xKilldeer2	xKilldeer2_TM_k1000099_cp10230_09s.img	-43	35	0	78	79	98	99	100
Linton1	Linton1_LCC_k1000081_cp4618_09s.img	-23	27	-3	50	70	99	100	100
Minot1	Minot1_TM_k1000080_cp10127_09s.img	-24	29	0	53	58	96	100	100
NewTown1	NewTown1_LCC_k1000094_cp10227_09s.img	-23	23	-1	45	60	99	100	100
Oakes1	Oakes1_TM_k1000061_cp9820_09s.img	-16	11	0	27	98	100	100	100
xWatford2	xWatford2_CLL_k1000096_cp4748_09s.img	-31	33	0	63	68	96	98	100
xWilliston2	xWilliston2_TM_k1000090_cp10328_09s.img	-25	33	-3	58	65	99	100	100
All Combined	allZones_ND_Prelim2_Mosaic_ppm09s.img	-46	63	-1	108	68	97	99	100

Note: Linear distortion is derived at the topographic surface.

Distortion Values by Preliminary Zone - 2alt

(Zone names based on the most populous city in the zone)

Zone Name	Raster File	Distortion in parts per million (ppm)				Percent of Zone within...			
		Minimum	Maximum	Mean	Range	±10ppm	±20ppm	±25ppm	±30ppm
xBeulah2alt	xBeulah2alt_LCC_k1000081_cp4730_09s.img	-26	27	-3	52	80	99	100	100
Bismarck1	Bismarck1_LCC_k1000081_cp4649_09s.img	-37	43	0	80	58	86	93	98
Bottineau1	Bottineau1_LCC_k1000066_cp4836_09s.img	-30	49	0	79	75	96	99	99
xBowman2	xBowman2_LCC_k100013_cp4617_09s.img	-30	36	1	66	70	95	99	100
CannonBall1	CannonBall1_LCC_k1000093_cp4617_09s.img	-34	37	0	71	55	95	99	100
Carrington1	Carrington1_LCC_k1000072_cp473130_09s.img	-31	28	1	59	63	98	100	100
DevilsLake1	DevilsLake1_LCC_k1000056_cp4810_09s.img	-32	34	-6	66	54	98	100	100
Dickinson1	Dickinson1_LCC_k1000112_cp4700_09s.img	-46	32	-1	77	68	96	99	100
Fargo1	Fargo1_TM_k1000035_cp9718_09s.img	-40	35	-2	76	73	97	99	100
xHettinger2	xHettinger2_LCC_k1000115_cp4618_09s.img	-28	29	0	57	77	99	100	100
Jamestown1	Jamestown1_LCC_k1000067_cp4657_09s.img	-25	31	2	56	55	97	100	100
xKilldeer2	xKilldeer2_TM_k1000099_cp10230_09s.img	-43	35	0	78	79	98	99	100
Linton1	Linton1_LCC_k1000081_cp4618_09s.img	-23	27	-3	50	70	99	100	100
Minot1	Minot1_TM_k1000080_cp10127_09s.img	-24	29	0	53	58	96	100	100
NewTown1	NewTown1_LCC_k1000094_cp10227_09s.img	-23	23	-1	45	60	99	100	100
Oakes1	Oakes1_TM_k1000061_cp9820_09s.img	-16	11	0	27	98	100	100	100
xWatford2	xWatford2_CLL_k1000096_cp4748_09s.img	-31	33	0	63	68	96	98	100
xWilliston2	xWilliston2_TM_k1000090_cp10328_09s.img	-25	33	-3	58	65	99	100	100
All Combined	allZones_ND_Prelim2alt_Mosaic_ppm09s.img	-46	49	-1	94	67	96	99	100

Note: Linear distortion is derived at the topographic surface.

Additional Alternatives

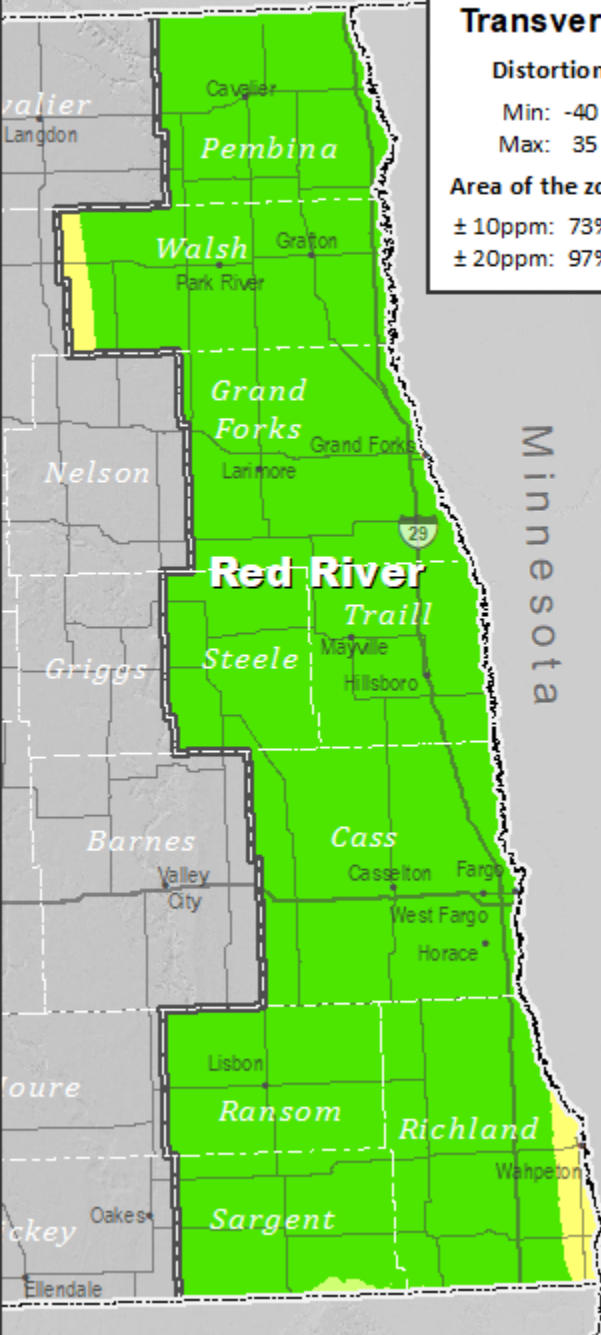
Option 1: Red River Transverse Mercator

Distortion Values (ppm)

Min: -40 Range: 76
Max: 35 Mean: -1.8

Area of the zone that is within:

± 10ppm: 73% ± 25ppm: 99%
± 20ppm: 97% ± 30ppm: 100%



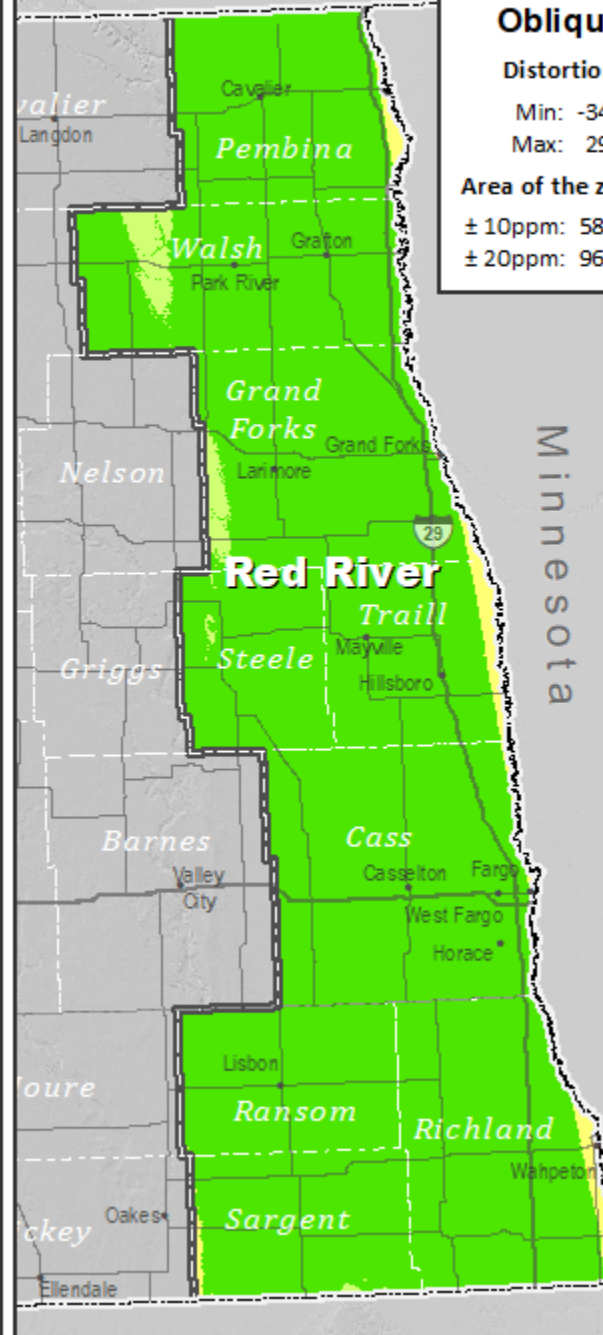
Option 2: Red River Oblique Mercator

Distortion Values (ppm)

Min: -34 Range: 63
Max: 29 Mean: -1.7

Area of the zone that is within:

± 10ppm: 58% ± 25ppm: 100%
± 20ppm: 96% ± 30ppm: 100%



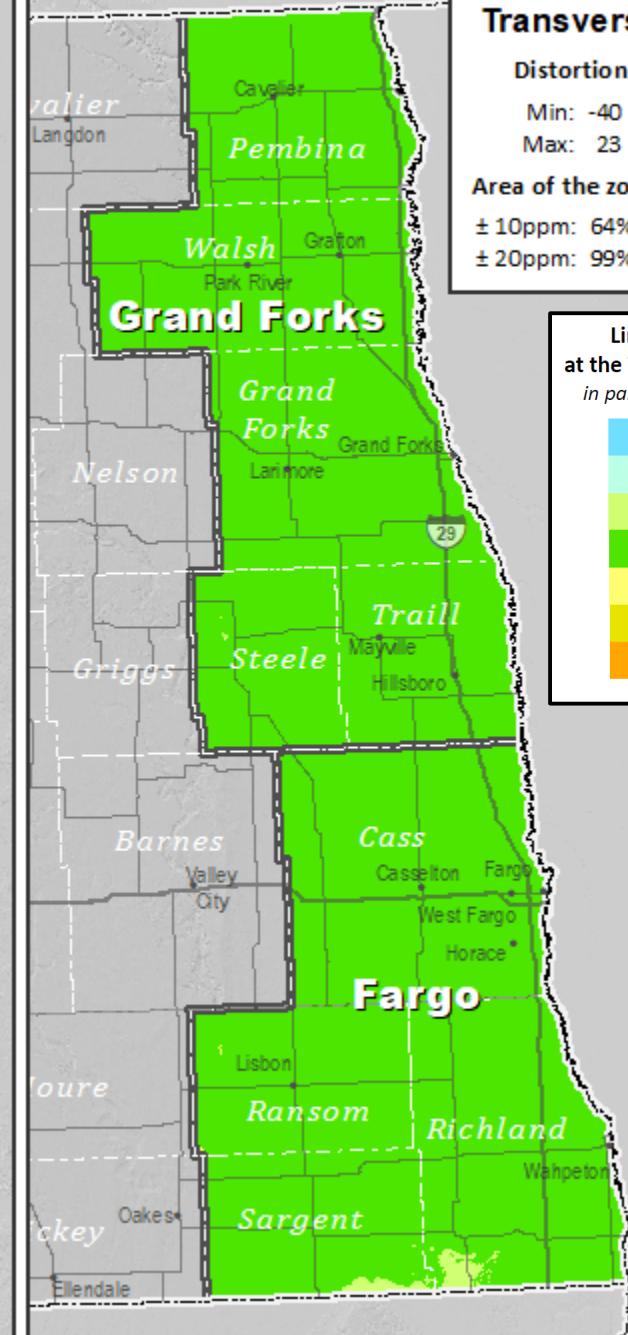
Option 3: Two Zones Transverse Mercator

Distortion Values (ppm)

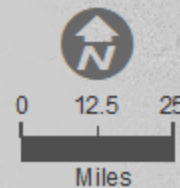
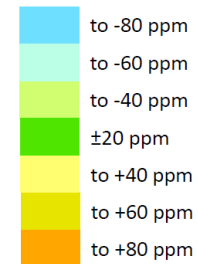
Min: -40 Range: 63
Max: 23 Mean: -4.6

Area of the zone that is within:

± 10ppm: 64% ± 25ppm: 100%
± 20ppm: 99% ± 30ppm: 100%

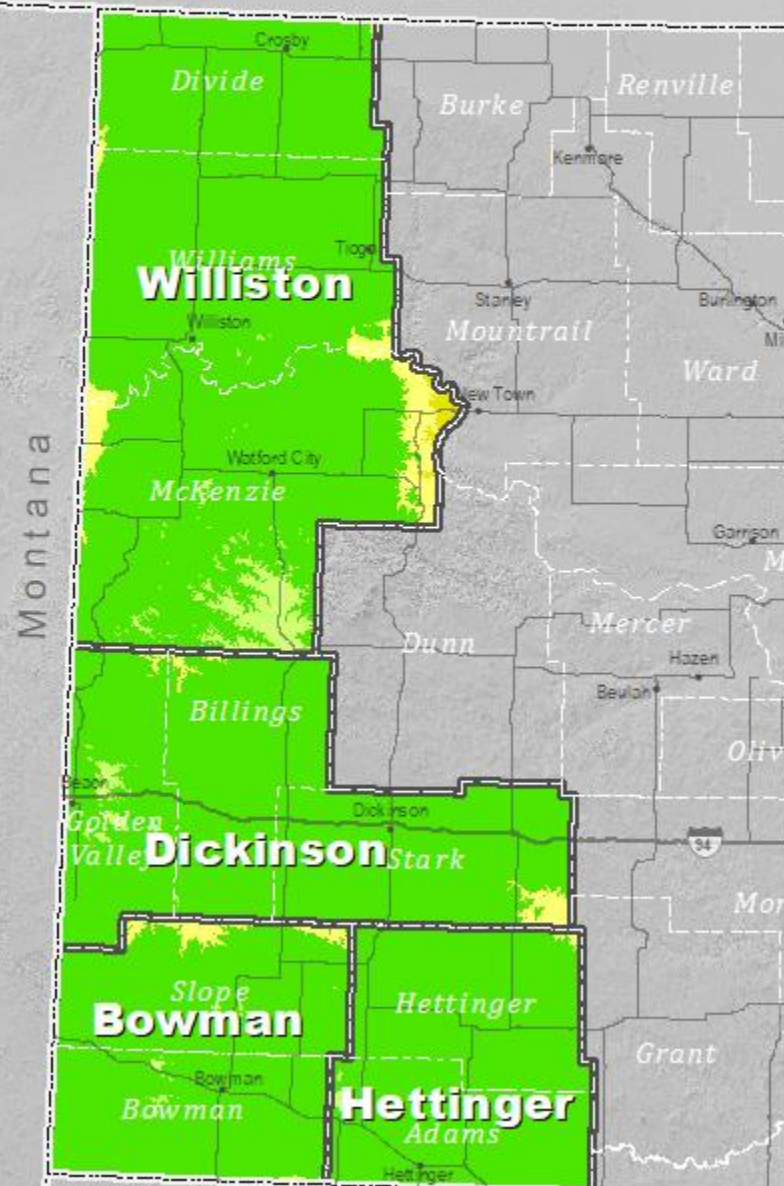


Linear Distortion
at the Topographic Surface
in parts per million (ppm)



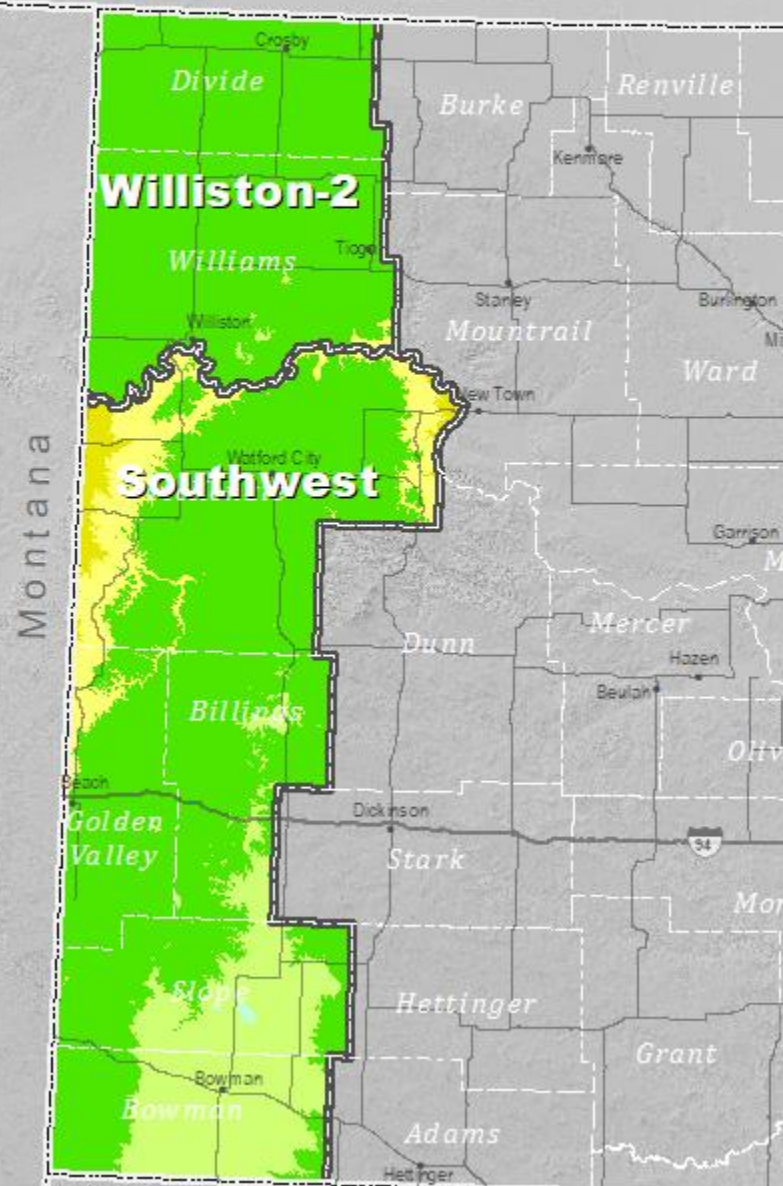
Option 1: Four Zones

Distortion Values (ppm)		Area of the zone that is within:	
Min: -46	Range: 108	±10ppm: 67%	±25ppm: 97%
Max: 62	Mean: -0.8	±20ppm: 94%	±30ppm: 99%



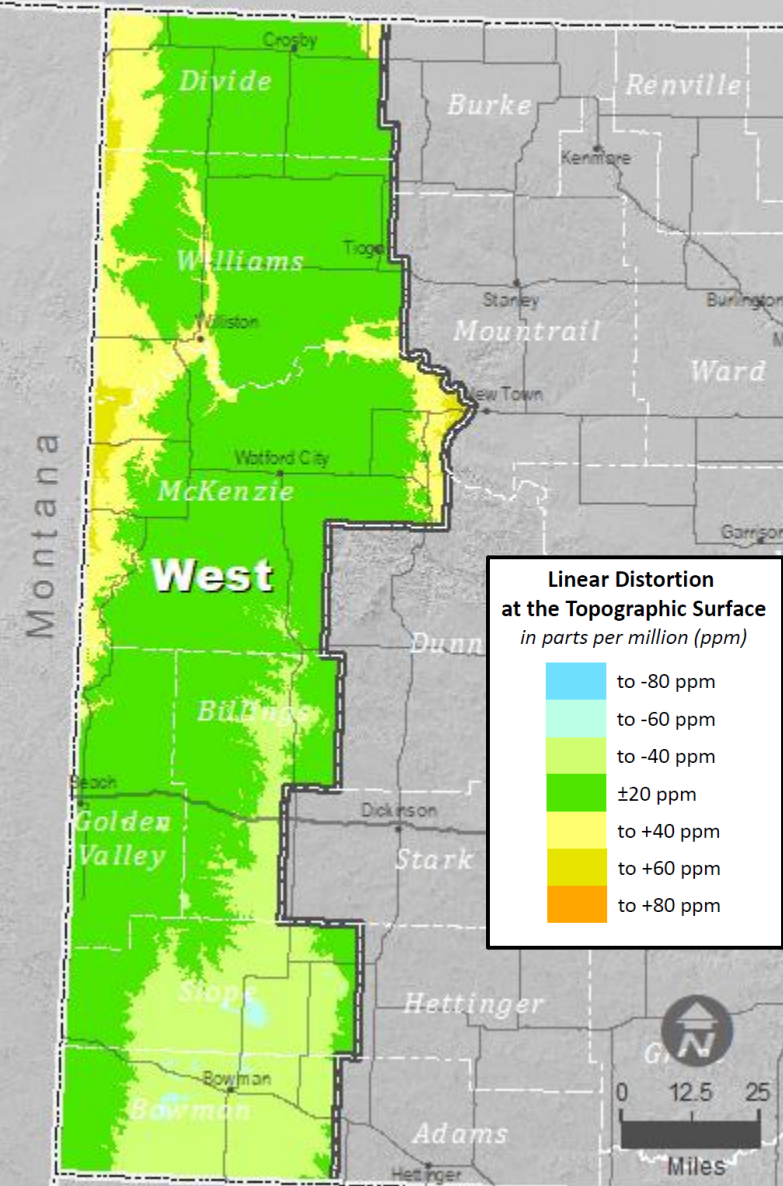
Option 2: Two Zones

Distortion Values (ppm)		Area of the zone that is within:	
Min: -54	Range: 118	±10ppm: 45%	±25ppm: 86%
Max: 64	Mean: -1.1	±20ppm: 77%	±30ppm: 93%



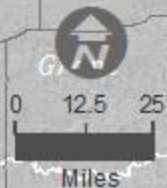
Option 3: One Zone

Distortion Values (ppm)		Area of the zone that is within:	
Min: -58	Range: 114	±10ppm: 42%	±25ppm: 79%
Max: 56	Mean: 0.1	±20ppm: 68%	±30ppm: 87%



Linear Distortion at the Topographic Surface in parts per million (ppm)

- to -80 ppm
- to -60 ppm
- to -40 ppm
- ±20 ppm
- to +40 ppm
- to +60 ppm
- to +80 ppm



Distortion Values by Zone

Option	Zone Name	Raster File	Distortion in parts per million (ppm)				Percent of Zone within...			
			Minimum	Maximum	Mean	Range	±10ppm	±20ppm	±25ppm	±30ppm
1 East	Red River TM	RedRiver_TM_k1000035_cp9718_09s.img	-40	35	-1.8	76	73	97	99	100
2 East	Red River OM	RedRiver_OM_k1000037_cp4727-9727_09s.img	-34	29	-1.7	63	58	96	100	100
3 East	Fargo-GrandForks	Fargo-GrandForks_ND_PreFinalAlt_Mosaic_ppm09s.img	-40	23	-4.6	63	64	99	100	100
3 East	Fargo	Fargo_TM_k1000032_cp9712_09s.img	-40	23	-5.8	63	56	98	100	100
3 East	GrandForks	GrandForks_TM_k1000034_cp9724_09s.img	-21	21	-3.7	42	71	100	100	100
1 West	Option 1	Opt1_West4Zones_Mosaic_ppm09s.img	-46	62	-0.8	108	67	94	97	99
1 West	Williston1	Williston1_TM_k1000092_cp10327_09s.img	-34	62	-1.4	96	62	91	95	98
1 West	Dickinson1	Dickinson1_LCC_k1000112_cp4700_09s.img	-46	32	-1.0	77	68	96	99	100
1 West	Bowman2	Bowman2_LCC_k100013_cp4617_09s.img	-30	36	0.5	66	70	95	99	99
1 West	Hettinger2	Hettinger2_LCC_k1000115_cp4618_09s.img	-28	29	0.2	57	77	99	100	100
2 West	Option 2	Opt2_West2Zones_Mosaic_ppm09s.img	-54	64	-1.1	118	45	77	86	93
2 West	Southwest	Southwest_TM_k1000107_cp10315_09s.img	-54	64	0.0	118	36	66	79	90
2 West	Williston2	Williston2_TM_k1000090_cp10328_09s.img	-25	33	-3.4	57	65	99	100	100
3 West	Option 3	West_TM_k1000103_cp10318_09s.img	-58	56	0.1	114	42	68	79	87

Note: Linear distortion is derived at the topographic surface.