University of Wisconsin-Extension

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EVALUATION OF NURE HYDROGEOCHEMICAL DATA FOR USE IN WISCONSIN GROUNDWATER STUDIES

by

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INTRODUCTION

Knowledge of the natural distribution of trace constituents (arsenic, lead, cadmium, and so forth) in Wisconsin groundwater is currently poor, yet information on the "background" concentrations of such constituents is frequently needed for many different types of groundwater investigations. A large data set (the National Uranium Resources Evaluation - NURE data) exists, containing thousands of geochemical analyses for groundwater in Wisconsin, but these data were not in useable form prior to this project. This project was undertaken to convert the data into a usable format and to evaluate the suitability of the data in defining the natural distribution of the approximately 50 constituents analyzed.

From 1974 to 1980, the United States Department of Energy and its predecessors systematically evaluated the uranium resources of the conterminous United States and Alaska. The earth-science research in the National Uranium Resource Evaluation (NURE) program sampled groundwater, lake water, and stream water on a 3-mile grid (one sample per 10 square miles) north of 44^0 latitude (figure 1 and figure 2). Sampling was undertaken on contract by the Oak Ridge National Laboratory. The data set contains analyses of groundwater samples from approximately 4000 sites.

Summary reports were prepared for the uranium-related variables (see reference list). Each report contains microfiche of the all the data. Geochemical parameters measured include: uranium by three methods, arsenic, selenium, silver, aluminum, boron, barium, beryllium, calcium, cerium, chloride, cobalt, chromium, copper, iron, lithium, magnesium, manganese, molybdenum, potassium, sodium, niobium, nickel, phosphorus, scandium, strontium, thorium, titanium, vanadium, yttrium, zinc, zirconium, sulfate, conductivity in lab, conductivity in field, dissolved oxygen, temperature, pH, total alkalinity, M alkalinity, P alkalinity, location in latitude and longitude, topographic quadrangle, surface geologic unit, type of well, casing, depth, use of well, frequency of pumping, owner of well, among several other variables. Map quadrangles at 1:250,000-scale include Green Bay, Eau Claire, Rice Lake, Iron Mountain, Ashland, Iron River, Escanaba (figure 1). Not all of these parameters were reported for each map area.

Subsequent studies by the Department of Energy included airborne radiometric and magnetic surveys, detailed uranium-based geochemical sampling, and detailed uranium endowment estimation.

PROJECT GOALS

The objectives of this project were to evaluate the utility of the NURE hydrogeochemical data set for use in groundwater studies in Wisconsin, and to demonstrate how this data set could be incorporated into a statewide groundwater data base.

Because Department of Energy policy did not permit refined analysis, Oak Ridge Laboratory was not permitted to prepare maps and statistical evaluations of the non-uranium related variables. At the time of data collection, Mudrey acted as liaison to Oak Ridge National Laboratory, the responsible organization for the collection and analysis of the data, and was able to request analysis of a few selected constituents. Areal differences in concentrations of some of the constituents were evident, suggesting that analysis of the data may not only

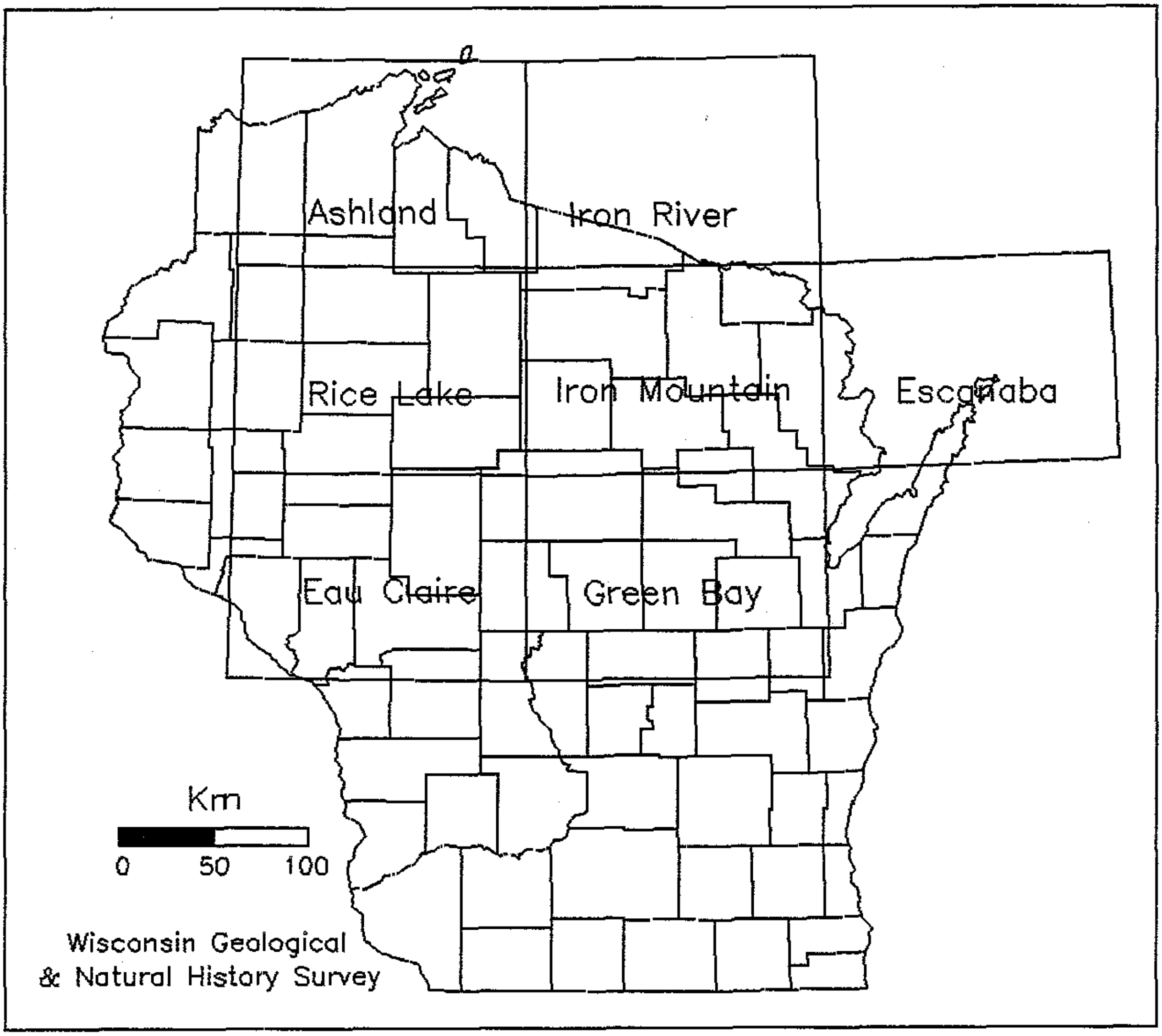


Figure 1 Index of quadrangle maps in NURE project

define ambient trace constituent water quality, but also define hydrogeologic provinces having significantly different ambient quality.

There is no other collection of ground-water quality data for Wisconsin that contains trace element data that are geographically well distributed over a large area (30,000 square miles) for which the data were collected and analyzed over a relatively short period of time using consistent sampling and analytical protocols. Samples were analyzed within a week of sampling, and all data in a map quadrangle were sampled within two months. This report will help to guide groundwater monitoring programs by assisting in the definition of ambient water quality, and defining the extent of naturally elevated values. More sophisticated evaluation of the data will permit the determination of whether or not these data should be incorporated into a larger Wisconsin groundwater quality data set.

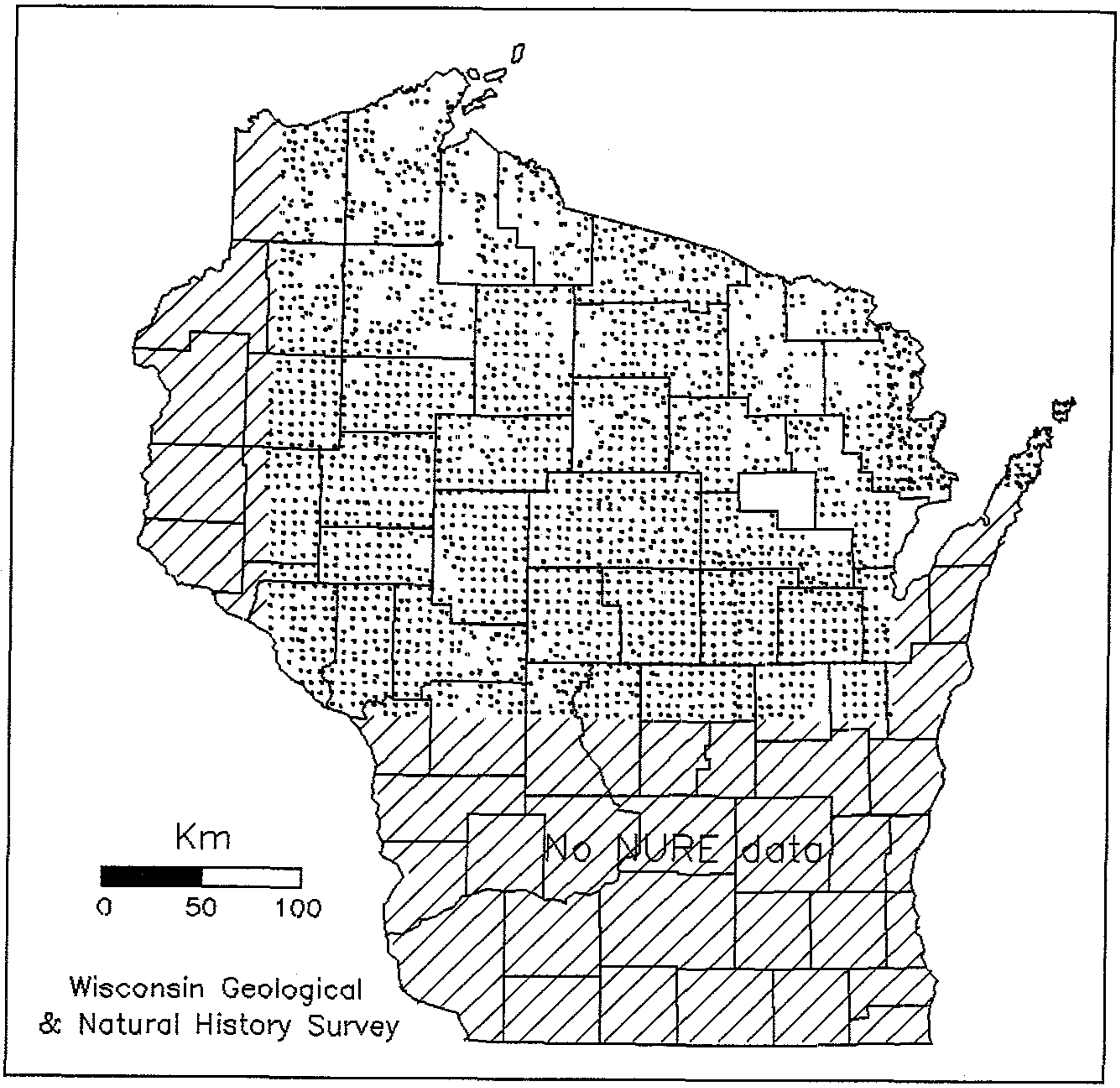


Figure 2 Map showing location of groundwater samples in Wisconsin in the NURE project.

METHODOLOGY

Seven magnetic data tapes were acquired from the U.S. Geological Survey or the Oak Ridge National Laboratory. A combination of U.S. Geological Survey and University of Wisconsin-Madison Computer Center equipment was used to convert the original data tapes to ASCII files. These files were loaded onto IBM-compatible microcomputers, and by a combination of software routines and database manipulations, converted into a microcomputer database. The files were cleaned where possible, and compared to the microfilm copy of the original dataset.

PRIMARY STATISTICS AND DATA MAPPING

Field samples were not generally acidified nor filtered, and as a result there may be differences with other survey data. As a consequence, each constituent must be evaluated separately, and consideration given to individual geochemical mobility, and details of the well from which the sample was taken. With these basic caveats in mind, basic statistical parameters for the ungrouped data were calculated and include mean (average), 95 percent confidence limit, standard deviation, skewness, kurtosis, maximum value (100th percentile), 90th percentile, median (50th percentile), 25th percentile, 10th percentile and minimum (0th percentile) and reported by the NCSS statistical package. NCSS (Number Cruncher Statistical System) is a copyrighted package of integrated statistical programs from NCSS, Kaysville, Utah. A refined analysis of data will require grouping the original data into sets with commonality, such as all wells producing from a particular horizon.

The mean is the arithmetic sum of all values for a constituent divided by the number of determinations. Samples at detection limit are assumed to have a value equal to the detection limit. The 95 percent confidence limit indicates that 95 percent of the data were within those values. Standard deviation is the square root of the variance which is the sum of the squares of the differences between each individual measurement and the mean divided by one less than the number of measurements. Kurtosis describes the degree to which the measured data distribution resemble a normal distribution. A normal distribution has a kurtosis value of zero; distributions with short tails have negative distributions; distributions with a lot of extreme values have a positive kurtosis. Skewness describes the symmetry of the natural distribution around the mean; positive values indicate an abundance high values compared to low values, and a negative skewness an abundance of low values compared to high values. The percentile values indicates what percent of the measurement s are less than the reported number. The 100th percentile is the maximum, and the 0th percentile is the minimum. The 50th percent is the value about which there is an equal number of measurements greater than and lesser than.

EVALUATION OF DATA

Usefulness of data varies considerably. For some constituents, the detection limit was sufficiently low that an acceptable data range was realized, and a geographic plot of the data has hydrogeologic meaning. For example, the arsenic geochemical map illustrates the geographic distribution of arsenic. Clearly, a naturally occurring arsenic province occurs in northern Outagamie County. The significance of that province is not known. For other data, detection limits were too high, for example scandium where only 49 measurements were above detection.

Values below detection in the original NURE dataset were designated by a negative value at the detection limit. For example, -40 represented that 40 ppb (parts per billion) was the detection limit, and that constituent for that sample was below detection. In our dataset, a flag column was created such that (in two columns) a value below a detection limit of 40 is coded as "<",40. In the original NURE dataset, missing data were coded as exceedingly large numbers (99999). In our dataset, such information is coded as null or missing.

CONSTITUENTS - DATA SUMMARY

The chemical constituents, analytical methods, detection limits, and first order statistical parameters are given below.

Constituents, analytical methods, detection limits

				<----Number of samples---->		
Constituent	Method	Detection Limit		Above Detection	Below Detection	Total
Ag	PSES	2	ppb	106	2629	2735
Al	PSES	10	ppb	528	2202	2730
As	AA	0.5	ppb	742	1996	2738
B	PSES	8	ppb	2630	105	2735
Ba	PSES	2	ppb	2620	115	2735
Be	PSES	1	ppb	108	2623	2731
Ca	PSES	0.1	ppm	2733	2	2735
Ce	PSES	30	ppb	32	123	155
Cl	SPEC	10	ppm	56	212	268
Co	PSES	2	ppb	442	2293	2735
Cr	PSES	4	ppb	122	2613	2735
Cu	PSES	2	ppb	1523	1212	2735
Fe	PSES	10	ppb	225	2509	2734
K	PSES	0.1	ppm	666	6	672
Li	PSES	4	ppb	1717	1018	2735
Mg	PSES	0.1	ppm	2728	7	2735
Mn	PSES	2	ppb	1810	925	2735
Mo	PSES	4	ppb	613	2122	2735
Na	PSES	0.1	ppm	2735	0	2735
Nb	PSES	4	ppb	456	2279	2735
Ni	PSES	4	ppb	353	2382	2735
P	PSES	40	ppb	345	2390	2735
Sc	PSES	1	ppb	49	2686	2735
Se	AA	0.2	ppb	1013	1725	2738
Si	PSES	0.1	ppb	667	0	667
SO_4	SPEC	5	ppm	1364	1366	2730
Sr	PSES	2	ppb	667	0	667
Th	PSES	2	ppb	472	2263	2735
Ti	PSES	2	ppb	55	2680	2735
U	FL	0.2	ppb	2007	727	2734
V	PSES	4	ppb	246	2489	2735
Y	PSES	1	ppb	764	1971	2735
Zn	PSES	4	ppb	2594	141	2735
Zr	PSES	2	ppb	98	2637	2735

Explanation

AA	Atomic absorption
FL	Fluorometry
PSES	Plasma source emission spectrometry
SPEC	Spectrophotometry
ppm	Parts per million
ppb	Parts per billion

Mean, confidence intervals, deviation, skewness kurtosis

		Mean	Confidence Interval		Standard	Skewness	Kurtosis
		(Average)	Lower 95%	Upper 95%	Deviation		
Ag	ppb	2.03	2.02	2.04	0.25	10.16	110.75
Al	ppb	15.93	10.91	20.94	133.72	47.63	2384.68
As	ppb	0.90	0.83	0.97	1.89	17.75	465.68
B	ppb	41.32	35.57	47.07	153.38	14.27	287.45
Ba	ppb	27.04	24.87	29.21	57.88	14.94	380.04
Be	ppb	1.02	1.00	1.03	0.31	35.59	1510.95
Ca	ppm	34.16	33.18	35.13	26.01	3.97	42.36
Ce	ppb	30.12	29.97	30.27	0.95	8.76	82.79
Cl	ppm	16.55	11.05	22.04	45.89	13.88	209.44
Co	ppb	2.94	2.36	3.52	15.49	38.02	1629.36
Cr	ppb	4.09	4.05	4.14	1.16	22.34	584.57
Cu	ppb	27.45	21.63	33.28	155.49	16.75	363.58
Fe	ppb	55.45	38.18	72.71	460.50	17.82	415.67
K	ppm	2.18	1.84	2.53	4.57	8.23	93.10
Li	ppb	4.35	3.81	4.90	14.48	29.45	1143.26
Mg	ppm	16.14	15.60	16.68	14.48	1.86	5.86
Mn	ppb	50.53	41.33	59.73	245.46	20.34	632.67
Mo	ppb	7.46	3.92	11.00	94.53	36.89	1361.47
Na	ppm	8.77	7.93	9.62	22.55	15.24	365.50
Nb	ppb	4.52	4.38	4.67	3.95	40.62	1932.08
Ni	ppb	5.26	4.49	6.02	20.32	41.49	1935.17
P	ppb	62.49	56.86	68.11	149.98	27.01	1055.37
Sc	ppb	1.01	1.00	1.01	0.16	36.17	1486.61
Se	ppb	0.29	0.27	0.30	0.40	12.32	211.22
Si	ppb	6.56	6.35	6.78	2.82	0.52	0.42
SO_4	ppm	14.15	11.73	16.57	64.42	30.68	1182.95
Sr	ppb	152.81	118.78	186.84	450.10	9.11	115.48
Th	ppb	9.92	9.73	10.11	5.03	6.51	71.55
Ti	ppb	7.97	1.02	14.92	185.57	42.91	2018.95
U	ppb	0.76	0.65	0.87	3.06	13.98	266.76
V	ppb	4.30	4.22	4.39	2.27	21.23	611.52
Y	ppb	1.09	1.05	1.13	1.00	26.50	834.89
Zn	ppb	281.69	254.71	308.68	720.03	9.97	173.60
Zr	ppb	2.58	1.75	3.41	22.11	50.00	2566.34

Percentile distributions

		100-%tile (Maximum)	90-%tile	75-%tile	50-%tile (Median)	25-%tile	10-%tile	0-%tile (Minimum)
Ag	ppb	5	2	2	2	2	2	2
Al	ppb	6768	15	10	10	10	10	1.659
As	ppb	59.2	1.4	0.5	1	1	1	0.5
B	ppb	4229	63	24	12	8	6	4
Ba	ppb	1826	56	28	14	6	3	2
Be	ppb	15	1	1	1	1	1	1
Ca	ppm	413.2	62.2	47.4	30.0	16.5	8.0	0.1
Ce	ppb	40	30	30	30	30	30	30
Cl	ppm	720	22	10	10	10	10	10
Co	ppb	708	2	2	2	2	2	2
Cr	ppb	40	4	4	4	4	4	4
Cu	ppb	4295	35	9	2	2	2	2
Fe	ppb	14140	10	10	10	10	10	0.729
K	ppm	69.5	3.8	1.8	1.0	0.7	0.5	0.1
Li	ppb	610	7	4	2	2	2	2
Mg	ppm	147.1	34.7	23.1	11.5	5.7	2.7	0.1
Mn	ppb	8841	92	18	3	2	2	2
Mo	ppb	3499	7	4	4	4	4	4
Na	ppm	694.9	16.7	8	4	2	2	0.2
Nb	ppb	194	5	4	4	4	4	4
Ni	ppb	978	4	4	4	4	4	4
P	ppb	6234	58	40	40	40	40	40
Sc	ppb	8	1	1	1	1	1	1
Se	ppb	10	0.4	0.3	0.2	0.2	0.2	0.1
Si	ppb	17.4	10.4	8.2	6.4	4.7	3.0	0.6
SO_4	ppm	2705	20	10	5	5	5	5
Sr	ppb	7387	269	98	49	28	20	2
Th	ppb	98	11	10	10	10	5	2
Ti	ppb	8983	2	2	2	2	2	2
U	ppb	74.53	1.46	0.44	0.12	0.02	0.02	0.02
V	ppb	82	4	4	4	4	4	4
Y	ppb	35	1	1	1	1	1	1
Zn	ppb	18182	663	242	80	24	8	4
Zr	ppb	1140	2	2	2	2	2	2

CONCLUSIONS

Hydrogeochemical parameters within the NURE groundwater dataset have mixed utility because in many cases the detection limit was too large to show much variation. Elements that appear to have broad utility with the NURE detection limit include: arsenic, barium, boron, calcium, copper, lithium, magnesium, manganese, sodium, selenium, sulfate, strontium, uranium, yttrium, zinc. Constituents whose detection limit is clearly inadequate include: silver, aluminum, beryllium, cobalt, chromium, iron, molybdenum, niobium,nickel, phosphorus, scandium, thorium, titanium, vanadium, and zirconium. In some areas of Wisconsin evaluation of these constituents may prove use full as that region may have elevated concentrations well above detection limit.

At the time the NURE program was cancelled, the Wisconsin Geological and Natural History Survey had developed a field protocol to continue the 3-mile sample grid into southern Wisconsin. Consideration should be given to extending the regional geochemical sampling concept of the NURE program. The present survey covers about the northern one-half of Wisconsin; similar data are lacking for southern Wisconsin.

Hydrogeochemical analysis should continue in order to understand and explain the regional variation of the chemical parameters.

During interrogation of the NURE data tapes, the stream and sediment data were also converted; however evaluation and analyses was not undertaken. A report similar to this, but using the surface water and stream sediment data could be undertaken at minimal cost.

REFERENCES

Arendt, J.W., and others, 1978, Hydrogeochemical and stream sediment reconnaissance basic data for Green Bay NTMS Quadrangle, Wisconsin: DOE Open-file Report GJBX-93 (78).

Arendt, J.W., and others, 1978, Hydrogeochemical and stream sediment reconnaissance basic data for Eau Claire NTMS Quadrangle, Wisconsin, Minnesota: DOE Open-file Report GJBX-94 (78).

Arendt, J.W., and others, 1978, Hydrogeochemical and stream sediment reconnaissance basic data for Rice Lake NTMS Quadrangle, Wisconsin: DOE Open-file Report GJBX-95 (78).

Arendt, J.W., and others, 1978, Hydrogeochemical and stream sediment reconnaissance basic data for Iron Mountain NTMS Quadrangle, Michigan, Wisconsin: DOE Open-File Report GJBX-97 (78).

Arendt, J.W., and others, 1979, Hydrogeochemical and stream sediment reconnaissance basic data for Ashland NTMS Quadrangle, Wisconsin, Michigan, Minnesota: DOE Open-file Report GJBX-61 (79).

Arendt, J.W., and others, 1980, Hydrogeochemical and stream sediment reconnaissance basic data for Iron River NTMS Quadrangle, Michigan, Wisconsin; DOE Open-file Report GJBX-115 (80).

Arendt, J.W., and others, 1981, Hydrogeochemical and stream sediment reconnaissance basic data for Escanaba Quadrangle, Michigan; Wisconsin: DOE open-file Report GJBX-218 (81).

Ferguson, R.B., Price, V., and Baucom, E.E., 1977a, Field manual for ground water reconnaissance: DOE Open-file Report GJBX-26(77), 72 p.

Ferguson, R.B., Price, V., and Baucom, E.E., 1977b, Field manual for stream sediment reconnaissance: DOE Open-file Report GJBX-30(77), 56 p.

Ferguson, R.B., Price, V., and Baucom, E.E., 1977cb, Field manual for stream water and sediment reconnaissance: DOE Open-file Report GJBX-80(77), 81 p.

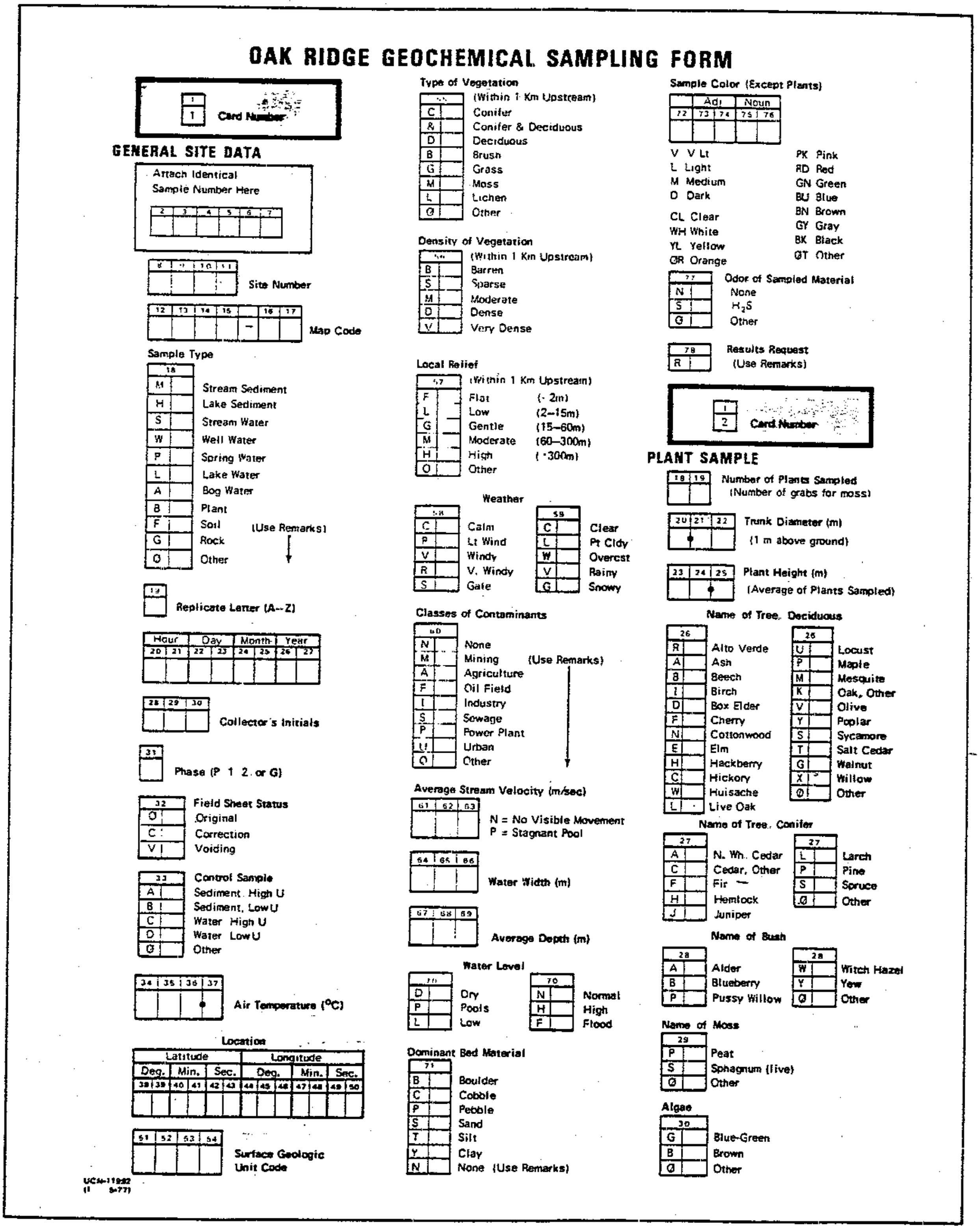
Kammerer, P.A., Jr., Ground-water-quality atlas of Wisconsin: Wisconsin Geological and Natural History Survey Information Circular 39, 39 p.

Oak Ridge Gaseous Diffusion Plant, 1980, Hydrogeochemical and stream sediment reconnaissance basic data reports compute program requests manual: DOE Open-file Report GJBX-21(80), 131 p.

Zinkl, R.J., D'Andrea, R.F., Jr., and Shettel, D.L., Jr., 1981, OREDIT: A Fortran computer program to process Oak Ridge HSSR data: DOE Open-file Report GJBX-10(81), 39 p.

APPENDIX 1 - Oak Ridge Geochemical Sampling Form

OAK RIDGE GEOCHEMICAL SAMPLING FORM
SHOWING FIELD DATA RECORDED ON MICROFICHE



OAK RIDGE GEOCHEMICAL SAMPLING FORM

Card Number (1): 1

GENERAL SITE DATA

Attach Identical Sample Number Here (2 3 4 5 6 7)

Site Number (8 9 10 11)

Map Code (12 13 14 15 – 16 17)

Sample Type (18)

M	Stream Sediment
H	Lake Sediment
S	Stream Water
W	Well Water
P	Spring Water
L	Lake Water
A	Bog Water
B	Plant
F	Soil (Use Remarks)
G	Rock
O	Other

Replicate Letter (A--Z) (19)

Hour		Day		Month		Year	
20	21	22	23	24	25	26	27

Collector's Initials (28 29 30)

Phase (P 1 2. or G) (31)

Field Sheet Status (32)

O	Original
C	Correction
V	Voiding

Control Sample (33)

A	Sediment. High U
B	Sediment, Low U
C	Water High U
D	Water Low U
O	Other

Air Temperature (°C) (34 35 36 • 37)

Location

Latitude						Longitude						
Deg.		Min.		Sec.		Deg.			Min.		Sec.	
38	39	40	41	42	43	44	45	46	47	48	49	50

Surface Geologic Unit Code (51 52 53 54)

UCN-11932
(1 9-77)

Type of Vegetation (Within 1 Km Upstream)

C	Conifer
&	Conifer & Deciduous
D	Deciduous
B	Brush
G	Grass
M	Moss
L	Lichen
O	Other

Density of Vegetation (Within 1 Km Upstream)

B	Barren
S	Sparse
M	Moderate
D	Dense
V	Very Dense

Local Relief (57) (Within 1 Km Upstream)

F	Flat	(- 2m)
L	Low	(2–15m)
G	Gentle	(15–60m)
M	Moderate	(60–300m)
H	High	(·300m)
O	Other	

Weather

58		59	
C	Calm	C	Clear
P	Lt Wind	L	Pt Cldy
V	Windy	W	Overcst
R	V. Windy	V	Rainy
S	Gale	G	Snowy

Classes of Contaminants (60) (Use Remarks)

N	None
M	Mining
A	Agriculture
F	Oil Field
I	Industry
S	Sewage
P	Power Plant
U	Urban
O	Other

Average Stream Velocity (m/sec) (61 62 63)
N = No Visible Movement
P = Stagnant Pool

Water Width (m) (64 65 66)

Average Depth (m) (67 68 69)

Water Level

70		70	
D	Dry	N	Normal
P	Pools	H	High
L	Low	F	Flood

Dominant Bed Material (71)

B	Boulder
C	Cobble
P	Pebble
S	Sand
T	Silt
Y	Clay
N	None (Use Remarks)

Sample Color (Except Plants)

	Adj		Noun	
72	73	74	75	76

V	V Lt	PK	Pink
L	Light	RD	Red
M	Medium	GN	Green
D	Dark	BU	Blue
CL	Clear	BN	Brown
WH	White	GY	Gray
YL	Yellow	BK	Black
OR	Orange	OT	Other

Odor of Sampled Material (77)

N	None
S	H_2S
O	Other

Results Request (78) (Use Remarks)

R	

Card Number (1): 2

PLANT SAMPLE

Number of Plants Sampled (Number of grabs for moss) (18 19)

Trunk Diameter (m) (1 m above ground) (20 • 21 22)

Plant Height (m) (Average of Plants Sampled) (23 24 • 25)

Name of Tree, Deciduous

26		26	
R	Alto Verde	U	Locust
A	Ash	P	Maple
B	Beech	M	Mesquite
I	Birch	K	Oak, Other
D	Box Elder	V	Olive
F	Cherry	Y	Poplar
N	Cottonwood	S	Sycamore
E	Elm	T	Salt Cedar
H	Hackberry	G	Walnut
C	Hickory	X	Willow
W	Huisache	O	Other
L	Live Oak		

Name of Tree, Conifer

27		27	
A	N. Wh. Cedar	L	Larch
C	Cedar, Other	P	Pine
F	Fir	S	Spruce
H	Hemlock	O	Other
J	Juniper		

Name of Bush

28		28	
A	Alder	W	Witch Hazel
B	Blueberry	Y	Yew
P	Pussy Willow	O	Other

Name of Moss (29)

P	Peat
S	Sphagnum (live)
O	Other

Algae (30)

G	Blue-Green
B	Brown
O	Other

STREAM OR LAKE SEDIMENT

Sample Condition

31	
D	Dry
W	wet

Sample Treatment

32	
N	None
S	Sieved
0	Other

33	34	
		Number of Grabs

36	36	
	•	% Organic Material (Field Estimate)

GENERAL WATER SAMPLES

Water Sample Treatment

37	
N	None
F	Filtered Only
C	Acidified Only
A	Acidified and Filtered
0	Other

Depth of Visibility (m)

38	39	40	
			C = Clear

41	42	43	44	45	
				•	Conductivity (μmhos/cm)

46	47	48	
	•		Dissolved O_2 (ppm)

49	50	51	
	•		Temperature (°C)

52	53	54	
	•		pH

55	
P	pH by Lo-Ion Paper

56	57	58	59	
			•	Total Alkalinity (ppm)

60	61	62	63	
			•	P Alkalinity (ppm)

64	65	66	67	
			•	M Alkalinity (ppm)

Appearance of Water

68	
C	Clear
M	Murky
A	Algal
0	Other

69	70	71	72	73	
					Discharge (liters/min)

74	75	76	77	
				Identification of Producing Horizon (Geologic Unit Code)

Confidence of Producing Horizon Identification

78	
H	High Degree
R	Probable
S	Possible

Source of Producing Horizon Identification

79	
P	Publication
W	Owner
U	User
G	Geologic Inference
0	Other

1	
3	Card Number

WELL WATER

Type of Well

18	
D	Drilled
P	Drive Point
G	Dug
U	Unknown
0	Other

Power Classification

19	
A	Artesian Flow
E	Electric
G	Gasoline
W	Wind
H	Hand
0	Other

Casing

20	
N	None (Below Water Table)
S	Steel
G	Galvanized
P	Plastic
U	Unknown
0	Other

Pipe Composition

21	
F	Steel
Z	Galvanized
C	Copper
P	Plastic
U	Unknown
0	Other

Sample Location

22	23	24	
		•	Meters from Well Head H = Holding Tank (Use Remarks)

Where Sample Taken With Respect To Pressure Tank

25	
B	Before
A	After
N	No Pressure Tank
F	From Pressure Tank (Use Remarks)

Use of Well

26	
M	Municipal
H	Household
S	Stock
I	Irrigation
A	All of above
X	H and S
Y	H and I
Z	S and I
N	None
O	Other

Frequency of Pumping

27	
C	Constant (hourly)
F	Frequent (daily)
I	Infrequent (weekly)
R	Rare (no recent use)

Depth to top of Producing Horizon

28	29	30	31	
			•	(Meters)

Confidence of Producing Depth

32	
H	High
R	Probable
S	Possible

Source of Producing Depth Information

33	
P	Publication
W	Owner
U	User
G	Geologic Inference
0	Other

Total Well Depth

34	34	36	37	
			•	(Meters)

Confidence of Total Depth

38	
H	High
R	Probable
S	Possible

Source of Total Depth Information

39	
P	Publications
W	Owner
U	User
G	Geologic Inference
O	Other

LAKE WATER

Type of Lake

55	
N	Natural
M	Manmade

Lake Area

56	57	58	59	
				(sq km)

REMARKS (Card 4)

APPENDIX 2 - AVAILABILITY OF DATA

FORMAT

The data are available on a single 5 1/4-inch double density computer disk. The information has been compressed, and a batch file on the disk expands the compressed data set into a comma-delimited file.

The procedure on the disk expands and recreates the ASCII data for the NURE hydrogeological groundwater data. It creates the following files:

```
ANALDAT  DEL    593938 06-23-93  14:13a
COUMAP   DEL     62566 06-23-93  14:12a
WELLPARM DEL    376367 06-23-93  14:13a
COMMENT  DEL    467017 06-23-93  14:12a
NURDATA  EXE    277086 06-23-93  14:22a (compressed file for disk)
README           16282 06-28-93  14:43a
```

Table ANALDAT.DEL consists of the chemical analytical data in comma-delimited form as follows:

SAMPLENO,AGFLAG,AG,ALFLAG,AL,ASFLAG,AS,BFLAG,B,BAFLAG,BA,BEFLAG,BE,CAFLAG,CA,CEFLAG,CE,CLFLAG,CL,COFLAG,CO,CRFLAG,CR,CUFLAG,CU,FEFLAG,FE,KFLAG,K,LIFLAG,LI,MGFLAG,MG,MNFLAG,MN,MOFLAG,MO,NAFLAG,NA,NBFLAG,NB,NIFLAG,NI,PFLAG,P,SCFLAG,SC,SEFLAG,SE,SO4FLAG,SO4,SRFLAG,SR,SIFLAG,SI,THFLAG,TH,TIFLAG,TI,U_METHOD,UFLAG,U,VFLAG,V,YFLAG,Y,ZNFLAG,ZN,ZRFLAG,ZR

Table WELLPARM.DEL consists of the general well parameters in comma-delimited form as follows:

SAMPLENO,TYPE,UNIT,CONTAM,DATE,LATITUDE,LNGITUDE,LABCOND,H2OTEMP,pHMETER,FIELDCND,TOTALALK,PALK,MALK,HUNIT,CONFUNIT,SRCEUNIT,DO,WELLTYPE,WELLPOWR,CASING,PIPECOMP,SAMPLOC,WELLUSE,DEPTWPH,CFDEPWPH,SRCEDWPH,CONFWLDP,SRCEWLDP,WELLDEPT

Table COMMENTS.DEL consists of the comments in comma-delimited form as follows:

SAMPLENO,COMMENTS

COMMENTS include information on the specific sample location (feet from a reference features), name and address of well owner, place within the plumbing system from which the sample was taken, and so forth. In addition, we determined the two-degree map sheet and county in which the measurements were made.

Table COUMAP.DEL consists of the comments in comma-delimited form as follows:

SAMPLENO,QUADNAME,COUNTY

FIELDS

The variables and the acronyms used in the original NURE dataset and our database are presented below.

Column name	Column description
AG	Concentration of silver in ppb
AGFLAG	If set indicates that silver was below detection of 2 ppb
AL	Concentration of aluminum in ppb
ALFLAG	If set indicates that aluminum was below detection of 10 ppb
AS	Concentration of arsenic in ppb
ASFLAG	If set indicates that arsenic as below detection of 0.5 ppb
B	Concentration of boron in ppb
BA	Concentration of barium in ppb
BAFLAG	If set indicates that barium was below detection of 2 ppb
BE	Concentration of beryllium in ppb
BEFLAG	If set indicates that beryllium was below detection of 1 pbb
BFLAG	If set indicates that boron was below detection of 8 ppb
CA	Concentration of calcium in ppm
CAFLAG	If set indicates that calcium was below detection of 0.1 ppm
CASING	Primary material of the well casing: N, none; S, steel; G, galvanized; P, plastic; U, unknown; O, other
CE	Concentration of cerium in ppb
CEFLAG	If set indicates that cerium was below detection of 30 ppb
CFDEPWPH	Confidence which the field personnel had in the recorded depth from which the well was producing: (H) high, (R) probable, (S) possible
CL	Elemental concentration of chlorine in ppm
CLFLAG	If set indicates that chlorine was below detection of 10 ppm
CO	Concentration of cobalt in ppb
COFLAG	If set indicates that cobalt was below detection of 2 ppb
COMMENTS	Any comments on sample, may include name and address of owner, topographic quadrangle, additional notes on sample location
COUNTY	Name of county in which sample was taken
CONFUNIT	Confidence in the identification of the hydrogeology unit as the site: H, high; R, probable; S, possible
CONFWLDP	Confidence that field personnel has in the recorded depth of the well: H, high; R, probable, S, possible
CONTAM	Classes of contaminants in the vicinity of the sample site: (N) none; (M) mining; (A) agriculture; (I) industry; (U) urban; (O) other
CR	Concentration of chromium in ppb
CRFLAG	If set indicates that chromium was below detection of 4 ppb
CU	Concentration of copper in ppb
CUFLAG	If set indicates that copper was below detection of 2 ppb
DATE	Date on which the sample was taken: YYMMDD
DEPTWPH	Depth to the top of the producing horizon
DO	Concentration of dissolved oxygen in ppm
FE	Concentration of iron in ppb
FEFLAG	If set indicates that iron was below detection of 10 ppb
FIELDCND	Conductivity of the sample, measured in the field in micromhos per centimeter
H2OTEMP	Temperature in degrees celsius of the water sample at the time of sampling
HUNIT	Identification of the hydrogeologic unit from the sample well: CS, Cambrian St Croixan sandstone; OG, Sinnipee Group; OP, Ordovician

	Prairie du Chien Group; ORS, Ordovician Bay de Noc Dolomite, Ogontz Dolomite, Bill Hill Dolomite, Bills Creek Dolomite; OS Ordovician Ancell Group; OSP, Ordovician St. Peter Formation; PCA, Proterozoic Amberg gray quartz monzonite; PCAN, Proterozoic anothosite; PCAP, Proterozoic aplite; PCAT, Proterozoic Athelstane pink quartz monzonite; PCBG, Proterozoic Belongia granite; PCBV, Proterozoic Beecher felsic metavolcanic rock; PCCV, Middle Proterozoic Chengwatana Volcanic Group; PCDG, Proterozoic Dunbar gneiss; PCDI, Proterozoic mafic intrusive, diorite and quartz diorite; PCET, Archean granite gneiss; PCFD, Middle Proterozoic Fond du Lac Formation; PCFV, Proterozoic felsic metavolcanic and metavolcaniclastic rock; PCGA, Archean magmatic gneiss and amphibolite; PCGB, undifferentiated Early Proterozoic mafic rock; PCGH, Proterozoic Granite Heights granite; PCGN, Early Proterozoic gneiss; PCGR, Archean granite; PCGU, Proterozoic granitic to dioritic gneiss; PCHG, Proterozoic Hogarty hornblende granite; PCHL, Proterozoic Hoskins Lake granite; PCHR, Proterozoic Hager rhyolite; PCHY, Proterozoic Hager syenite; PCIB, Proterozoic intrusive breccia complex; PCIM, undifferentiated Early Proterozoic felsic rock; PCKA, Middle Proterozoic rock; PCKM, Proterozoic Kalinke quartz monzonite; PCLG, Protrozoic leucogranite; PCMC, Middle Proterozoic Mellen Intrusive Complex; PCMD, Proterozoic Marinette quartz diorite; PCMM, undifferentiated Proterozoic mafic metavolcanic rock; PCMS, Proterozoic Michigamme Slate; PCMV, Proterozoic mafic metavolcanic rock; PCMY, Proterozoic mylonite; PCND, Proterozoic Newingham granodiorite; PCNG, Proterozoic Ninemile Granite; PCPL, Middle Proterozoic Portage Lake Volcanic Group; PCPR, Proterozoic Riverton Iron-formation; PCPU, Proterozoic Paint River Group; PCQM, Archean Quinnesec mafic metavolcanic rock; PCQS, Proterozoic quartz syenite; PCQT, undifferentiated Early Proterozoic sedimentary rock; PCRF, Proterozoic metavolcanic rock; PCRK, undifferentiated Precambrian granite and undifferentiated igneous and metamorphic rock; PCRL, Precambrian red lithic sandstone; PCRM, Proterozoic Red River porphyritic quartz monzonite; PCSC, undifferentiated Proterozoic metasedimentary rock and schist; PCSG, Archean Stevens Point gray granite; PCSL, Early Proterozoic slate; PCSV, Precambrian metamorphosed sedimentary and metavolcanic rock; PCSY, Proterozoic syenite and nepheline syenite; PCTF, Proterozoic Twelve Foot Falls quartz diorite; PCTY, Proterozoic Tyler Formation; PCWM, Proterozoic Waupaca quartz monzonite; PCWR, Proterozoic Wolf River hornblende granite and quartz monzonite; QAL, Quaternary alluvium; QGO, Quaternary glacial outwash, gravel and sand; QGT, Quaternary till, stratified moraine deposits; QPG, undifferentiated glacial deposits; SND, Silurian dolomite
ID	Alphanumeric identifier (equals M + sample number)
K	Concentration of potassium in ppm
KFLAG	If set indicates that potassium was below detection of 0.1 ppm
LABCOND	Conductivity of the sample measured in the laboratory in micromhos per centimeter
LATITUDE	Latitude of the specific sample site
LI	Concentration of lithium in ppb
LIFLAG	If set indicates that lithium was below detection of 4 ppb
LNGITUDE	Longitude of the specific sample site
MALK	Amount of reagent B required to neutralize the acid in a water sample that has first been treated with phenolphthalein and titrated with reagent B (PALK). It should be approximately equal to the total alkalinity (TALK) of the sample

MG	Concentration of magnesium in ppm
MGFLAG	If set indicates that magnesium was below detection of 0.1 ppm
MN	Concentration of manganese in ppb
MNFLAG	If set indicates that manganese was below detection of 2 ppb
MO	Concentration of molybdenum in ppb
MOFLAG	If set indicates that molybdenum was below detection of 4 ppb
NA	Concentration of sodium in ppm
NAFLAG	If set indicates that sodium was below detection of 0.1 ppm
NB	Concentration of niobium in ppb
NBFLAG	If set indicates that silver was below detection of 4 ppb
NI	Concentration of nickel in ppb
NIFLAG	If set indicates that nickel was below detection of 4 ppb
P	Concentration of phosphorus in ppb
PALK	Phenolphthalein alkalinity measured by titration with 0.02 N sulfuric acid to a phenolphthalein indicator endpoint (pH=8.3). Reported as an equivalent amount of $CaCO_3$ in ppm; minimum detection 20 ppm
PFLAG	If set indicates that silver was below detection of 40 ppb
pHMETER	pH of the sample as read from a meter
PIPECOMP	Composition of the pipe from which the sample was taken: F, steel; Z, galvanized; C, copper; P, plastic; U, unknown; O, other
QUADNAME	Name of the NTMS 2-degree map sheet that includes the sample site
SAMPLENO	Oak Ridge sample identification number
SAMPLOC	Point in the well system at which the sample was collected with respect to the storage or pressure tank: B, before; A, after; N, no pressure tank; F, from pressure tank
SC	Concentration of scandium in ppb
SCFLAG	If set indicates that scandium was below detection of 1 ppb
SE	Concentration of selenium in ppb
SEFLAG	If set indicates that selenium was below detection of 0.2 ppb
SI	Concentration of silicon in ppm
SIFLAG	If set indicates that silicon was below detection of 0.1 ppm
S04	Concentration of sulfate in ppm
S04FLAG	If set indicates that sulfate was below detection of 5 ppm
SR	Concentration of strontium in ppb
SRCEDWPH	Identifies the source of information about the depth to the top of the producing horizon for a well from which a sample has been collected: P, publication; W, owner; U, user; G, geologic inference; O, other
SRCEUNIT	Indicates the source of the information for the hydrogeologic unit at the sample site: P, publication; W, owner; U, user; G, geologic inference; O, other
SRCEWLDP	Identifies the source of information about the depth of the well: P, publication; W, owner; U, user; G, geologic inference; O, other
SRFLAG	If set indicates that strontium was below detection of 2 ppb
TH	Concentration of thorium in ppb
THFLAG	If set indicates that thorium was below detection of 2 ppb
TI	Concentration of titanium in ppb
TIFLAG	If set indicates that titanium was below detection of 2 ppb
TOTALALK	Measure of the substances in the water that neutralize acid. total alkalinity expressed as m of 0.02 N sulfuric acid required (milli-equivalents per liter) to titrate to a pH of 4.5 (endpoint for bromocresol-green/methyl-red indicator solution)
TYPE	Type of sample: W, well water; P, spring water
U	Concentration of uranium in ppb
UFLAG	If set indicates that uranium was below detection of 0.2 ppb

U-METHOD	Describes the method used to analyze for uranium: 0, not analyzed (4 samples); 1, fluorometry (2536 samples); 2, mass spectrometry (195 samples); 5, fluorometry (3 samples) - note samples originally described as sediment are actually spring samples
UNIT	Hydrogeologic bedrock unit at the sample site: CS, Cambrian St.Croixan sandstone; OG, Sinnipee Group; OP, Ordovician Prairie du Chien Group; ORS, Ordovician Bay de Noc Dolomite, Ogontz Dolomite, Bill Hill Dolomite, Bills Creek Dolomite; OS Ordovician Ancell Group; PCA, Proterozoic Amberg gray quartz monzonite; PCAN, Proterozoic anothosite; PCAP, Proterozoic aplite; PCAT, Proterozoic Athelstane pink quartz monzonite; PCBG, Proterozoic Belongia granite; PCBM, Proterozoic Michigamme Slate; PCBV, Proterozoic Beecher felsic metavolcanic rock; PCBX, Proterozoic Baraga Group; PCCV, Middle Proterozoic Chengwatana Volcanic Group; PCDG, Proterozoic Dunbar gneiss; PCDI, Proterozoic mafic intrusive, diorite and quartz diorite; PCFD, Middle Proterozoic Fond du Lac Formation; PCFV, Proterozoic felsic metavolcani and metavolcaniclastic rock; PCGA, Archean magmatic gneiss and amphibolite; PCGB, undifferentiated Early Proterozoic mafic rock; PCGH, Proterozoic Granite Heights granite; PCGN, Early Proterozoic gneiss; PCGR, Archean granite; PCGU, Proterozoic granitic to dioritic gneiss; PCHG, Proterozoic Hogarty hornblende granite; PCHL, Proterozoic Hoskins Lake granite; PCHR, Proterozoic Hager rhyolite; PCHY, Protrozoic Hager syenite; PCIB, Proterozoic intrusive breccia complex; PCIM, undifferentiated Early Proterozoic felsic rock; PCKA, Middle Proterozoic rock; PCKM, Proterozoic Kalinke quartz monzonite; PCLG, Protrozoic leucogranite; PCMC, Middle Proterozoic Mellen Intrusive Complex; PCMD, Proterozoic Marinette quartz diorite; PCME, Proterozoic metagabbro; PCMM, undifferentiated Proterozoic mafic metavolcanic rock; PCMQ, McCaslin Quartzite; PCMS, Proterozoic Michigamme Slate; PCMT, Proterozoic mafic tuff; PCMV, Proterozoic mafic metavolcanic rock; PCMY, Proterozoic mylonite; PCND, Proterozoic Newingham granodiorite; PCNG, Proterozoic Ninemile Granite; PCPL, Middle Proterozoic Portage Lake Volcanic Group; PCPM, Proterozoic Peshtigo Monzonite; PCPU, Proterozoic Paint River Group; PCQM, Archean Quinnesec mafic metavolcanic rock; PCQS, Proterozoic quartz syenite; PCQT, undifferentiated Early Proterozoic sedimentary rock; PCRF, Proterozoic metavolcanic rock; PCRK, undifferentiated Precambrian granite and undifferentiated igneous and metamorphic rock; PCRL, Precambrian red lithic sandstone; PCRM, Proterozoic Red River porphyritic quartz monzonite; PCSC, undifferentiated Proterozoic metasedimentary rock and schist; PCSG, Archean Stevens Point gray granite; PCSL, Early Proterozoic slate; PCSV, Precambrian metamorphosed sedimentary and metavolcanic rock; PCSY, Proterozoic syenite and nepheline syenite; PCTF, Proterozoic Twelve Foot Falls quartz diorite; PCTY, Proterozoic Tyler Formation; PCWM, Proterozoic Waupaca quartz monzonite; PCWR, Proterozoic Wolf River hornblende granite and quartz monzonite; PCWV, Proterozoic Waupee metavolcanic and volcaniclastic rock; QAL, Quaternary alluvium; QGO, Quaternary glacial outwash, gravel and sand; QGT, Quaternary till, stratified moraine deposits; QPG, undifferentiated glacial deposits; SND, Silurian dolomite
V	Concentration of vanadium in ppb
VFLAG	If set indicates than vanadium was below detection of 4 ppb
WELLDEPT	Depth of the well
WELLPOWR	Source of energy used at the well: A, artesian flow; E, electricity; G, gasoline; W, wind; H, hand pump; O, other

WELLTYPE	Type of well: D, driller; P, driven point; G, dug; U, unknown; O, other
WELLUSE	Most typical use of the well from which a water sample was obtained: M, municipal; H, household; S, stock; I, irrigation; A, all of above; X, H and S;Y, H and I; N, none; O, other
Y	Concentration of Yttrium in ppb
YFLAG	If set indicates that yttrium was below detection of 1 ppb
ZN	Concentration of zinc in ppb
ZNFLAG	If set indicates that zinc was below detection of 4 ppb
ZR	Concentration of zirconium in ppb
ZRFLAG	If set indicates that zirconium was below detection of 2 ppb

AVAILABILITY

The diskette is available as Wisconsin Geological and Natural History Survey Open-file Report WOFR 93-2 from the Map and Publications Section, Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, Wisconsin 53705.

APPENDIX 3 - MAPS OF CONSTITUENTS

To assist in the preliminary interpretation of the information, maps of selected constituents are presented. In general, the lower 50 percent of measurements are not plotted, and increasing sized symbols are used to depict the 50th to 70th percentile, 70th to 85th percentile, 85th to 95th percentile, and the 95th to 100th percentile divisions. For some constitutes, 98 percent of the data were below detection (beryllium), whereas for others all data where above detection (pH).

Histograms were prepared for each of the geochemical parameters. In all cases, 20 bins or intervals were chosen, generally each with the size of the detection limit. The number of samples below the detection limit was not plotted, and if bins great than 20 times the detection limit were occupied, they were not plotted. Instead the number of measurements in those bins were tabulated in the histogram. The user is invited to replot the data from the database for more precise histograms.

Aluminum

Only 20 percent of the data were above detection limit of 10 ppb, and do not appear at this level of analysis to define any significant geochemical provinces.

Arsenic

A little more than 27 percent of data were above detection limit of 0.5 ppb, and clearly define a naturally occurring arsenic province along the Cambrian-Ordovician boundary in eastern Wisconsin. Areas of significantly elevated values occupy northwestern Outagamie County and adjacent areas. Data suggest that these anomalies originate in the lower part of the Ordovician section.

Barium

Most barium samples were above detection of 2 ppb and define two areas of elevated values, west of Lake Winnebago and in Taylor and Clark Counties.

Beryllium

About 4 percent of the beryllium samples were above detection limit of 1 ppb, and do not appear to define any large beryllium-rich geochemical provinces.

Boron

Most samples for boron were above detection limit of 8 ppb, and appear to define a boron-rich province east of Lake Winnebago. Boron is commonly associated with saline water, and helps to define the saline water province in Calumet and Brown Counties. The hydrochemical position of this anomaly coincides with project distribution of Saline Formation units between the Ordovician and Silurian rock units.

Calcium

Only 2 samples were below the detection limit of 0.1 ppm for calcium. Calcium-rich water is defined by dolomite bedrock aquifers in eastern Wisconsin and along with Mississippi River in western Wisconsin. The elevated band of calcium determinations in western Wisconsin through Taylor and adjacent counties is explained by well documented calcareous till and other glacial material. Calcium-rich till from the Green Bay lobe in northeastern Wisconsin does not appear to have significant calcium-geochemical anomalies, in part because of the greater degree of leaching of that till unit.

Cerium

Cerium was only determined in the Escanaba map area, and does not appear to define a cerium province.

Chromium

About 4 percent of the samples were above the detection limit of 4 ppb for chromium. No significant geochemical trends were defined.

Chloride

Chloride analyses were reports only for the Ashland, Iron River, and Escanaba map area. No clear trends were defined.

Cobalt

About 16 percent of the samples were above the cobalt detection limit of 2 ppb, and no clear geochemical trends were defined.

Copper

A little over half of the copper determinations were above the detection limit of 2 ppb. Because composition of the plumbing was not used as a data filter in this analysis, trends are not interpreted to have hydrogeochemical significance.

Iron

About 8 percent of the samples were above detection of 10 ppb for iron. There appears to be a clustering of elevated values in southeastern Shawano County and adjacent area.

There is a gross discrepancy between the NURE iron data and the summary prepared by Kammerer in which he reports 90 percent of samples exceeded 10 micrograms per liter (10 ppb). The NURE sample were not acidified, and precipitation and flocculation of hydrous iron oxides may well have occurred prior to filtration in the laboratory. The effect of possible sequestering of other heavy metals by the iron flocculant must be evaluated on a metal by metal basis.

Lithium

About 63 percent of the samples were above detection of 4 ppb for lithium. Lithium is geochemically similar to boron is distribution, and reflect the saline province east of Lake Winnebago.

Magnesium

Almost all samples where above detection limit of 0.1 ppm for magnesium. Most elevated magnesium data are probably related to dissolution of dolomite in bedrock or dolomite clasts in glacial material. Comparison of magnesium molality with calcium molality would help to define a magnesium versus a magnesium-calcium (dolomite) province.

Manganese

About 66 percent of samples were above detection limit of 2 ppb. There are no clearly defined manganese provinces at this level of data analysis.

Molybdenum

About 22 percent of the samples were above detection limit of 4 ppb for molybdenum. A molybdenum province that coincides with the arsenic province in Outagamie and adjacent counties is clearly defined.

Nickel

About 13 percent of the samples were above detection limit of 4 ppb for nickel. A clearly defined nickel province that spatially corresponds to the Outagamie arsenic province suggest that a polymetallic (As, Mo, Ni, Th, V) hydrogeochemical province exists in eastern Wisconsin and may relate to documented faults.

Niobium

About 17 percent of the samples were above detection limit of 4 ppb for niobium. There is no clearly defined geochemical trend in the data at this level of analysis.

Phosphorus

About 13 percent of the samples were above detection limit of 40 ppb for phosphorus, and almost all of those samples clearly define a natural phosphorus province in western Wisconsin. The producing horizon for these samples appears to be the Tunnel City Group, a well known phosphorus-bearing body of rock. This information suggests that elevated phosphorus may well occur in southern Wisconsin were Tunnel City units are the producing aquifer.

Potassium

Potassium was analyzed for only in the Ashland, Iron River, and Escanaba map areas, and almost all samples were above detection limit of 0.1 ppm. No trends appear evident.

Scandium

Only 49 of 2735 samples reported scandium above detection of 1 ppb.

Selenium

About 37 percent of samples were above detection of 0.2 ppb for selenium. There appears to be no clearly defined selenium province at this level of data analysis.

Silicon

Silicon was analyzed by plasma source emission spectrometry. Multiply Si by 2.1 to convert silicon (Si) to silica (SiO_2). Silicon was only determined in the Ashland, Iron River and Escanaba map area. There are no clearly defined trends.

Silver

About 4 percent of the samples were above detection of 2 ppb for silver. There appears to be no geochemical trends.

Sodium

All sodium determinations were above detection limit of 0.1 ppm. The largest sodium geochemical province corresponds with the saline province in eastern Wisconsin.

Strontium

Strontium was determined only for the Ashland, Iron River and Escanaba map area. There are no clearly defined geochemical trends.

Sulfate

Half of the sulfate determinations were above detection limit of 5 ppm. A large sulfate province is clearly defined around Lake Winnebago, and corresponds in part with the saline water province in Calumet County, but also is define west of Lake Winnebago in Winnebago and Outagamie Counties.

Thorium

About 17 percent of the samples were above detection limit of 2 ppb. A weak anomaly is defined in southeastern Shawano County.

Titanium

Only 55 samples where above the detection limit of 2 ppb for titanium. No clearly define hydrogeochemical provinces are evident.

Uranium

About 73 percent of the data were above detection limit of 0.2 ppb for uranium. A large, clearly defined uranium hydrogeochemical province is evident in the Shawano-Waupaca County area centers about Split Rock in Shawano County. This area has been of uranium exploration interest since the late 1940s and numerous bedrock occurrences of uranium are known. A weak uranium hydrogeochemical band is seen trending northwest to southeast from Rusk to Marathon County, and corresponds with the calcareous till of the most recent glaciation.

Vanadium

About 9 percent of the samples are above the detection limit of 4 ppb for vanadium. The clearly defined vanadium hydrogeochemical province in Shawano County is slightly north of the arsenic province in Outagamie County.

Yttrium

About 28 percent of the samples are above the detection limit of 1 ppb for yttrium. A weak hydrogeochemical province that corresponds with the vanadium and arsenic provinces in Shawano and Outagamie County is defined.

Zinc

Almost all samples were above detection limit of 4 ppb for zinc. Because composition of the plumbing was not used as a data filter in this analysis, trends are not interpreted to have hydrogeochemical significance.

Zirconium

Only 98 samples were above the detection limit of 2 ppb for zirconium. There is no clearly defined hydrogeochemical trends defined.

Dissolved Oxygen

Most groundwater dissolved oxygen is below 6 ppm with no clearly defined trends at this level of data analysis.

pH

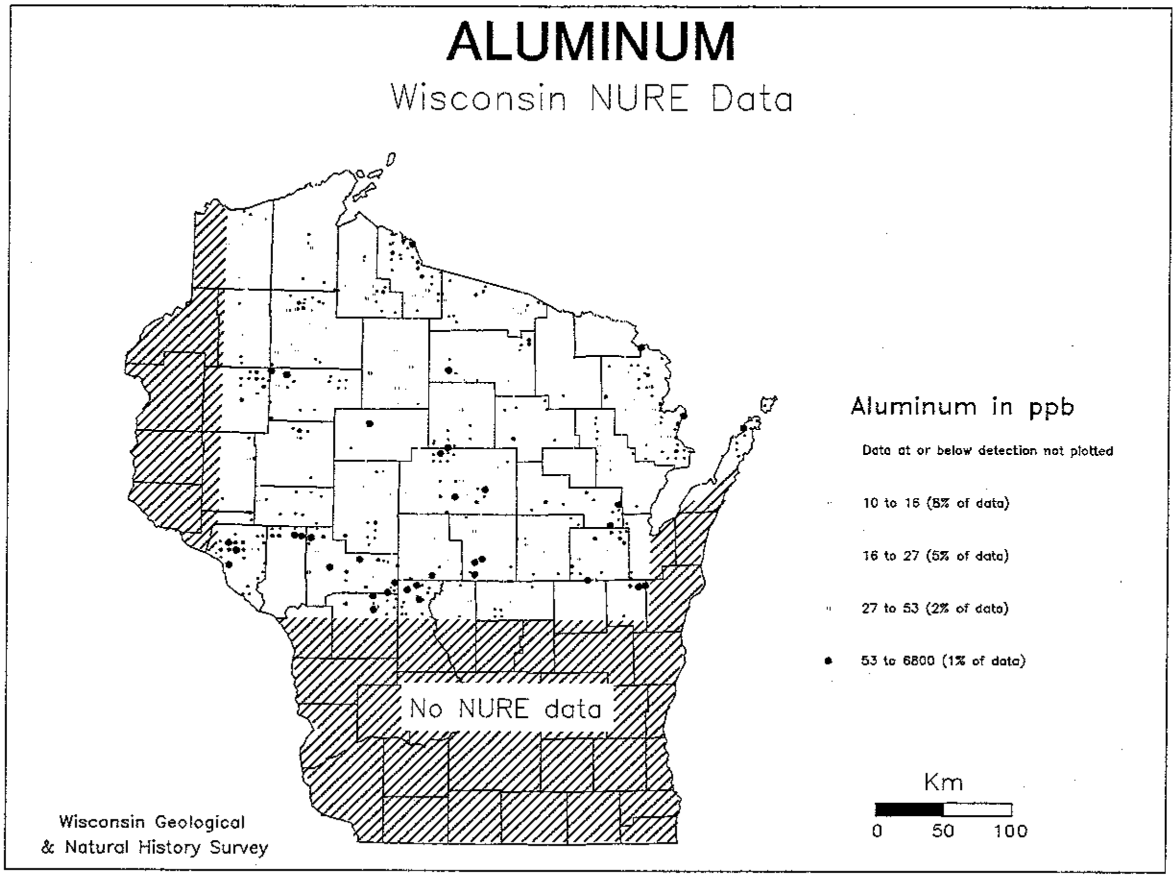
Very acidic groundwater (less than 5.7 pH units, CO_2 saturation) is preponderant in northern and western Wisconsin. Low pHs appear to correspond with non-reactive aquifer material of quartz sandstone (southern part of the survey area) and with quartzose surficial material (northern Wisconsin). Slightly basic to basic ph (greater than 8.4 pH units, calcite saturation) is preponderant in eastern Wisconsin in area of dolomite or calcareous till.

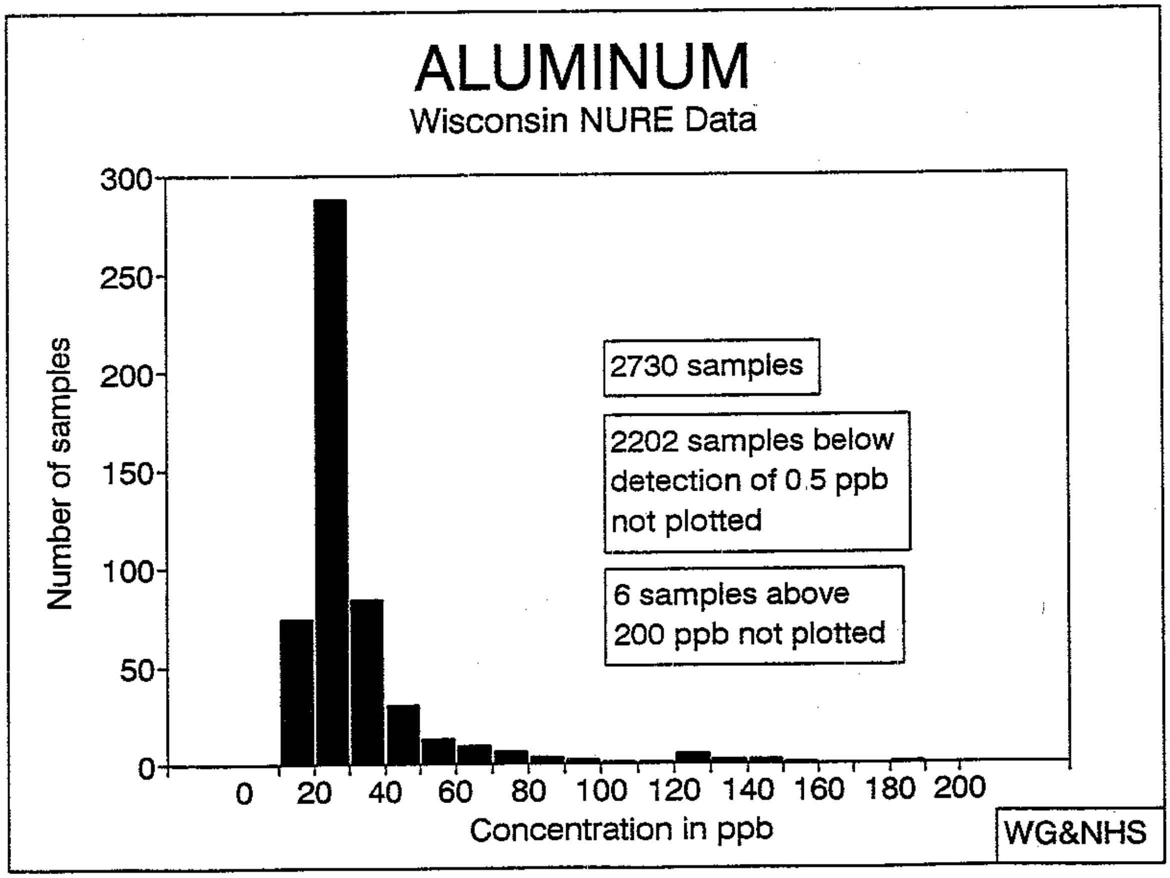
Field Conductivity

Low conductivity (below 130 micromhos per cm) are preponderant in western and northern Wisconsin, and correspond with non-reactive aquifer material of quartz sandstone and quartzose till. High conductivity (greater than 500 micromhos per cm) dominate the southeastern part of the survey area and correspond with calcareous parent material or saline water.

Alkalinity

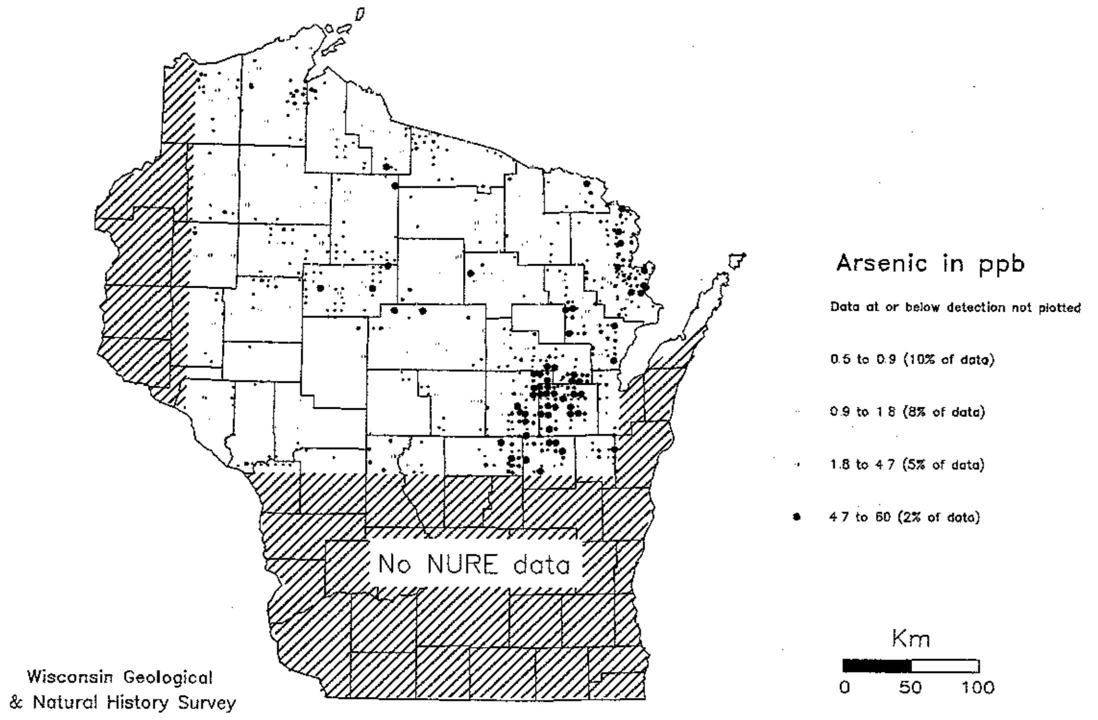
Very low alkalinity water (below 20 ppm) is evident in the southwestern part of the survey area and generally corresponds to phosphorus-rich water. High alkalinity water (greater than 325 ppm) is evident in the southeastern part of the survey area and corresponds to calcareous aquifer material.


ALUMINUM
Wisconsin NURE Data
Aluminum in ppb
Data at or below detection not plotted
10 to 16 (8% of data)
16 to 27 (5% of data)
27 to 53 (2% of data)
53 to 6800 (1% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


ALUMINUM
Wisconsin NURE Data
300
250
200
150
100
50
0
Number of samples
2730 samples
2202 samples below detection of 0.5 ppb not plotted
6 samples above 200 ppb not plotted
0
20
40
60
80
100
120
140
160
180
200
Concentration in ppb
WG&NHS

ARSENIC

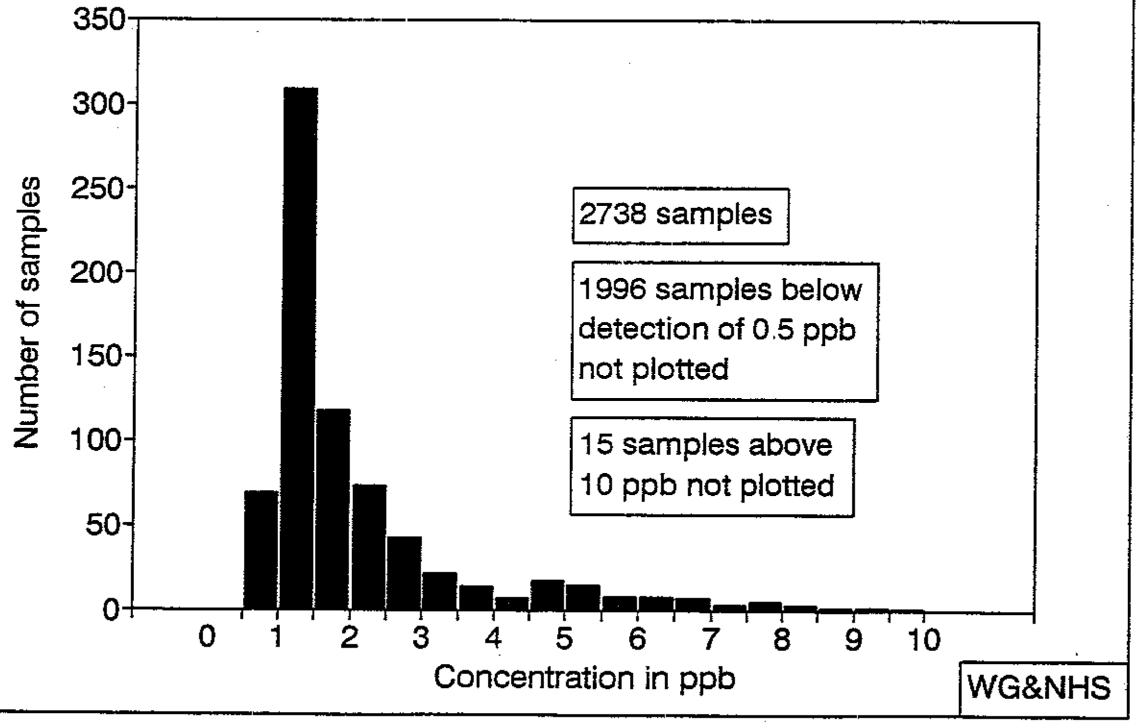
Wisconsin NURE Data



Wisconsin Geological
& Natural History Survey

ARSENIC

Wisconsin NURE Data

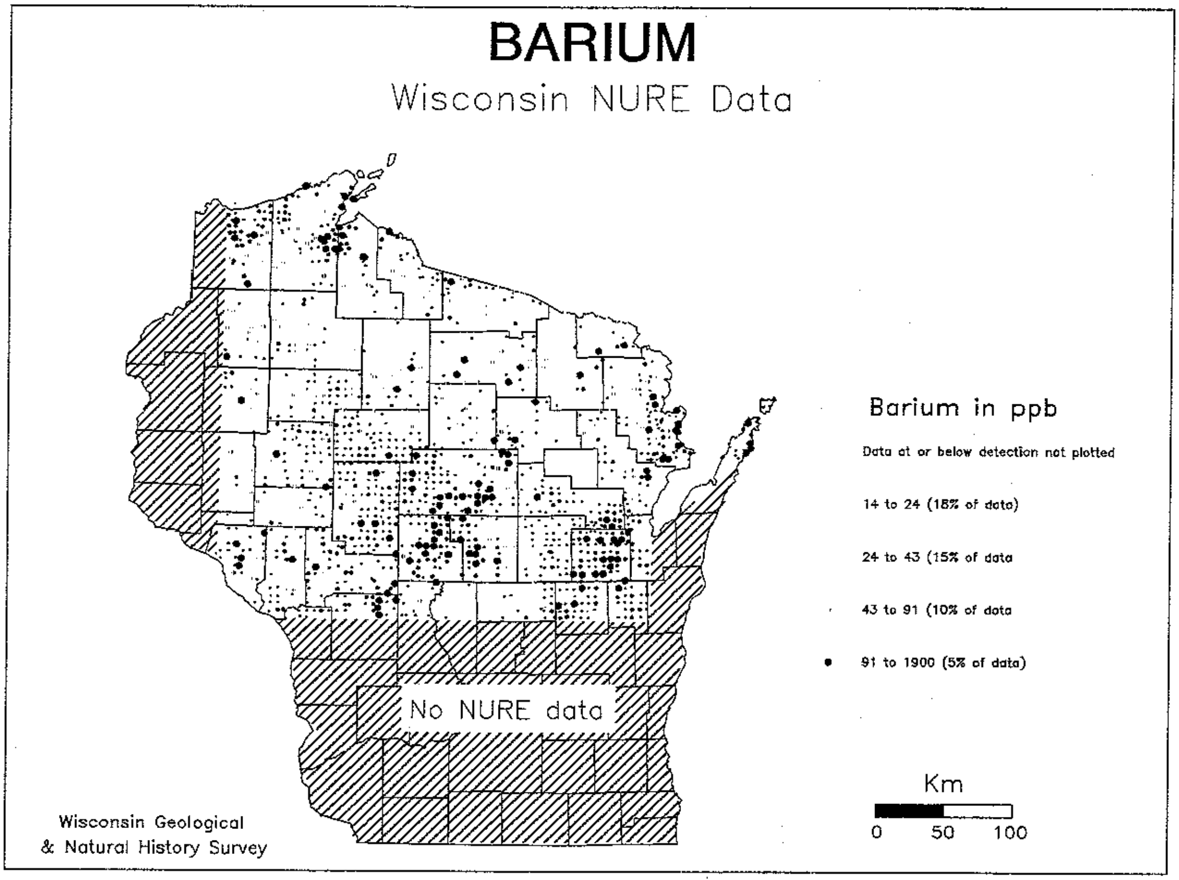


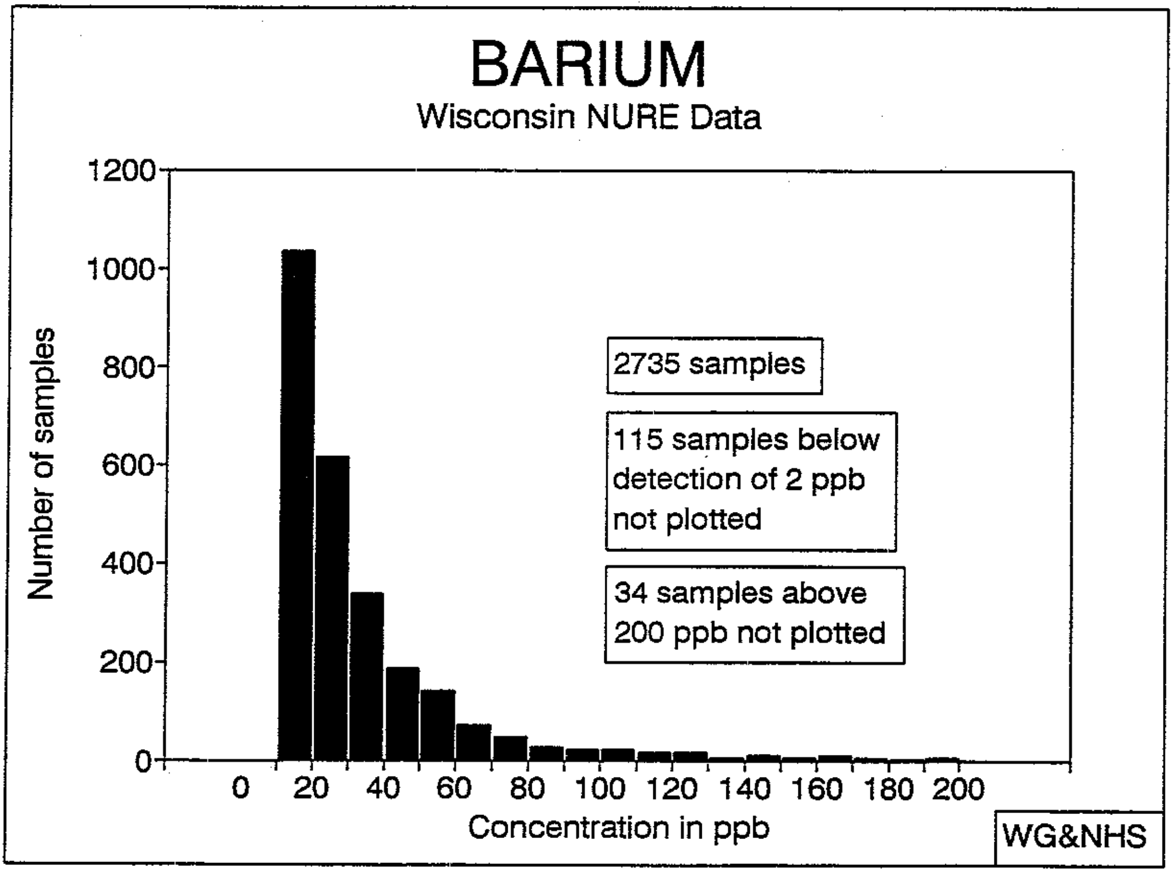
2738 samples

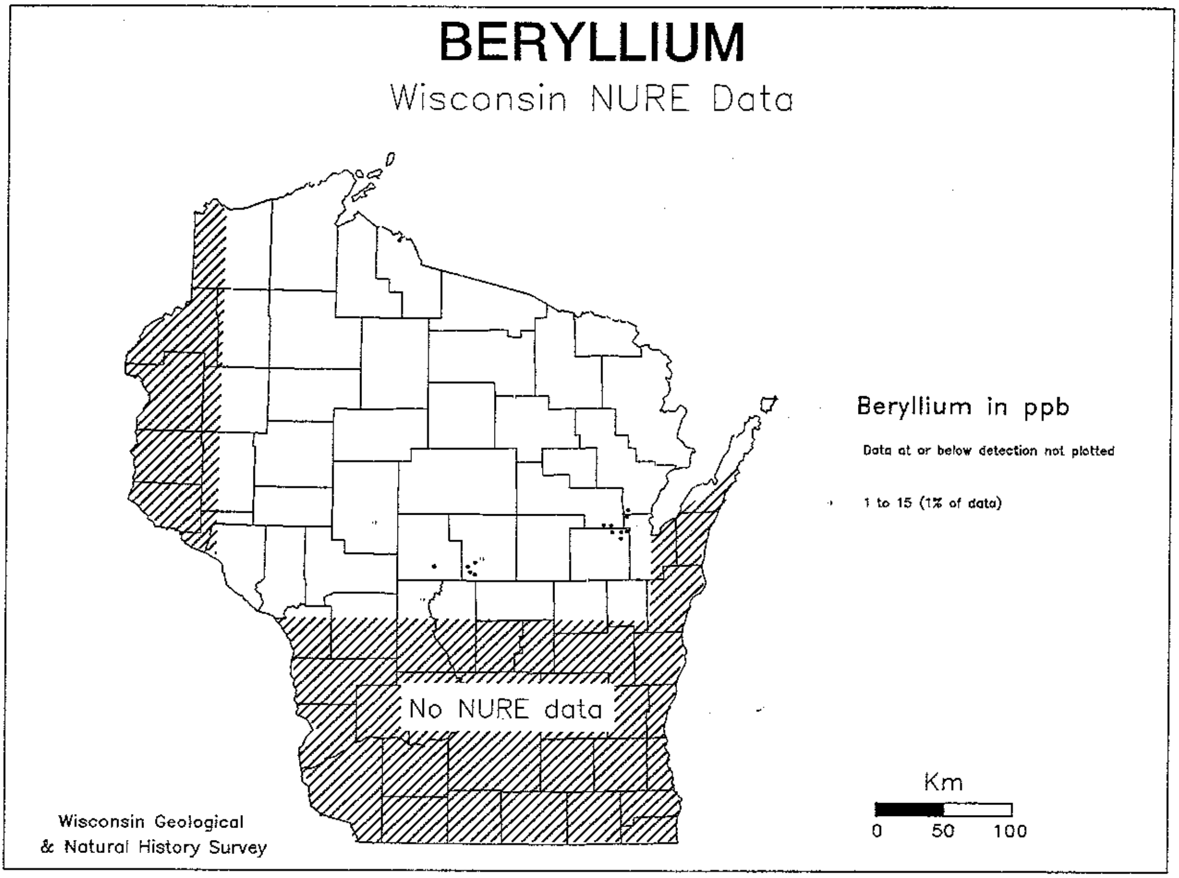
1996 samples below detection of 0.5 ppb not plotted

15 samples above 10 ppb not plotted

WG&NHS

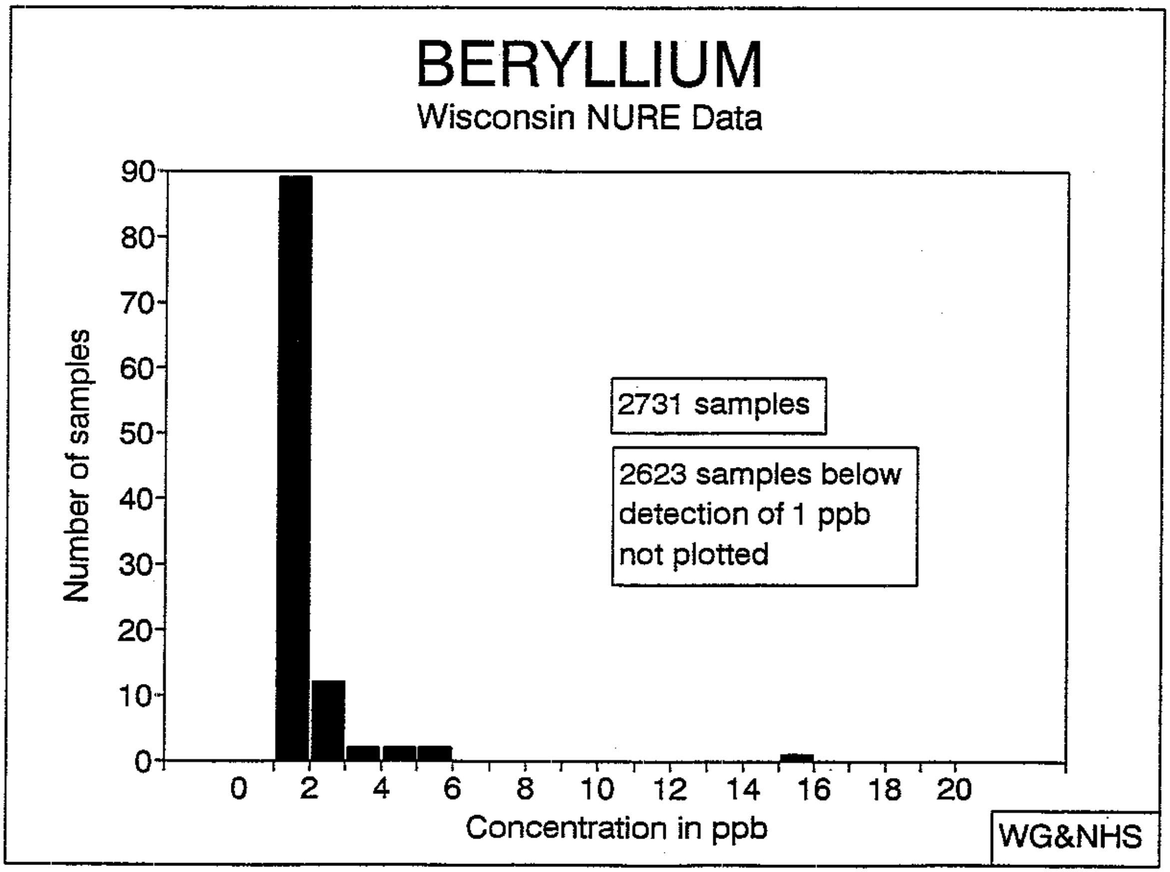

BARIUM
Wisconsin NURE Data
Barium in ppb
Data at or below detection not plotted
14 to 24 (18% of data)
24 to 43 (15% of data
43 to 91 (10% of data
● 91 to 1900 (5% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


BARIUM
Wisconsin NURE Data
Number of samples
0
200
400
600
800
1000
1200
2735 samples
115 samples below detection of 2 ppb not plotted
34 samples above 200 ppb not plotted
0
20
40
60
80
100
120
140
160
180
200
Concentration in ppb
WG&NHS



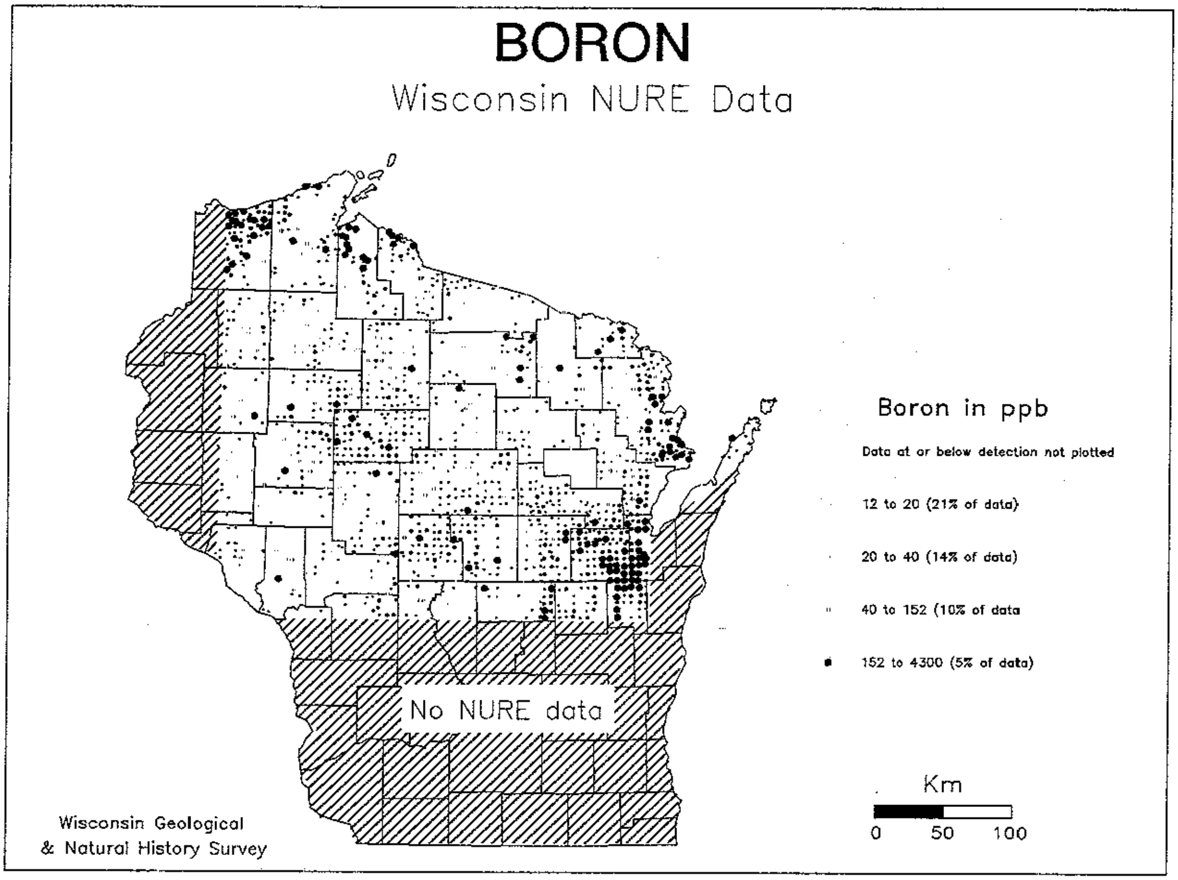
BERYLLIUM

Wisconsin NURE Data



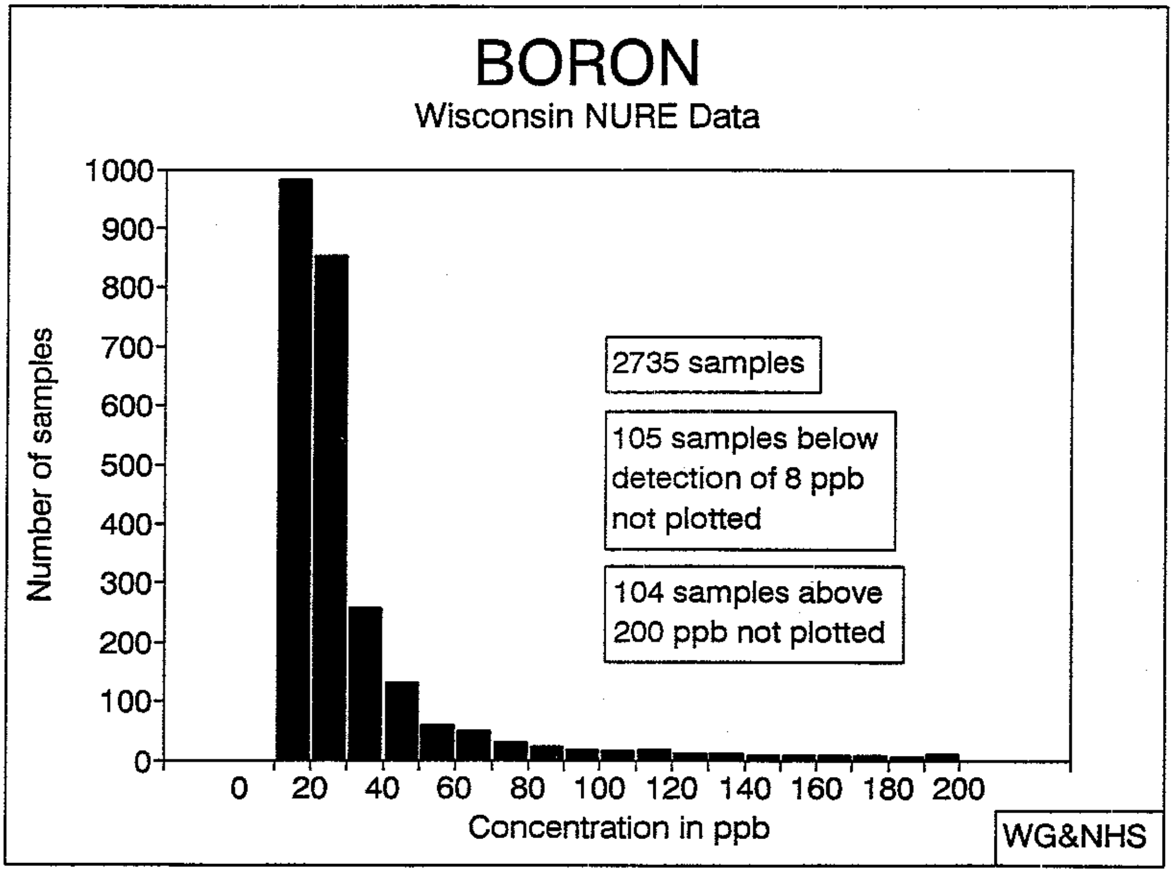
BERYLLIUM

Wisconsin NURE Data



BORON

Wisconsin NURE Data



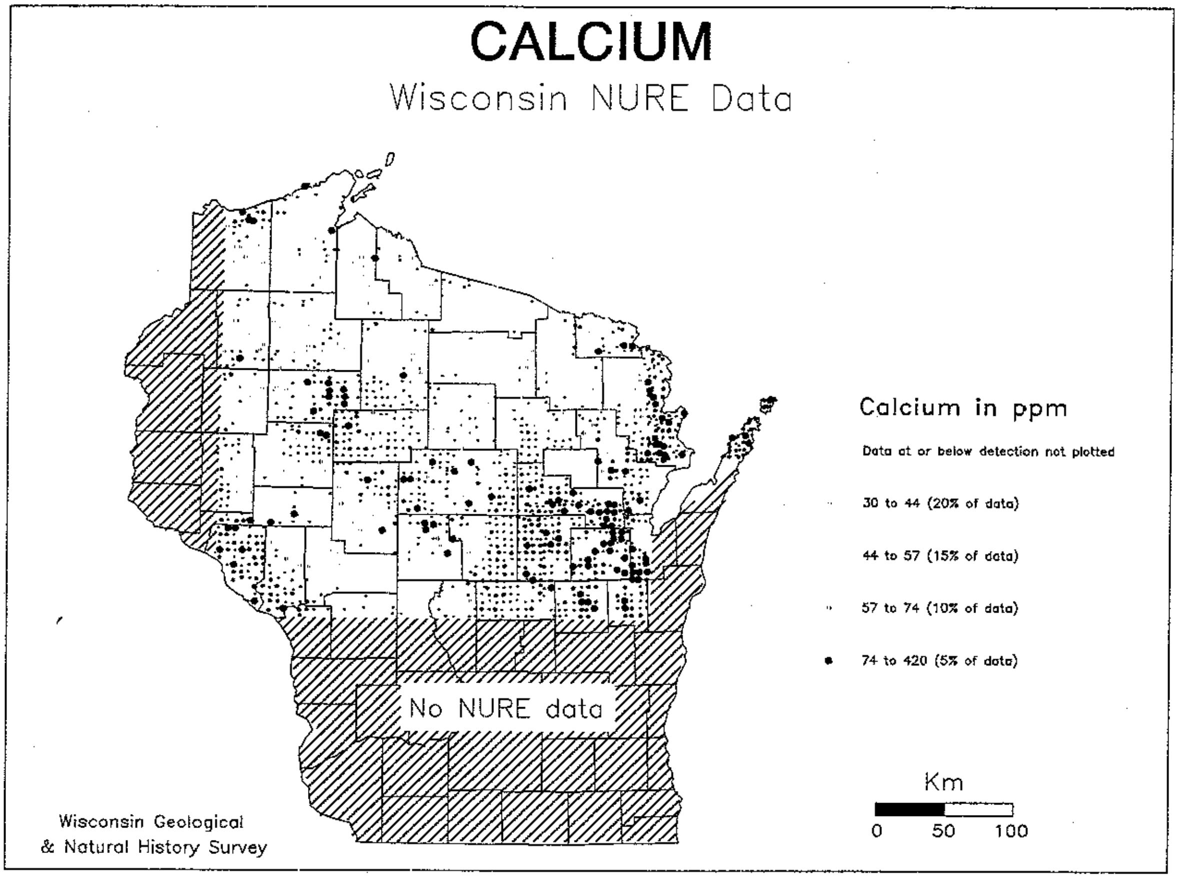
BORON

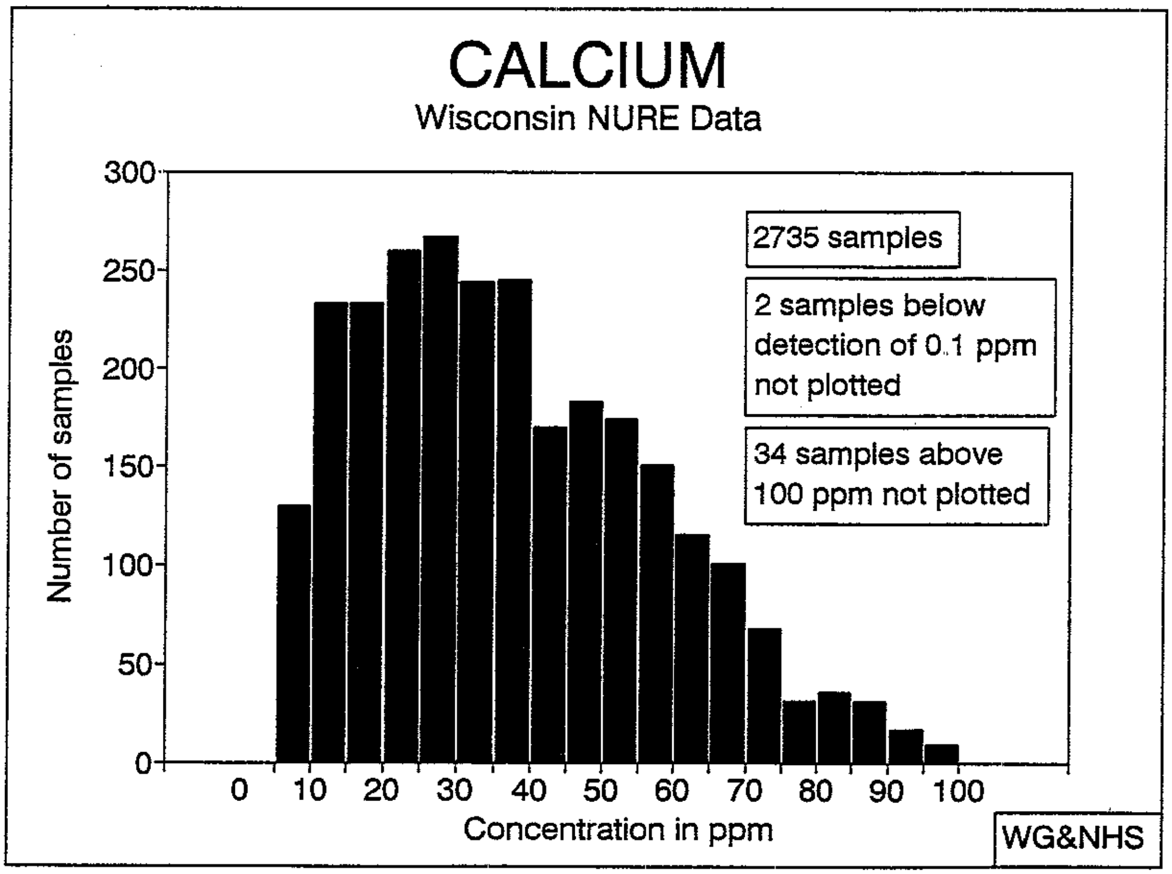
Wisconsin NURE Data

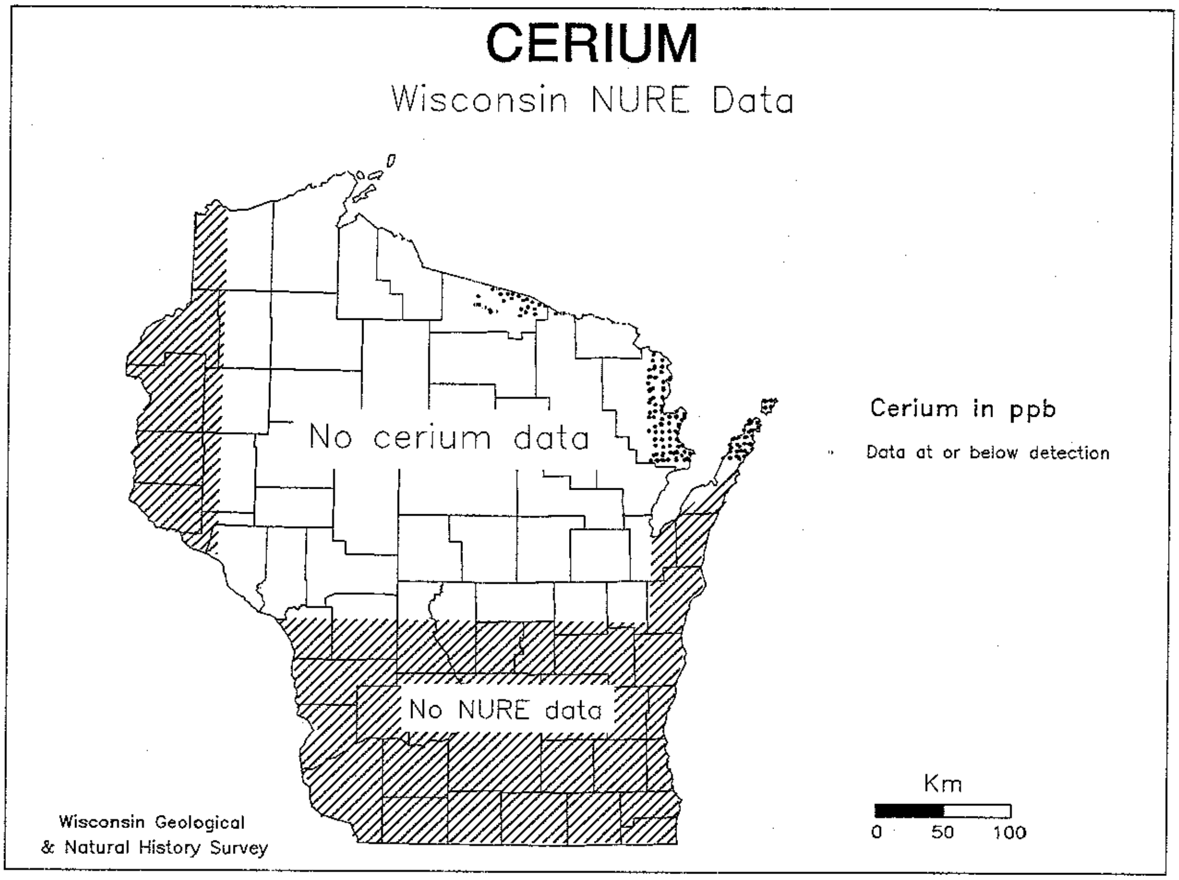
2735 samples

105 samples below detection of 8 ppb not plotted

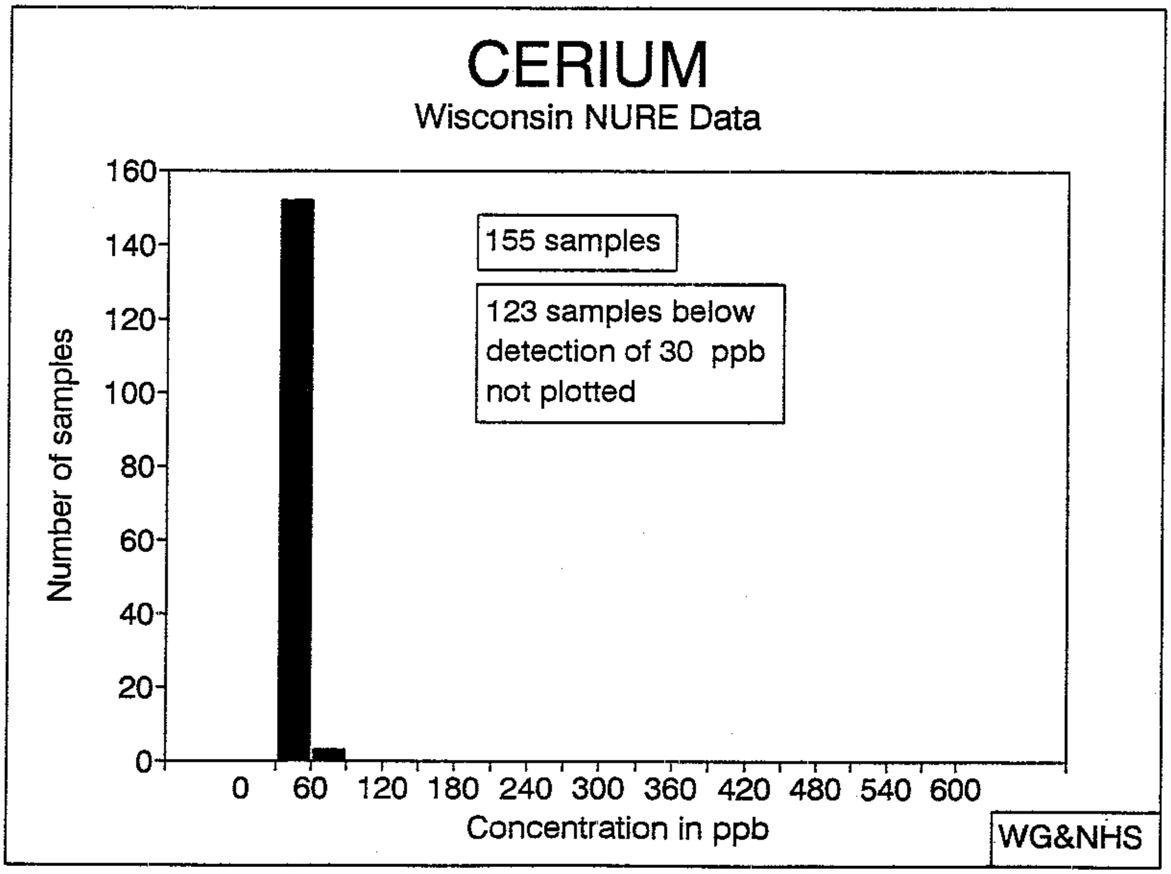
104 samples above 200 ppb not plotted


CALCIUM
Wisconsin NURE Data
Calcium in ppm
Data at or below detection not plotted
30 to 44 (20% of data)
44 to 57 (15% of data)
57 to 74 (10% of data)
74 to 420 (5% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


CALCIUM
Wisconsin NURE Data
2735 samples
2 samples below detection of 0.1 ppm not plotted
34 samples above 100 ppm not plotted
Number of samples
0
50
100
150
200
250
300
0
10
20
30
40
50
60
70
80
90
100
Concentration in ppm
WG&NHS


CERIUM

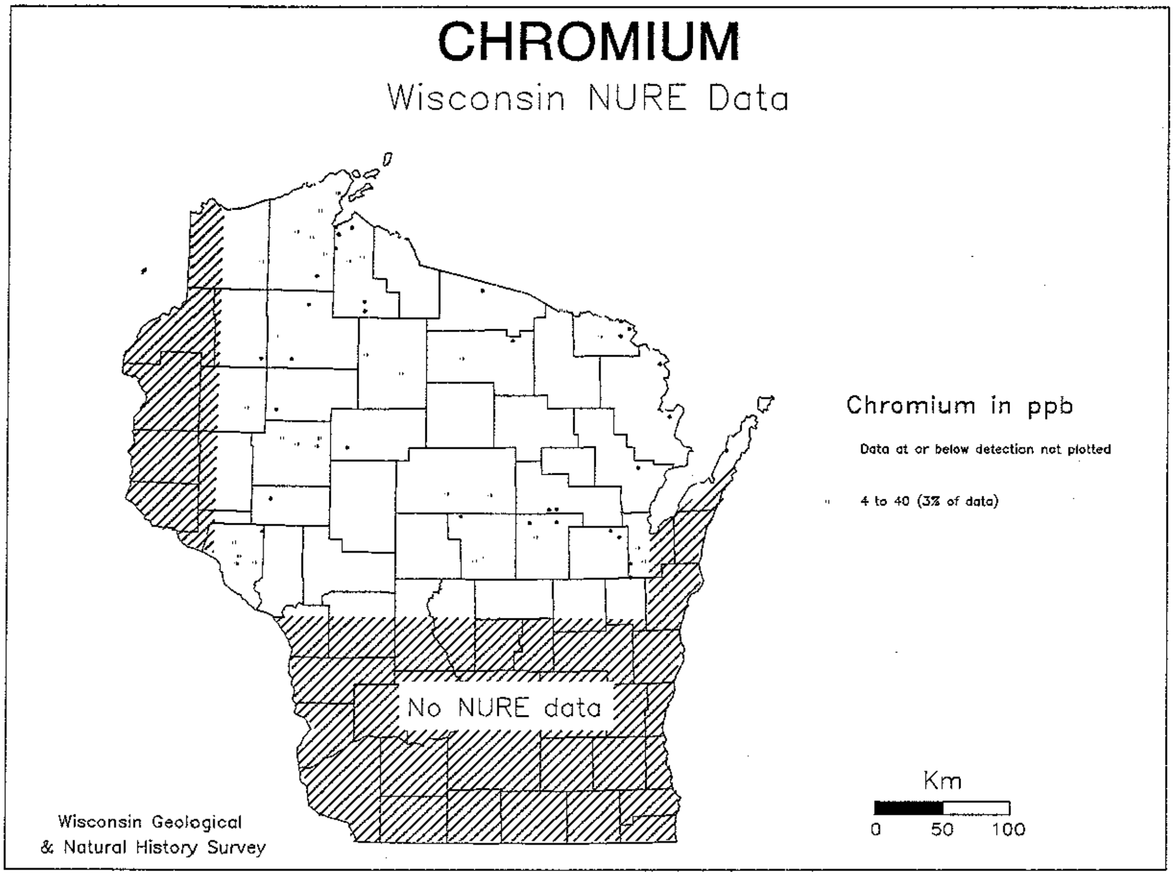
Wisconsin NURE Data


CERIUM

Wisconsin NURE Data

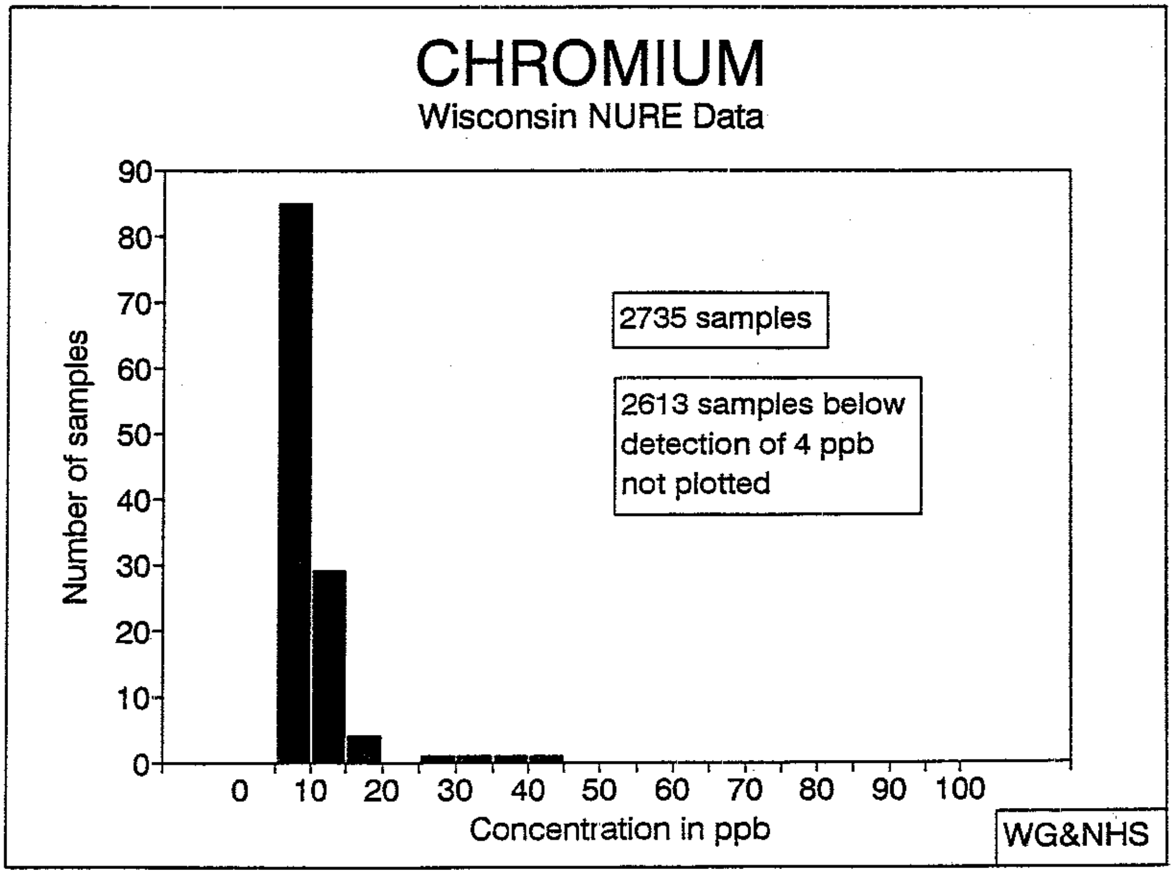
155 samples

123 samples below detection of 30 ppb not plotted



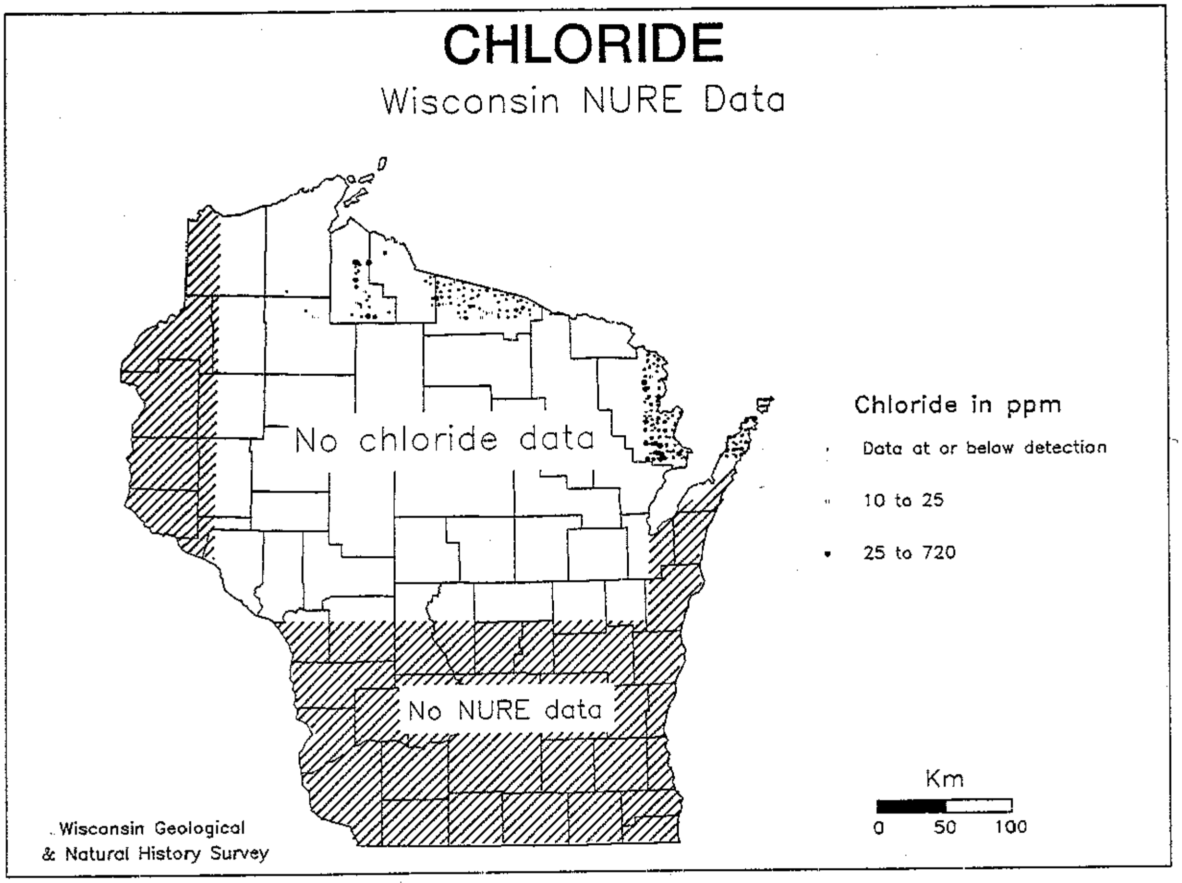
CHROMIUM

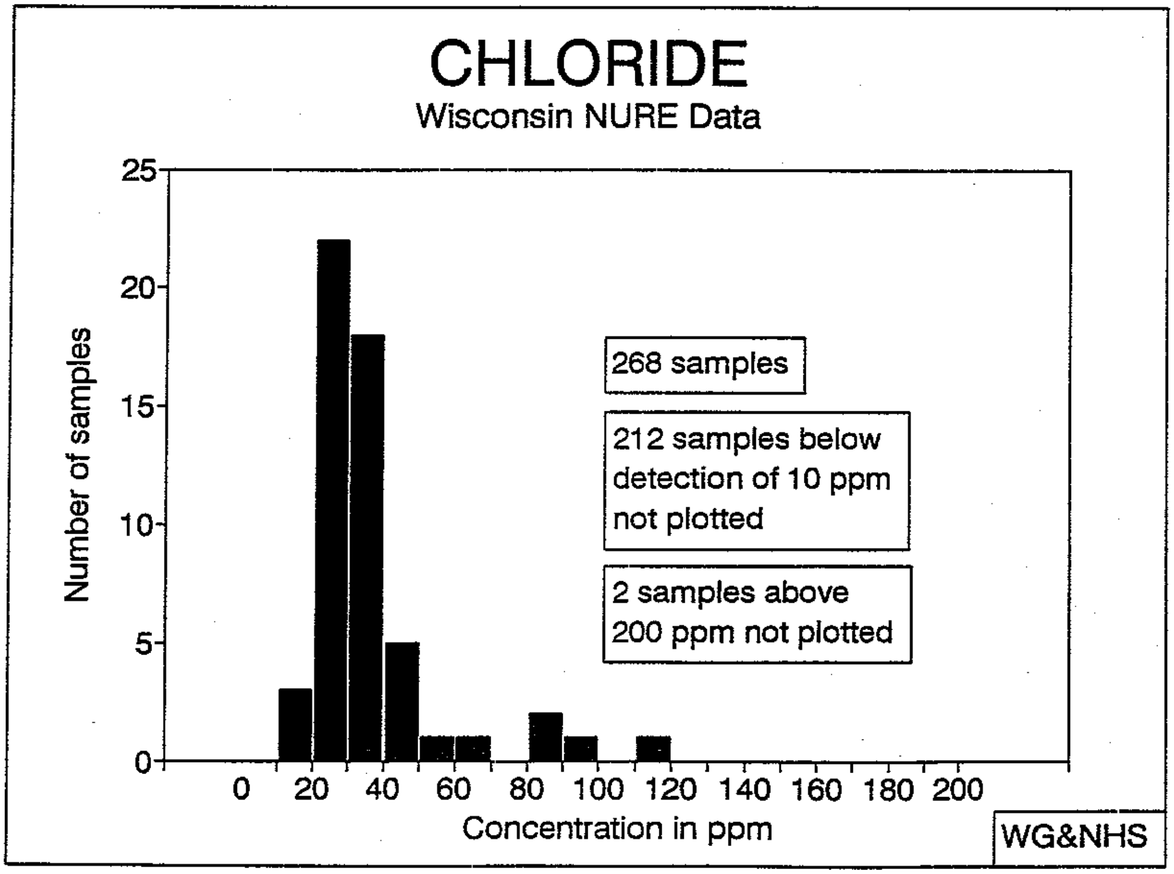
Wisconsin NURE Data



CHROMIUM

Wisconsin NURE Data

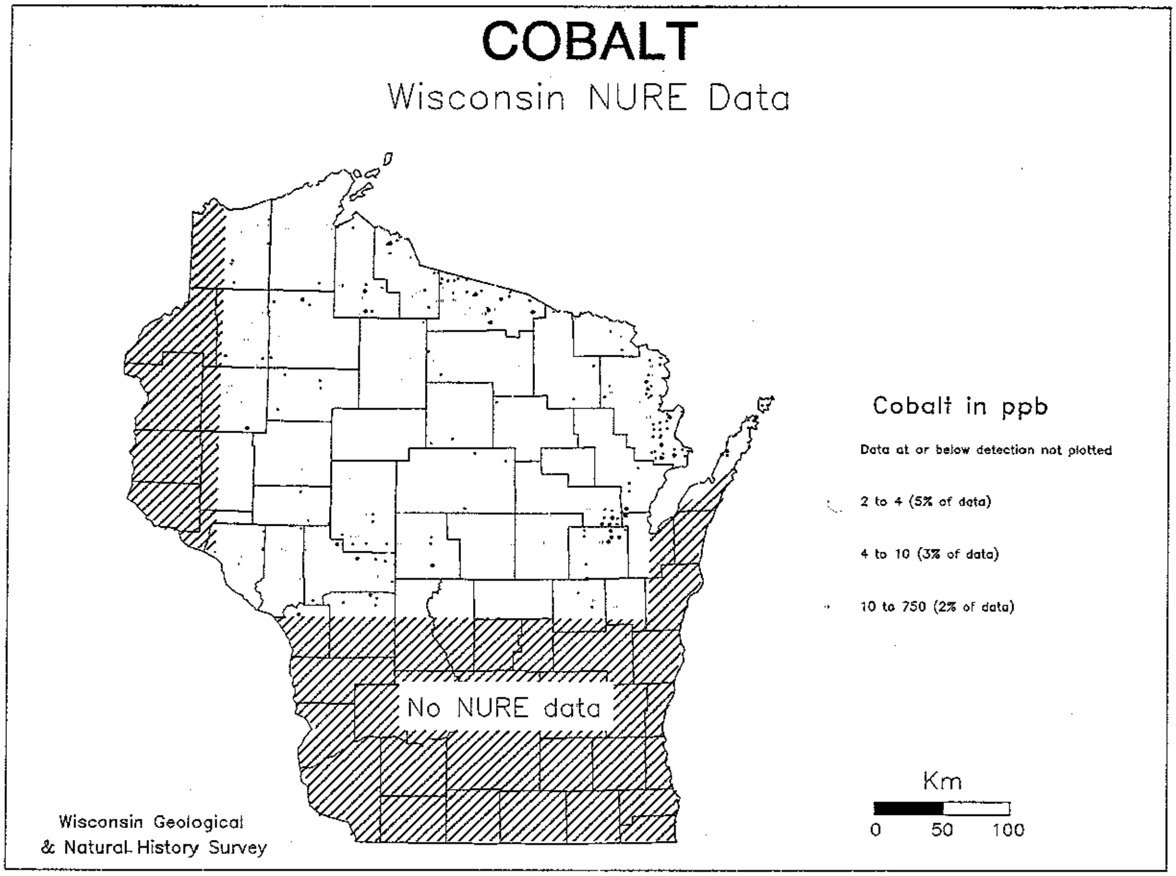

CHLORIDE
Wisconsin NURE Data

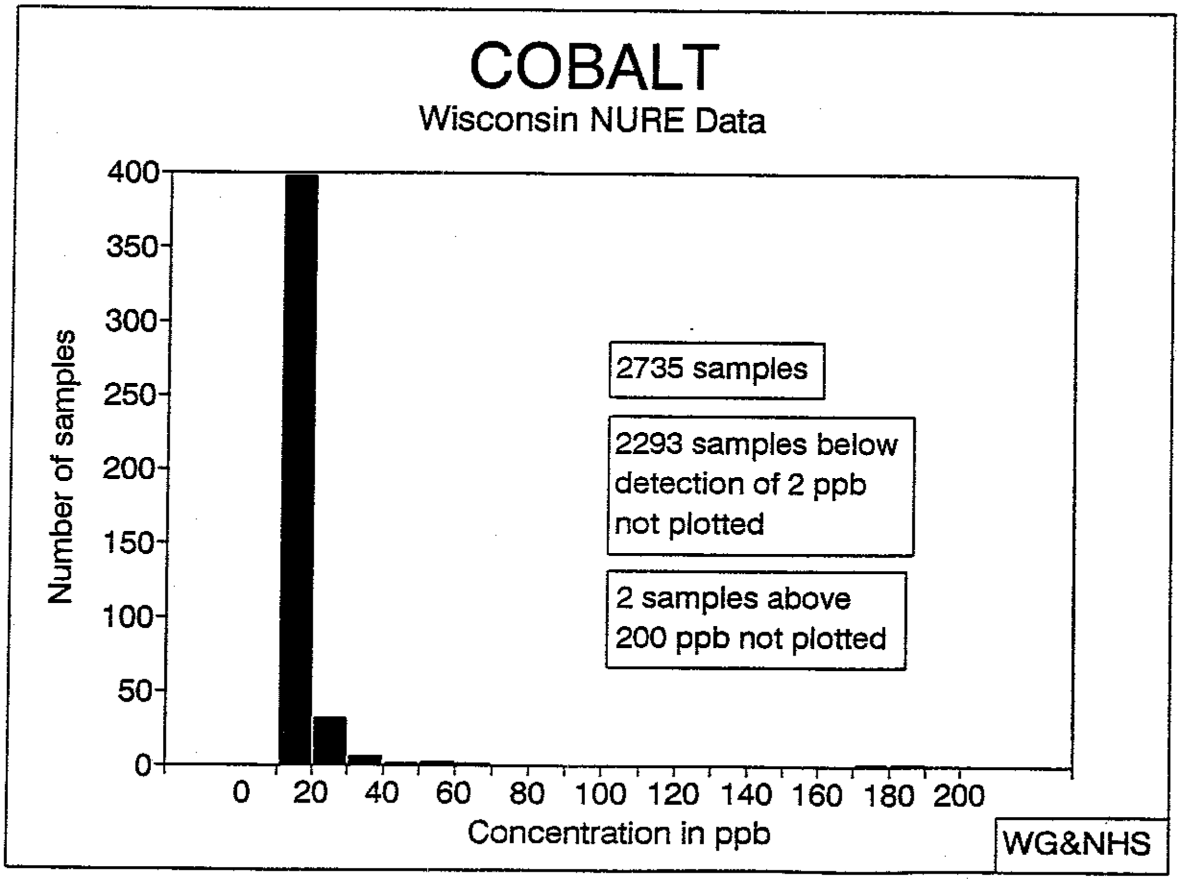

CHLORIDE
Wisconsin NURE Data

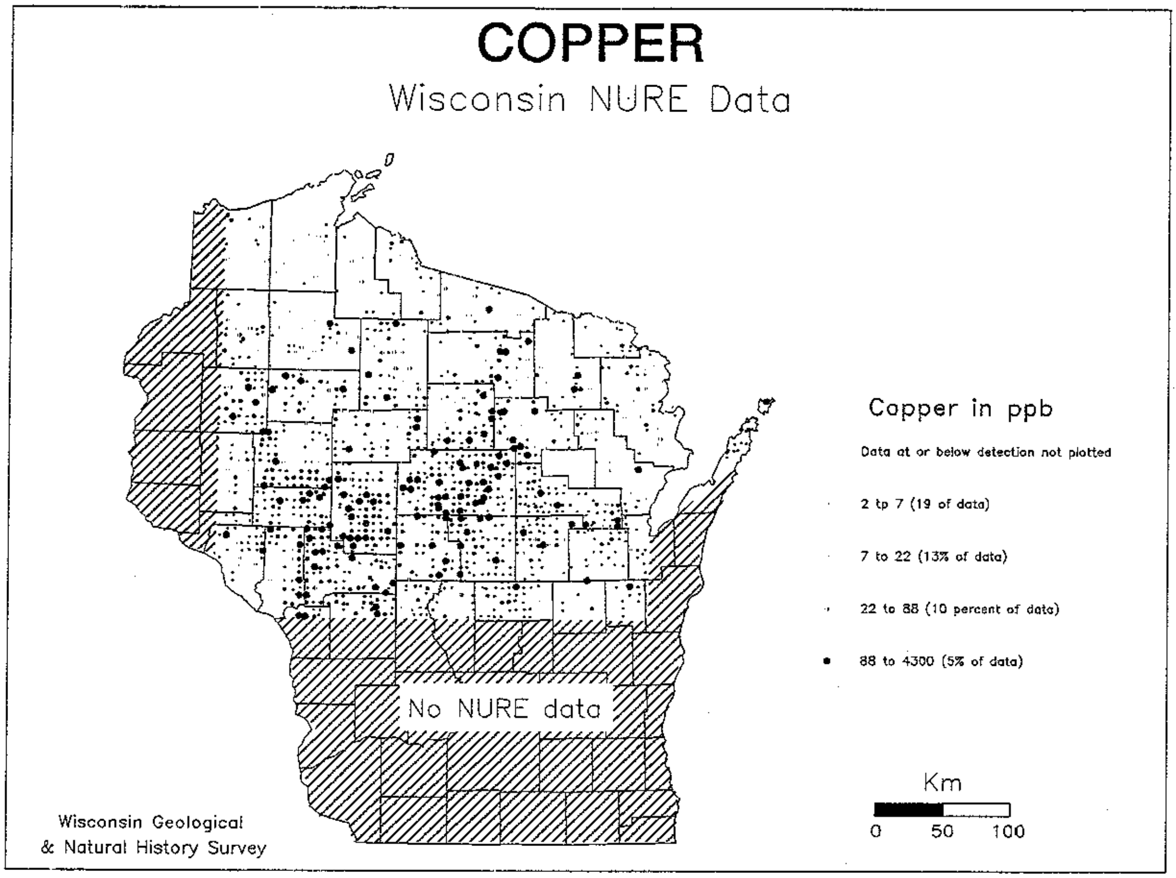
268 samples

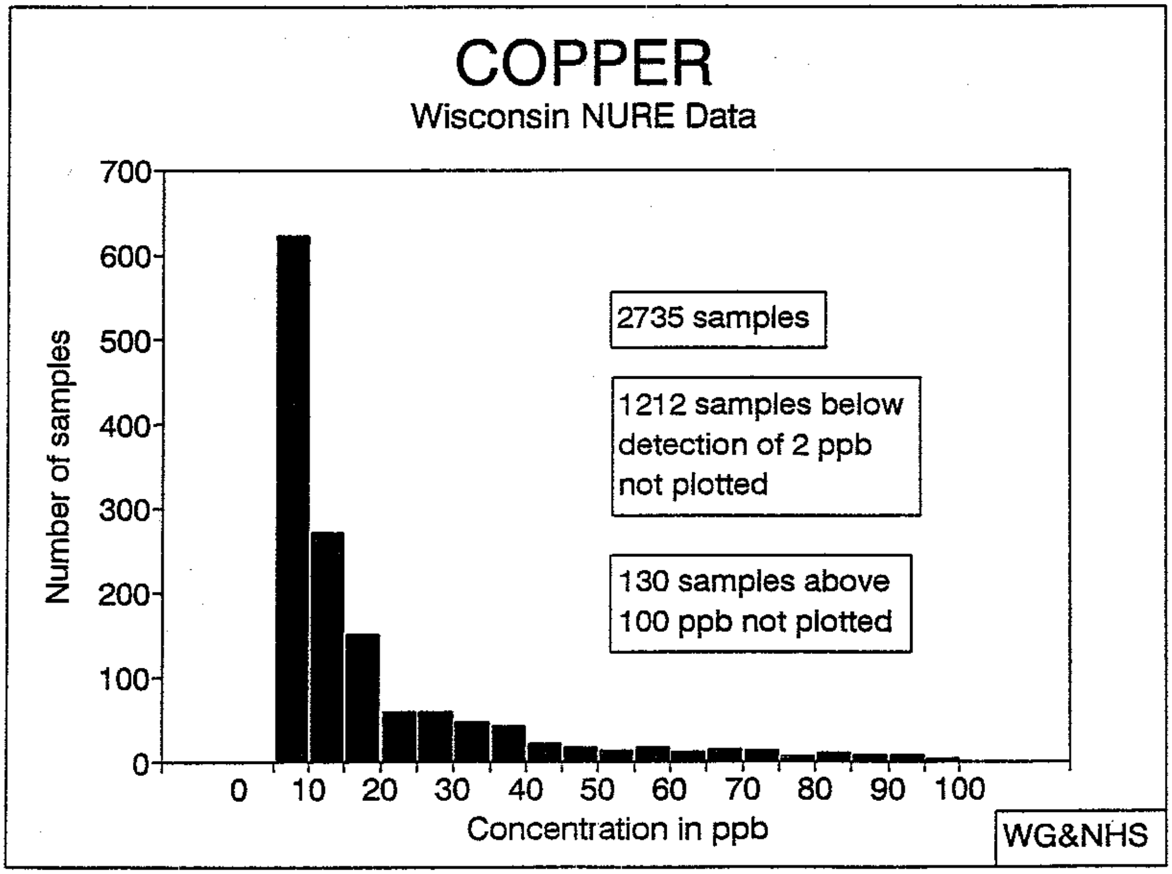
212 samples below detection of 10 ppm not plotted

2 samples above 200 ppm not plotted


COBALT
Wisconsin NURE Data
Cobalt in ppb
Data at or below detection not plotted
2 to 4 (5% of data)
4 to 10 (3% of data)
10 to 750 (2% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


COBALT
Wisconsin NURE Data
400
350
300
250
200
150
100
50
0
Number of samples
0
20
40
60
80
100
120
140
160
180
200
Concentration in ppb
2735 samples
2293 samples below detection of 2 ppb not plotted
2 samples above 200 ppb not plotted
WG&NHS

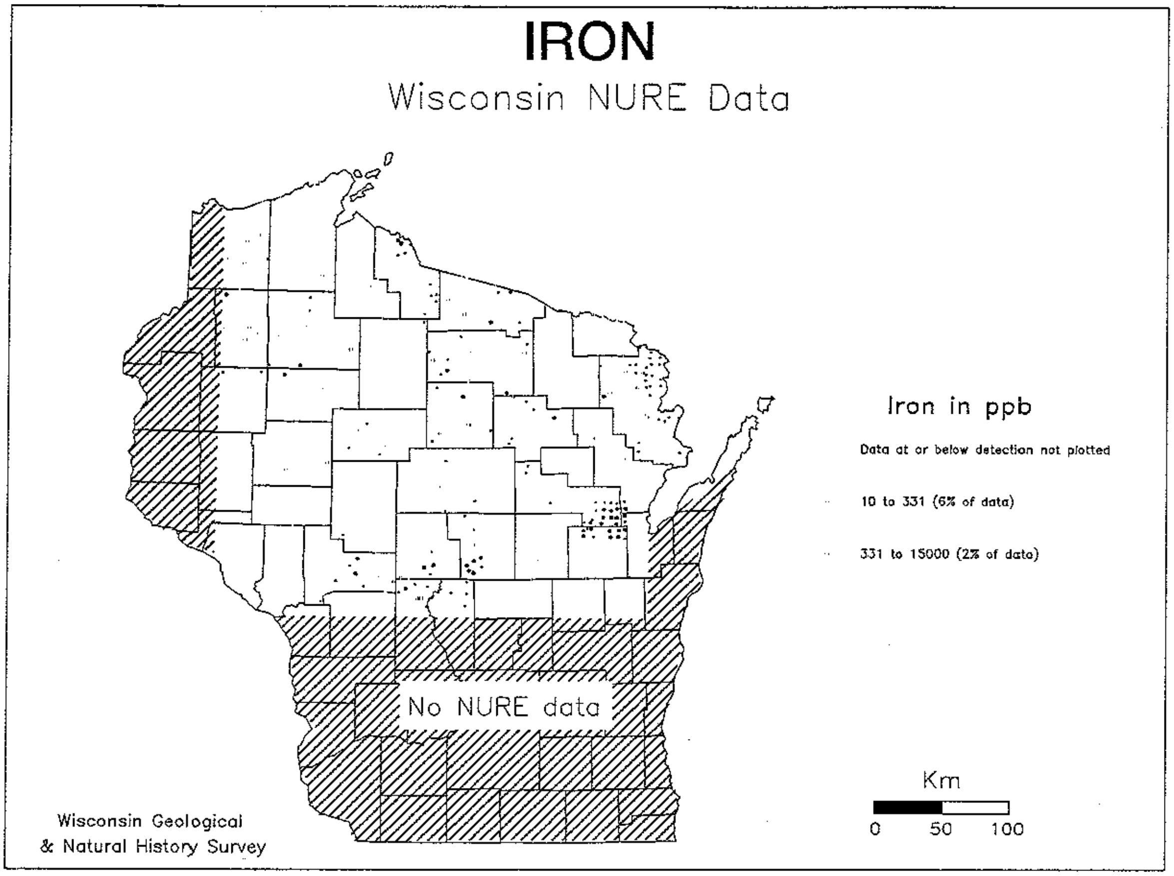


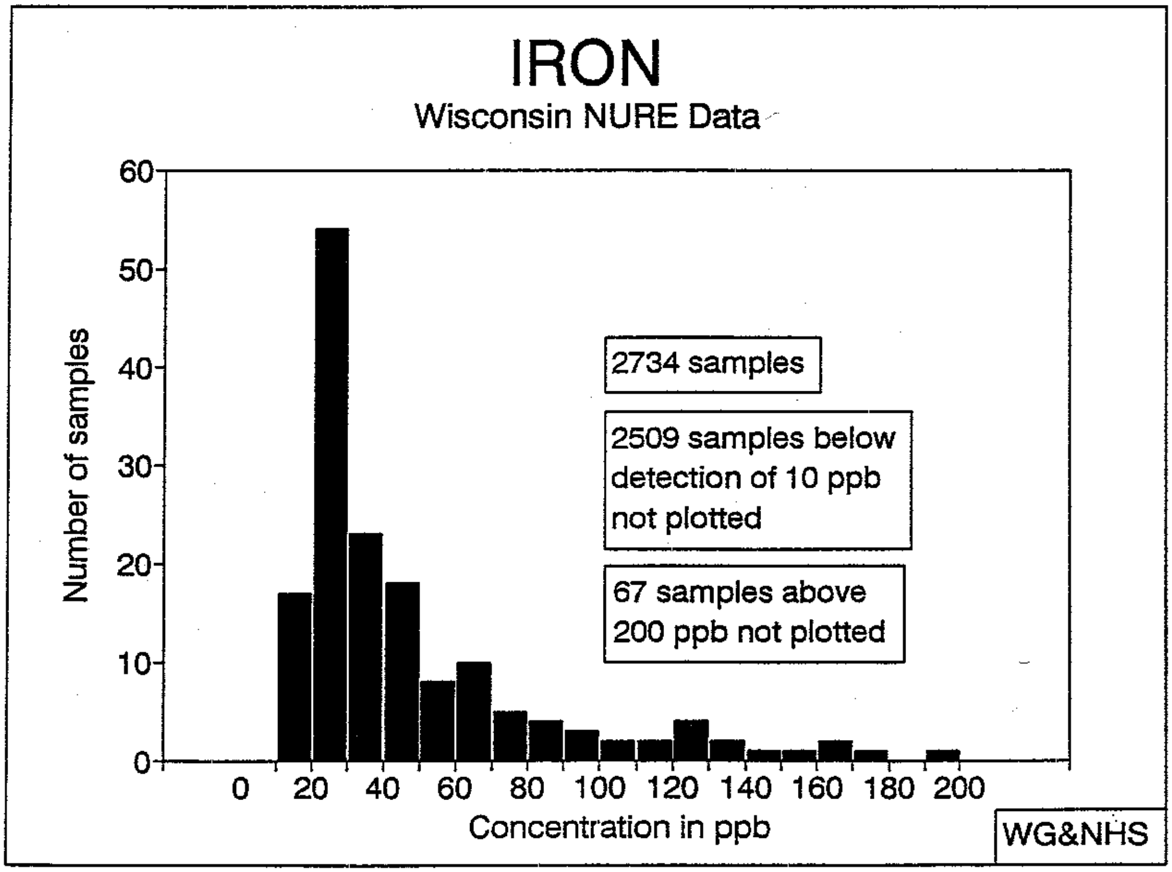


2735 samples

1212 samples below detection of 2 ppb not plotted

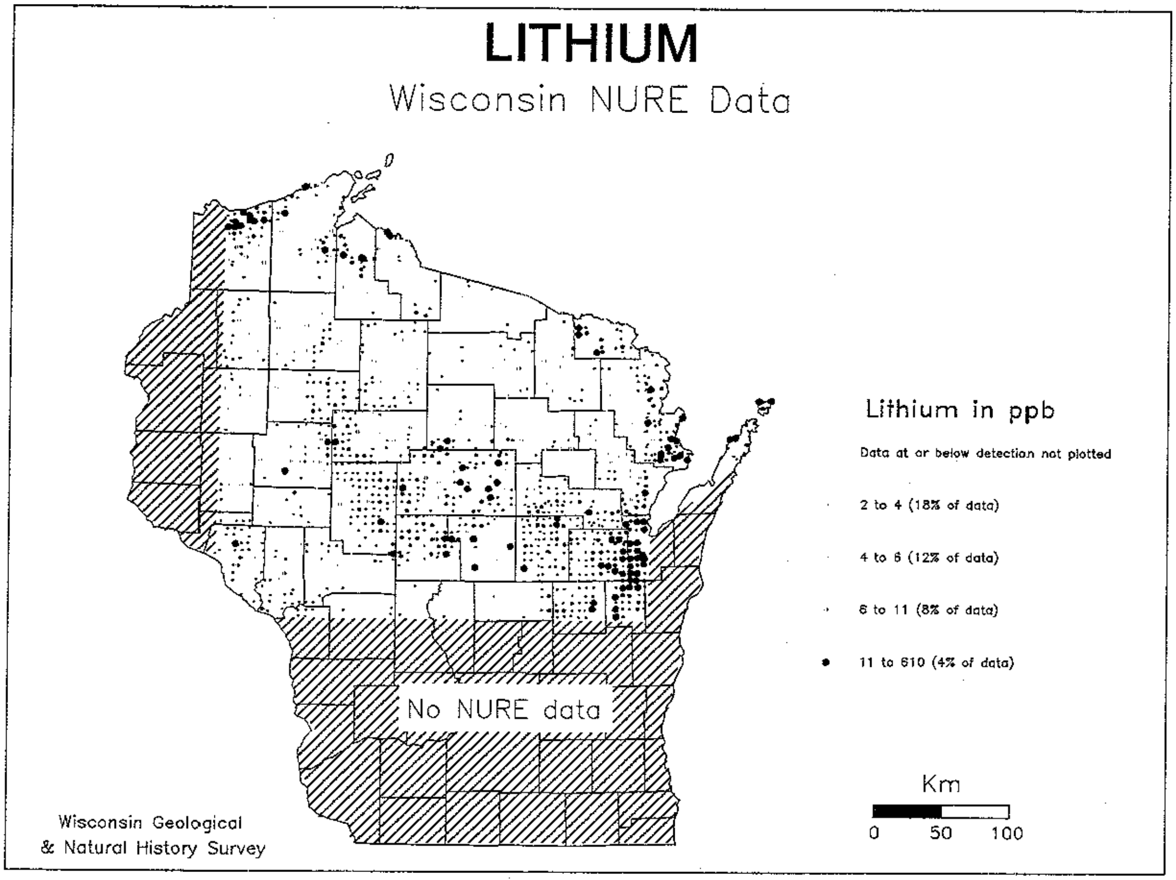
130 samples above 100 ppb not plotted


IRON
Wisconsin NURE Data
Iron in ppb
Data at or below detection not plotted
10 to 331 (6% of data)
331 to 15000 (2% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


IRON
Wisconsin NURE Data
Number of samples
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
Concentration in ppb
2734 samples
2509 samples below detection of 10 ppb not plotted
67 samples above 200 ppb not plotted
WG&NHS

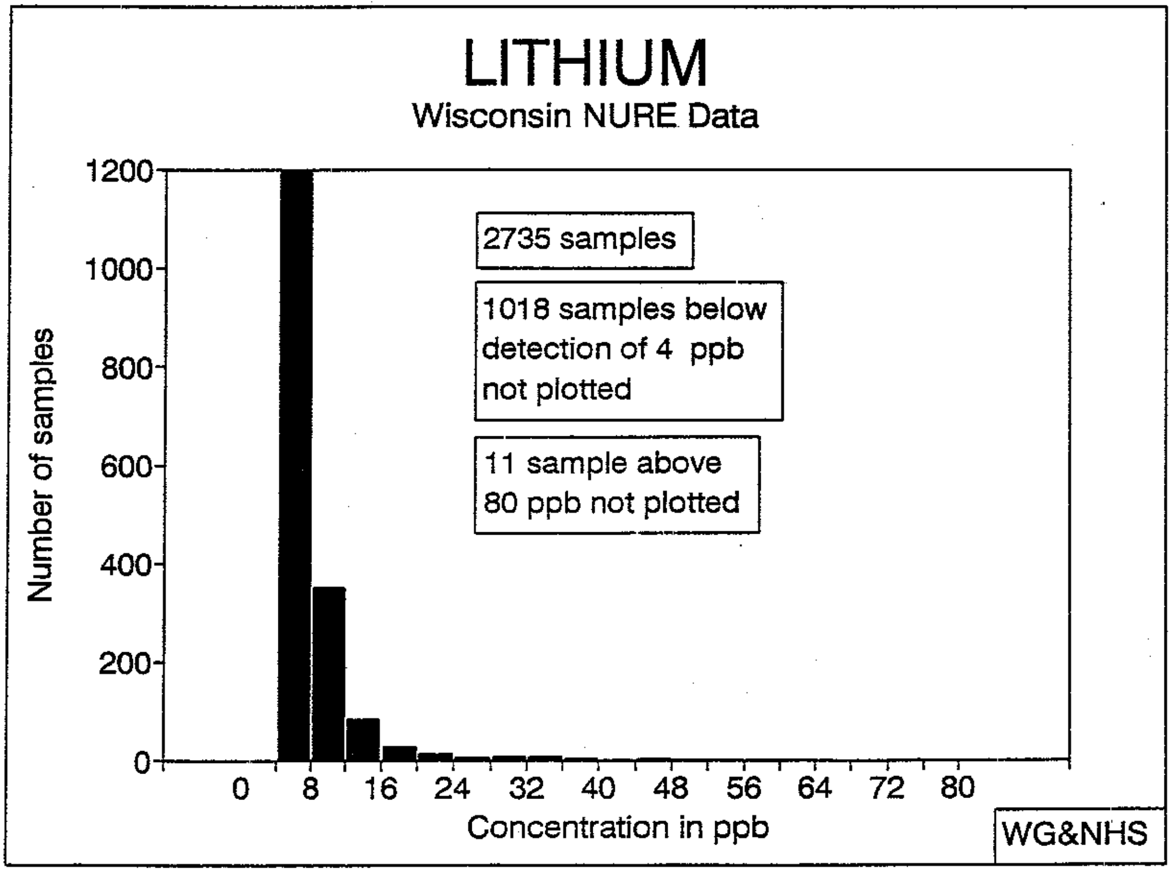
LITHIUM

Wisconsin NURE Data



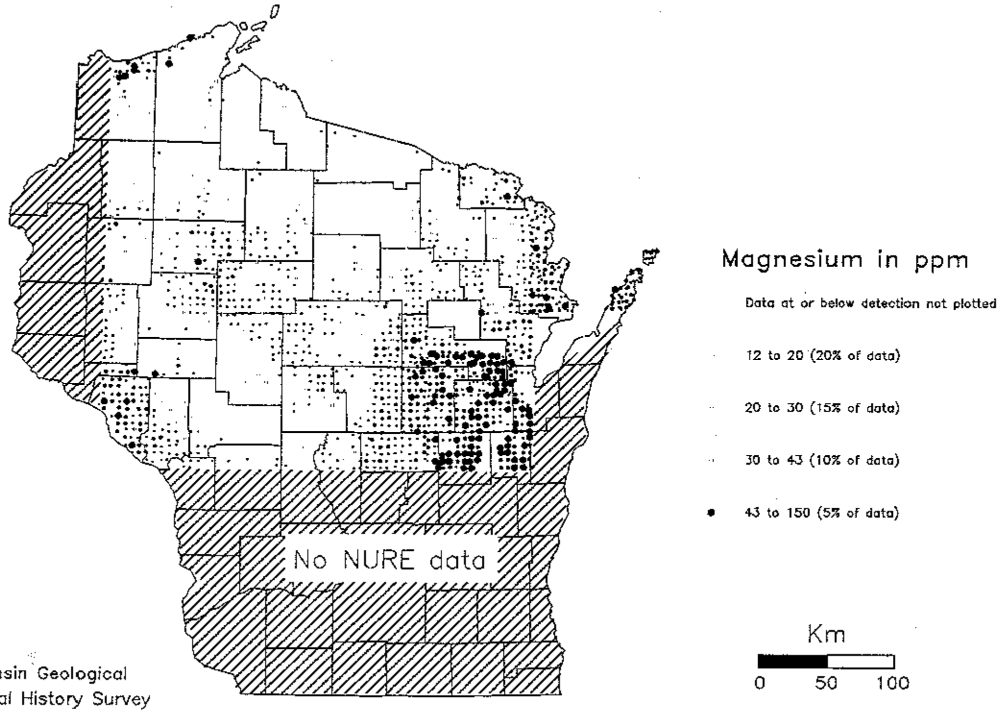
LITHIUM

Wisconsin NURE Data



MAGNESIUM

Wisconsin NURE Data



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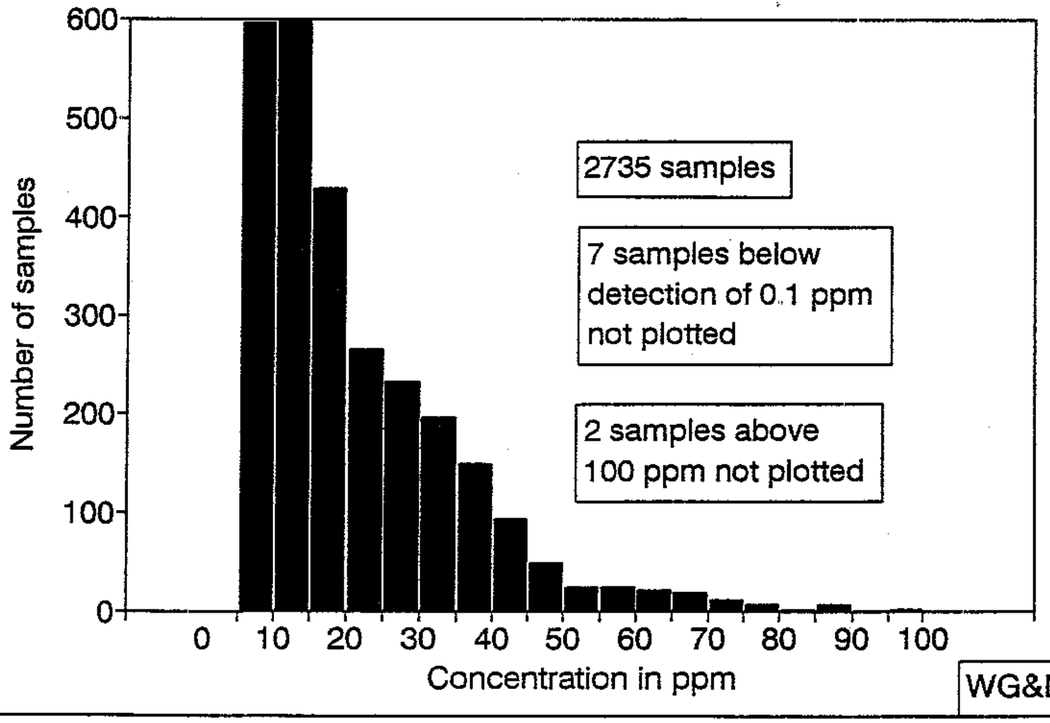
MAGNESIUM

Wisconsin NURE Data

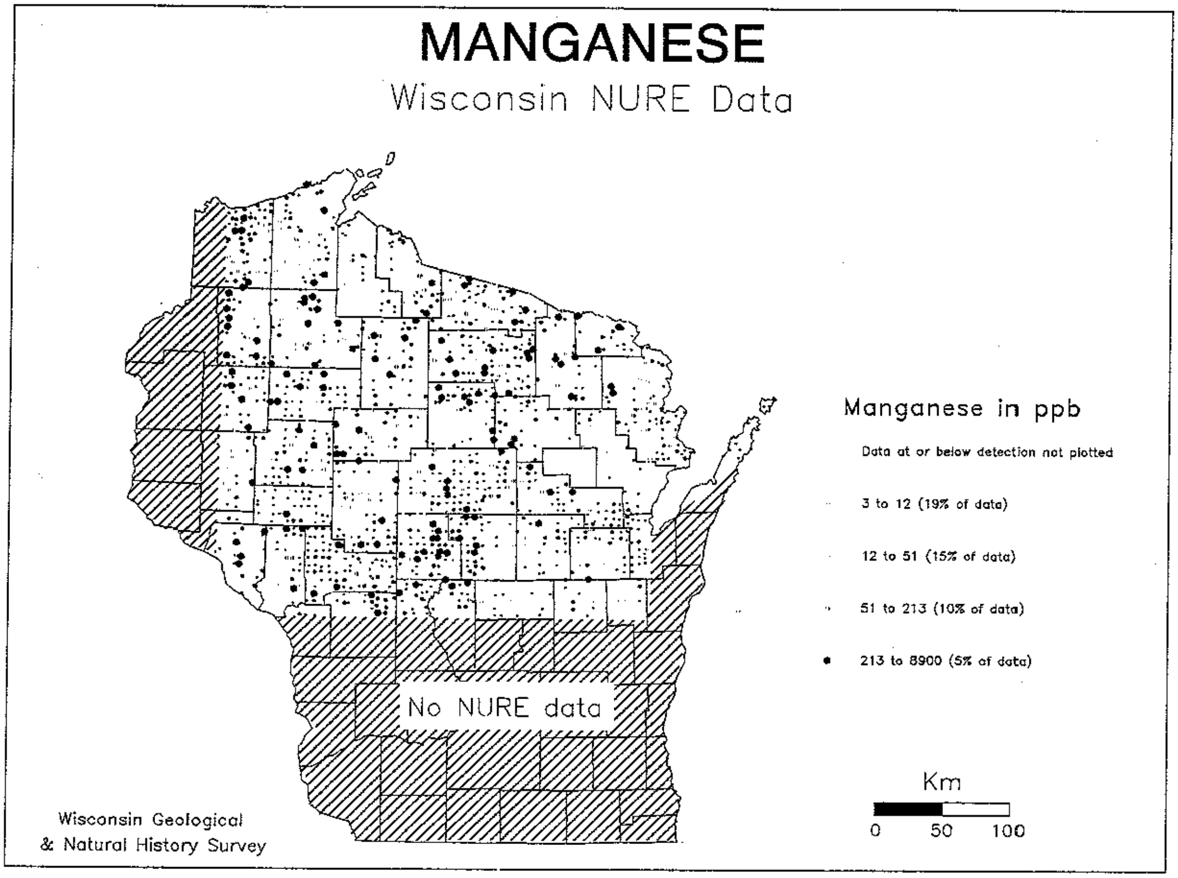


2735 samples

7 samples below detection of 0.1 ppm not plotted

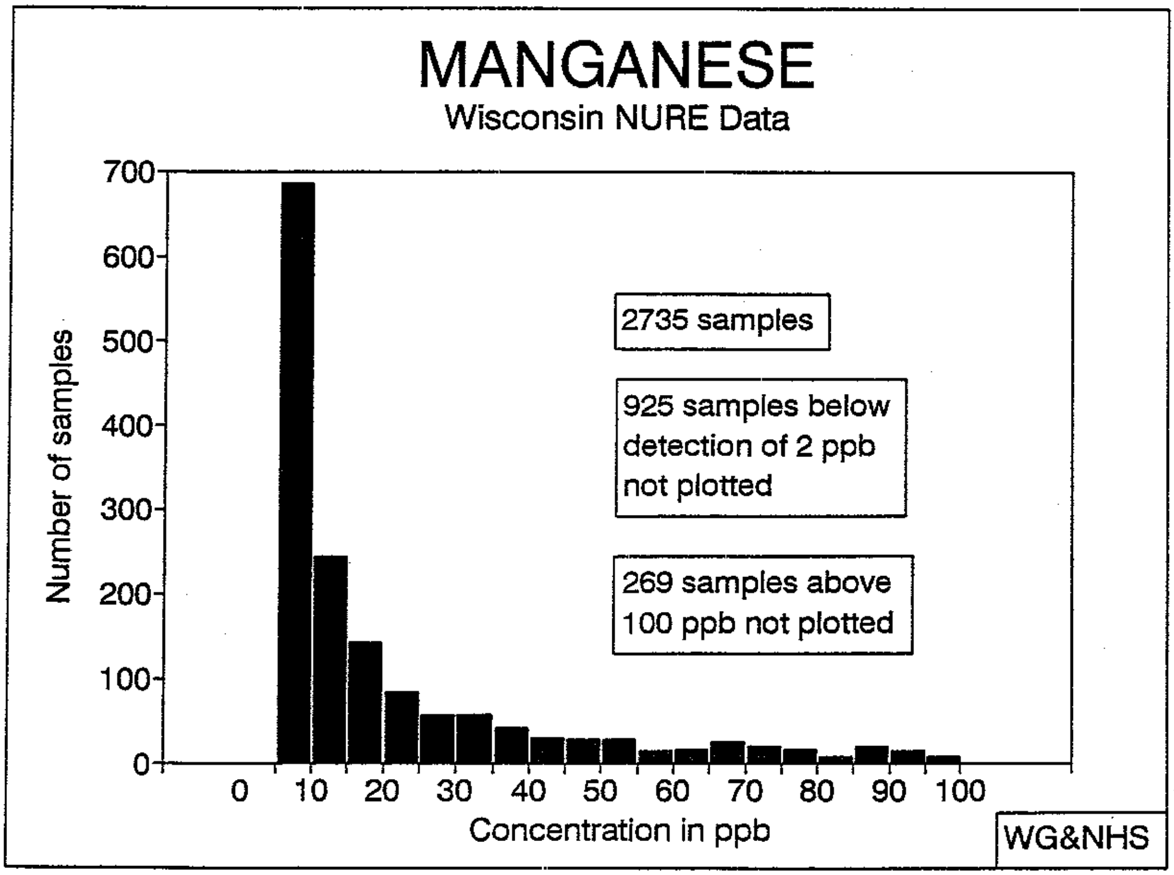
2 samples above 100 ppm not plotted

WG&NHS



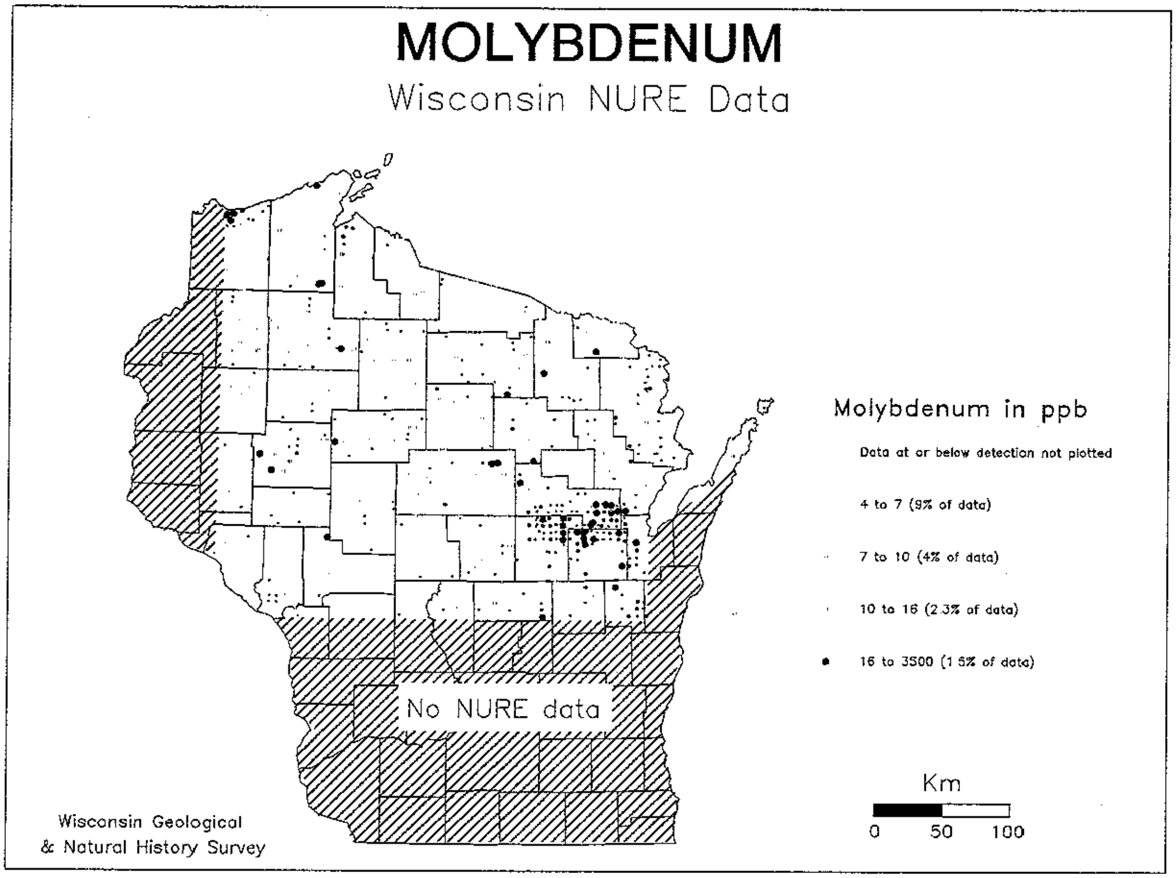
MANGANESE

Wisconsin NURE Data



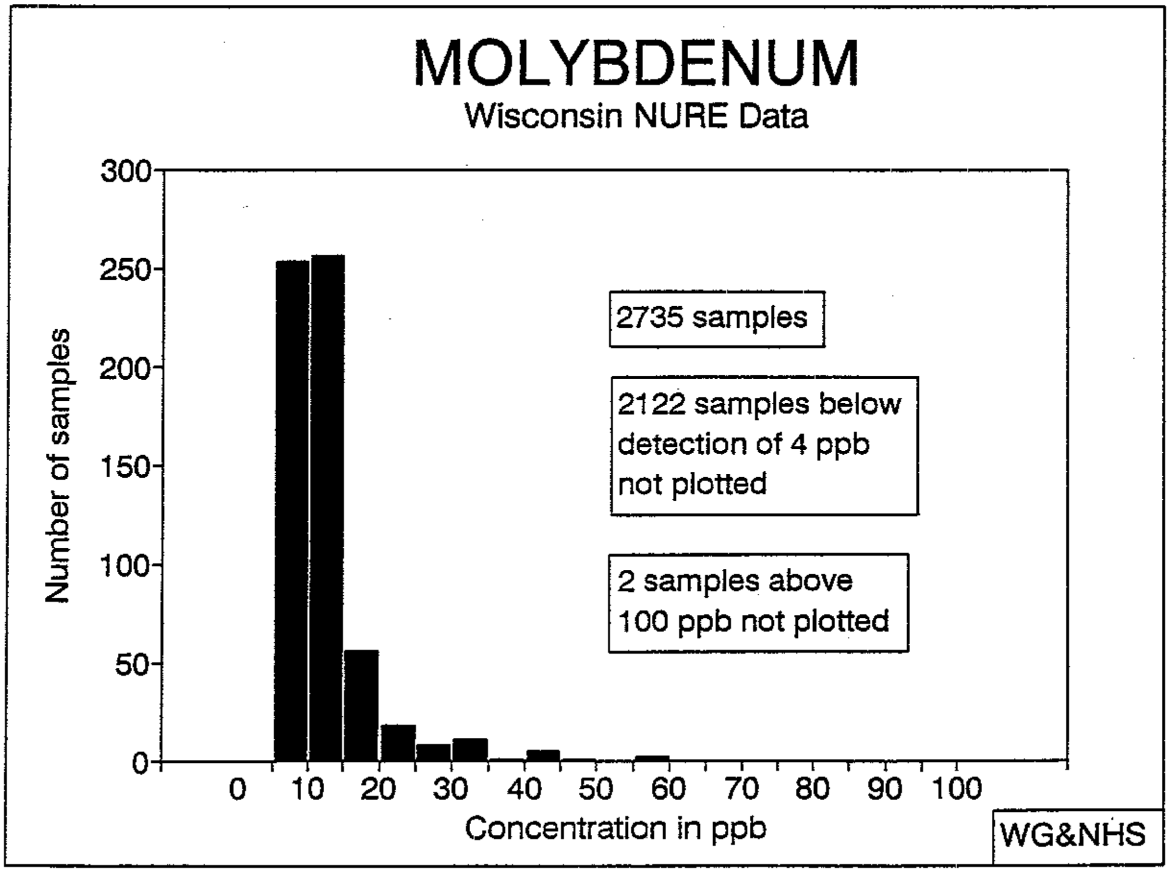
MANGANESE

Wisconsin NURE Data



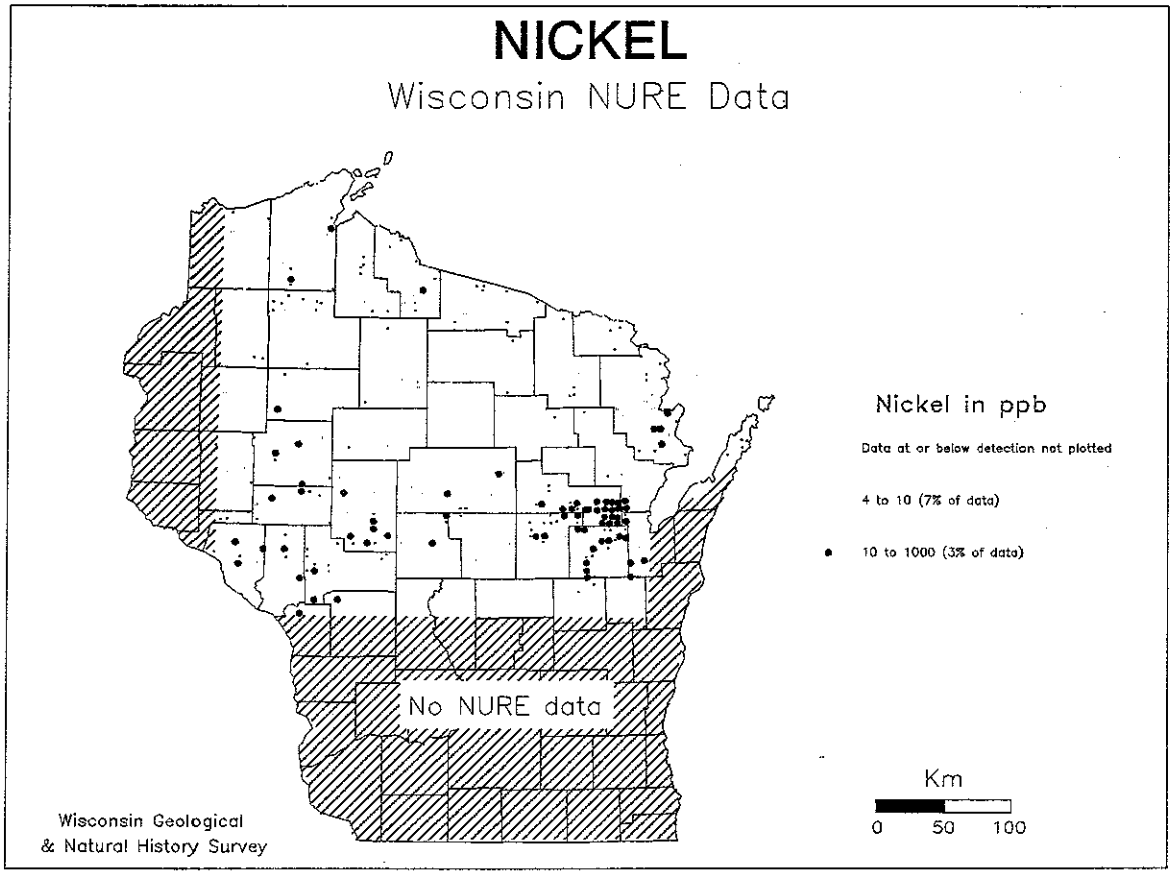
MOLYBDENUM

Wisconsin NURE Data



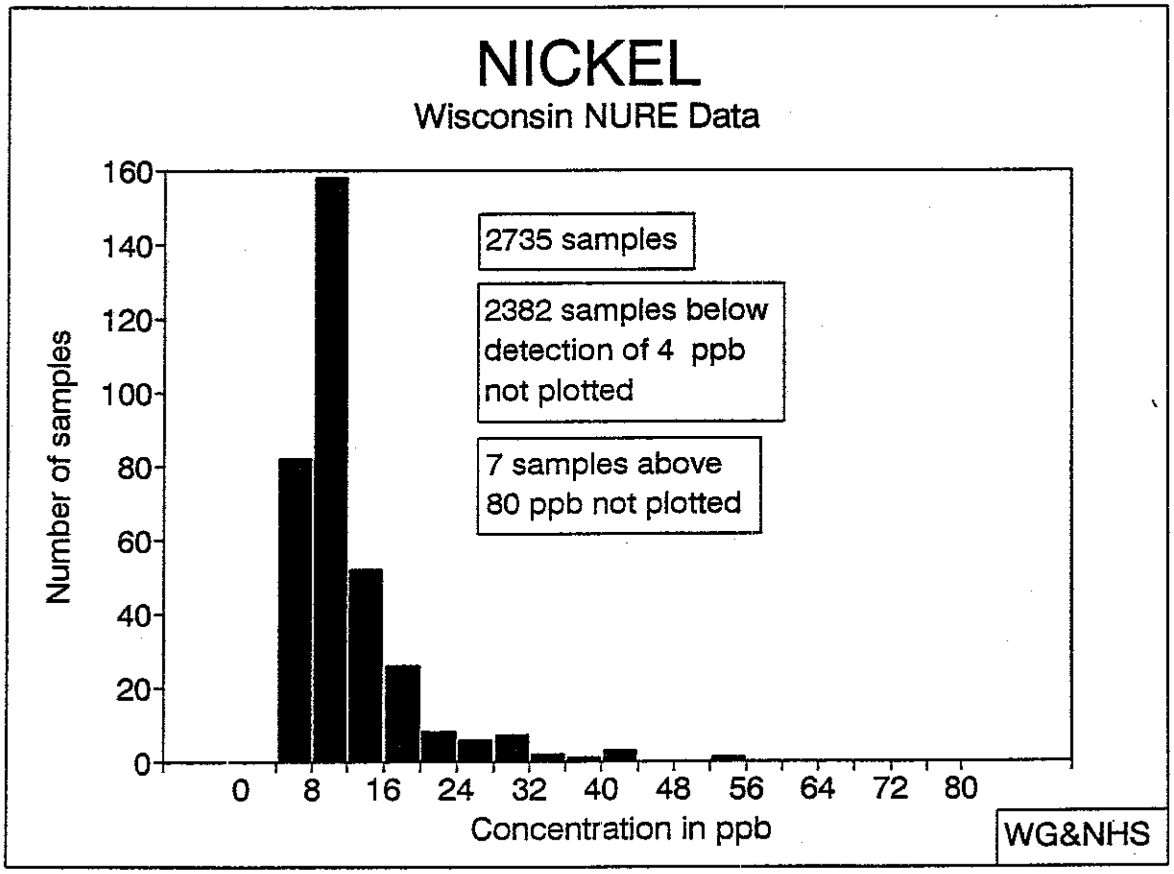
MOLYBDENUM

Wisconsin NURE Data



NICKEL

Wisconsin NURE Data



NICKEL

Wisconsin NURE Data

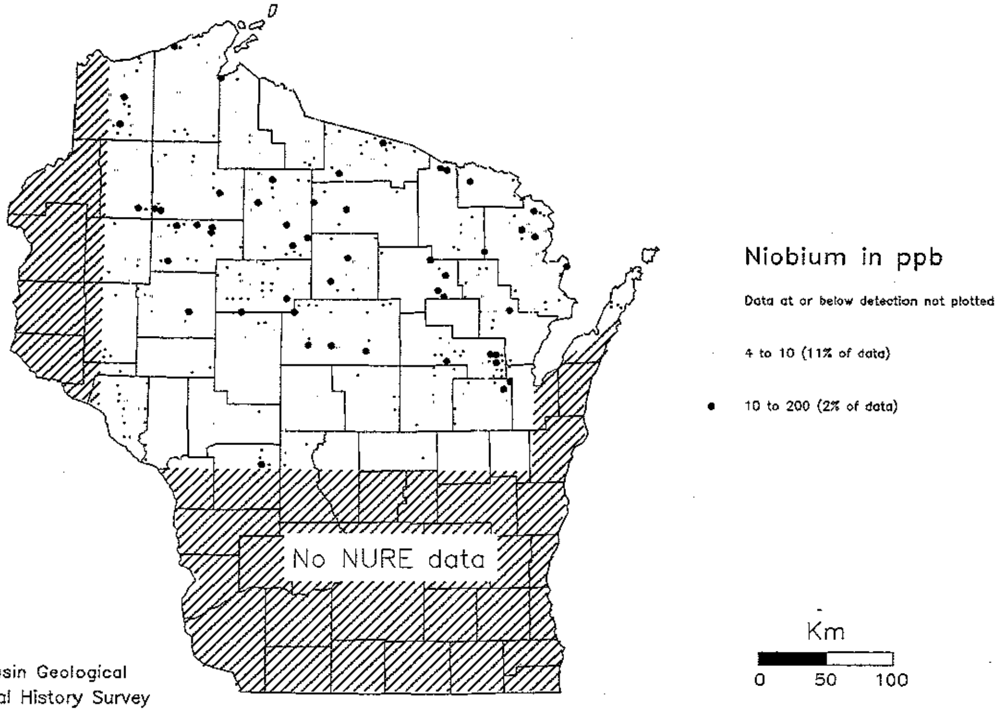
2735 samples

2382 samples below detection of 4 ppb not plotted

7 samples above 80 ppb not plotted

NIOBIUM

Wisconsin NURE Data



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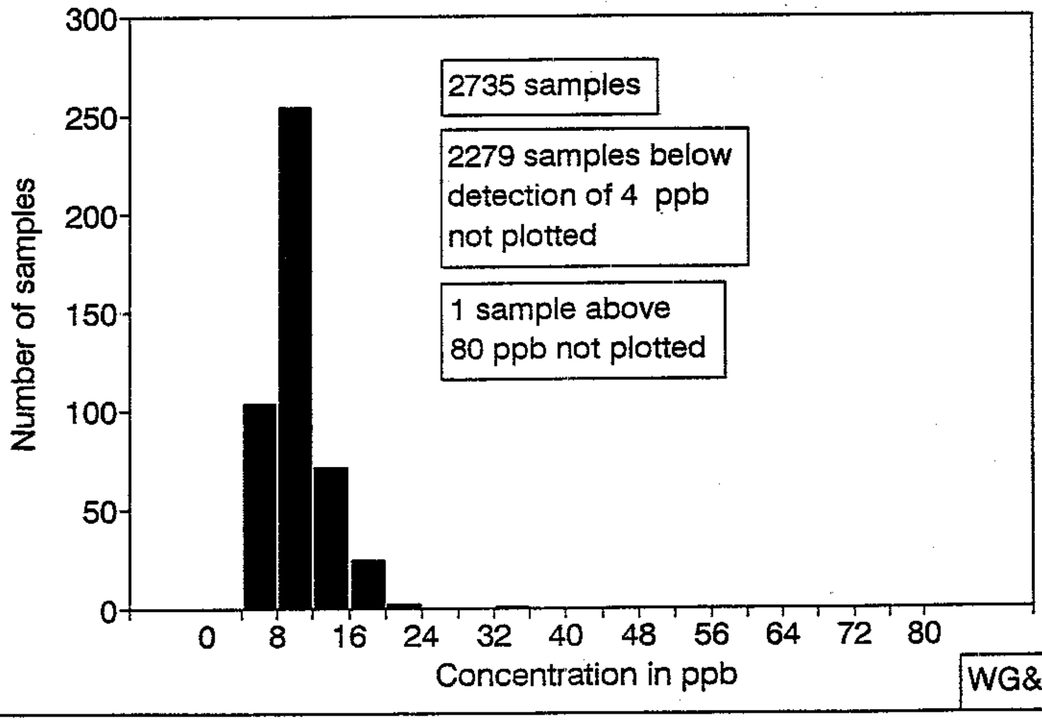
NIOBIUM

Wisconsin NURE Data



2735 samples

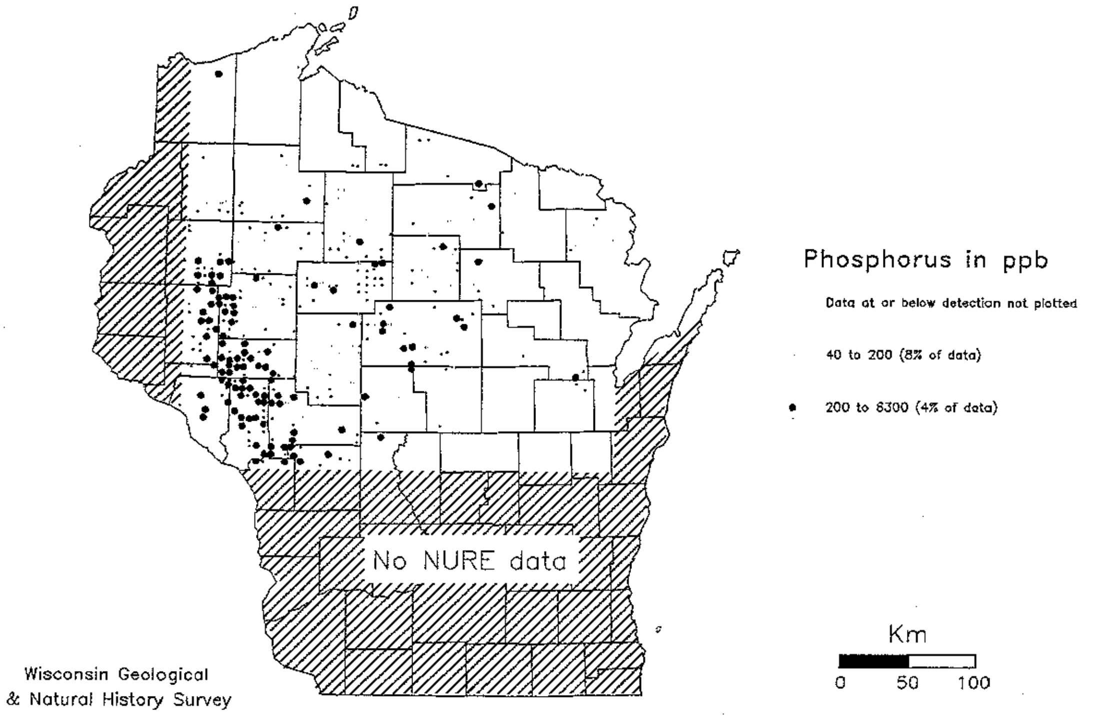
2279 samples below detection of 4 ppb not plotted

1 sample above 80 ppb not plotted

WG&NHS

PHOSPHORUS

Wisconsin NURE Data



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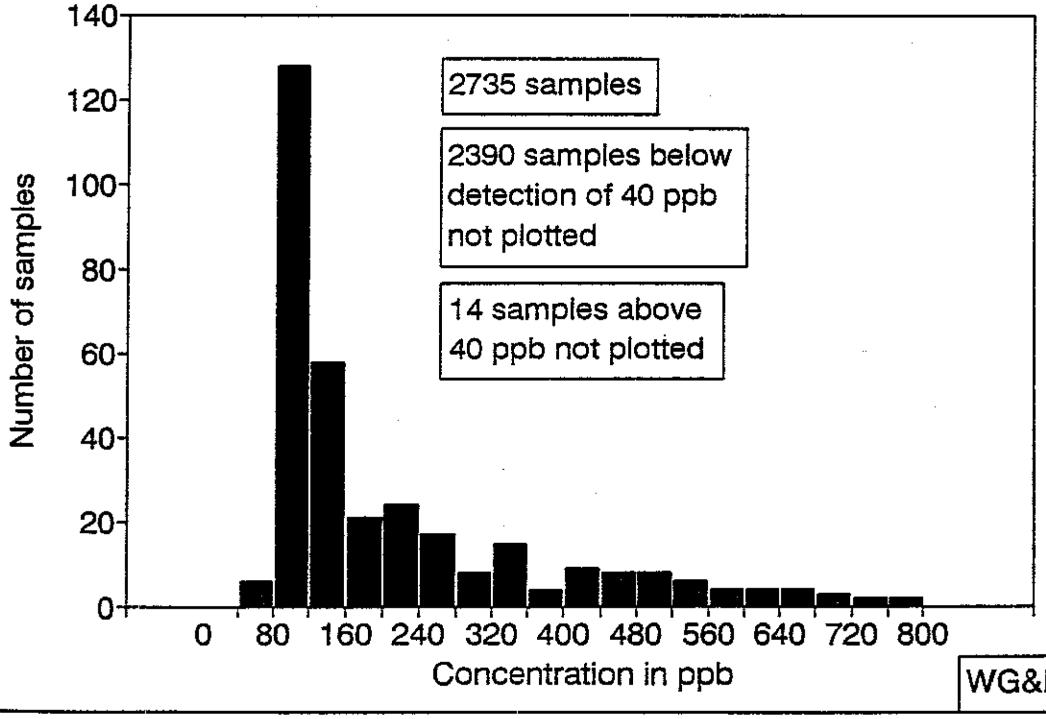
PHOSPHORUS

Wisconsin NURE Data

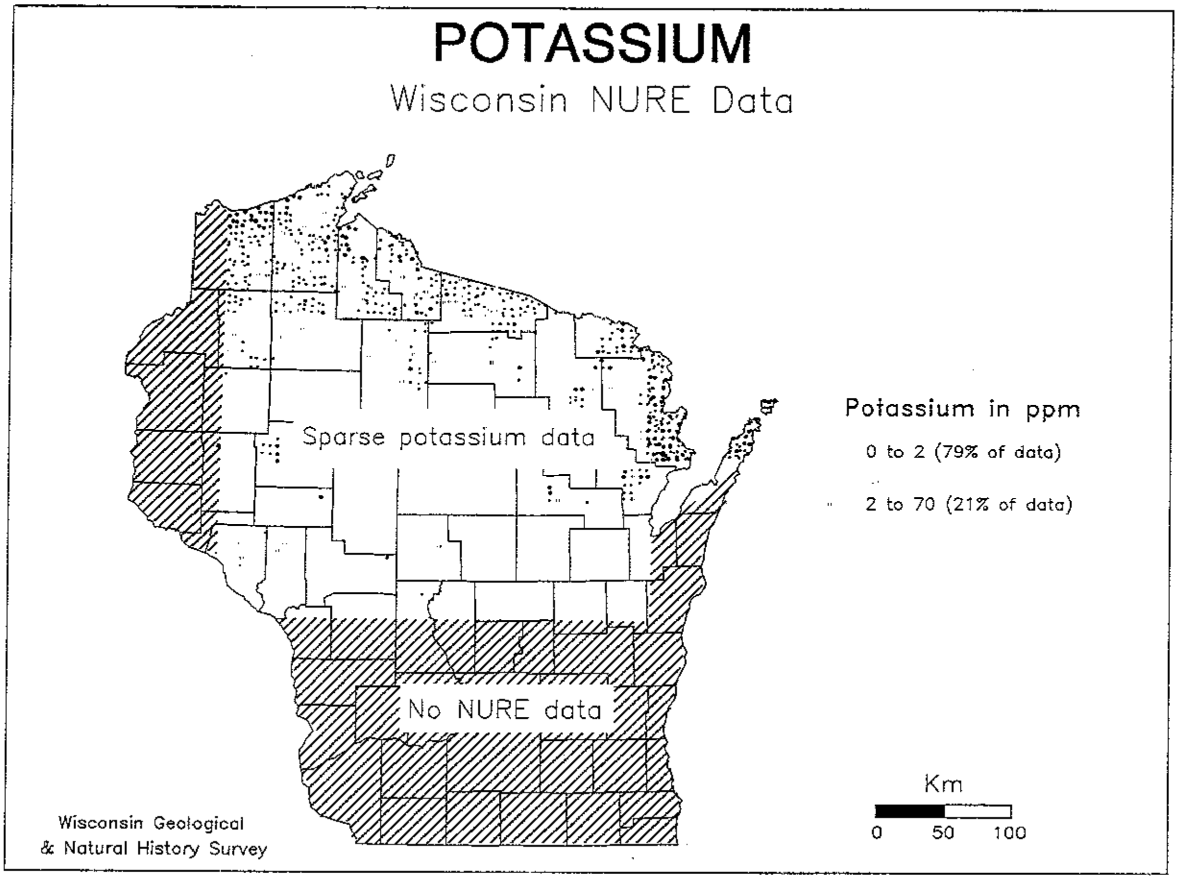


2735 samples

2390 samples below detection of 40 ppb not plotted

14 samples above 40 ppb not plotted

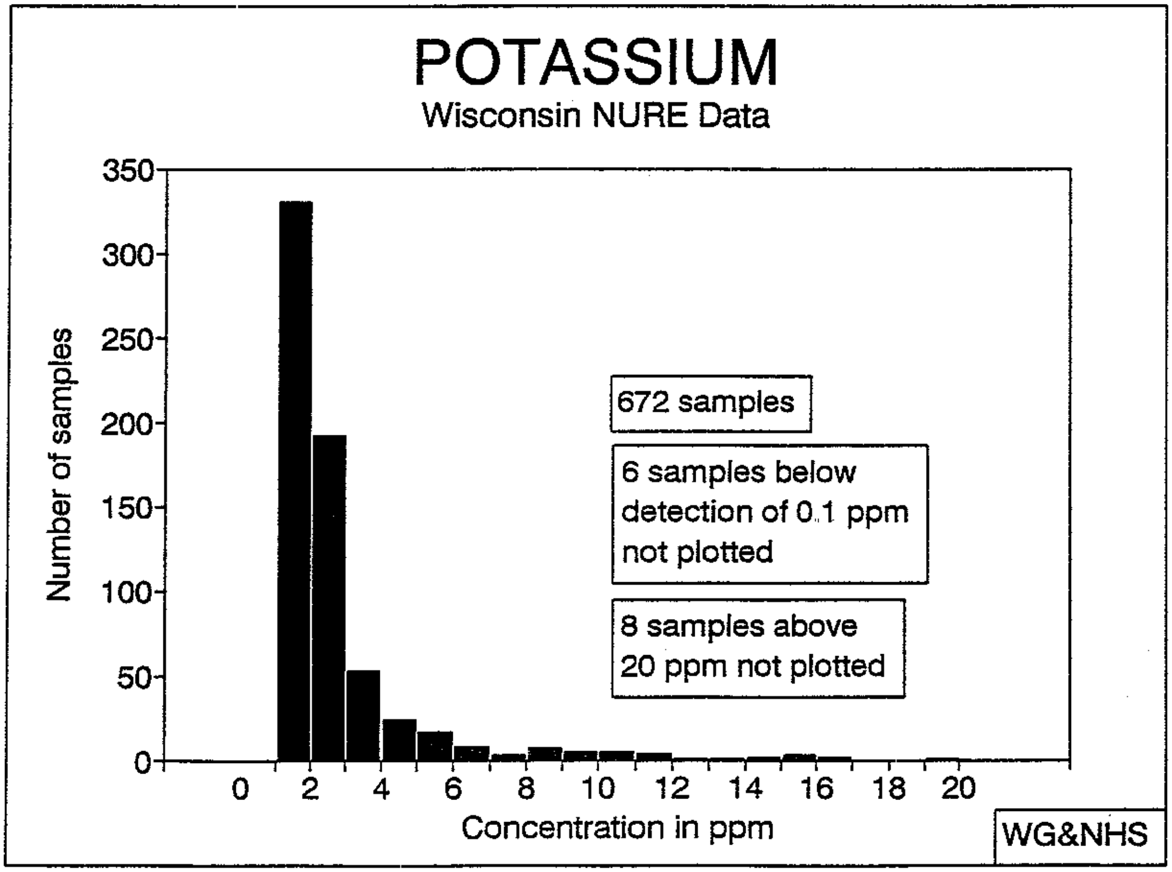
WG&NHS



POTASSIUM

Wisconsin NURE Data

Wisconsin Geological & Natural History Survey



POTASSIUM

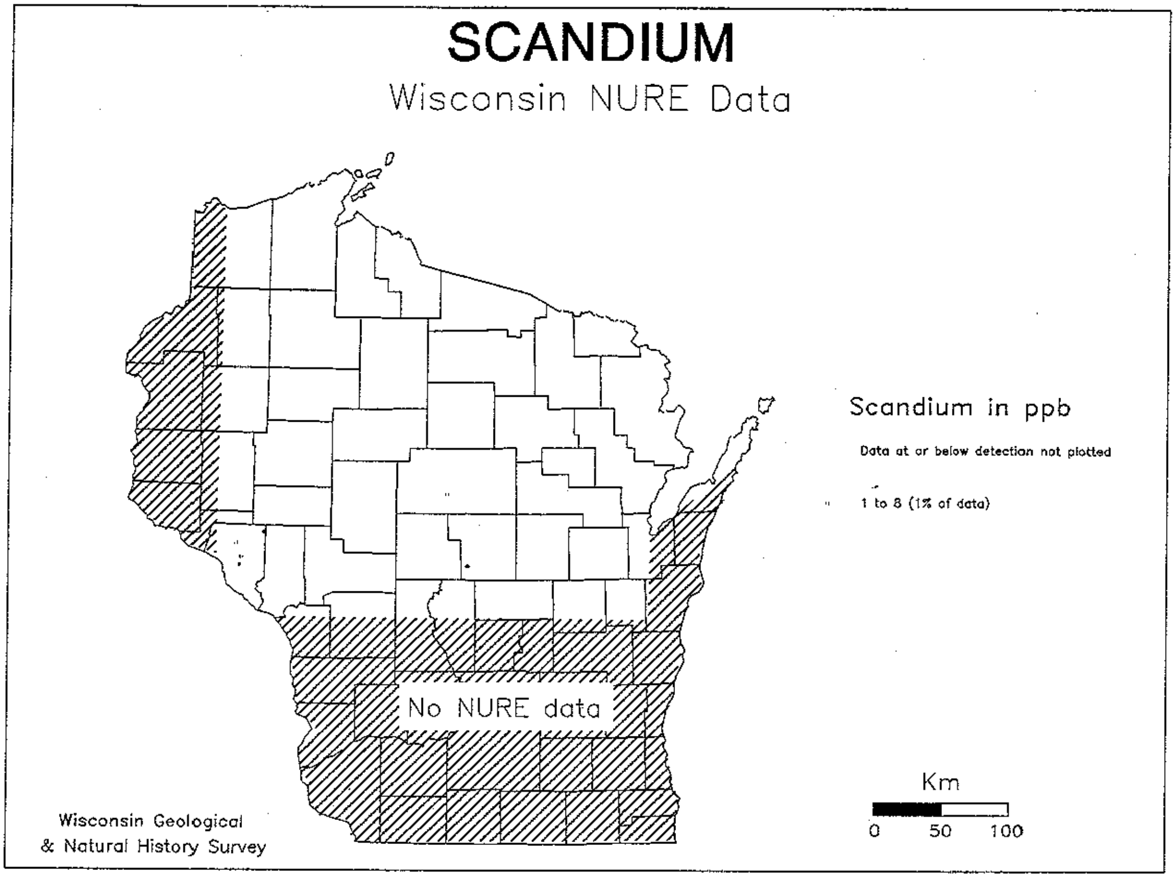
Wisconsin NURE Data

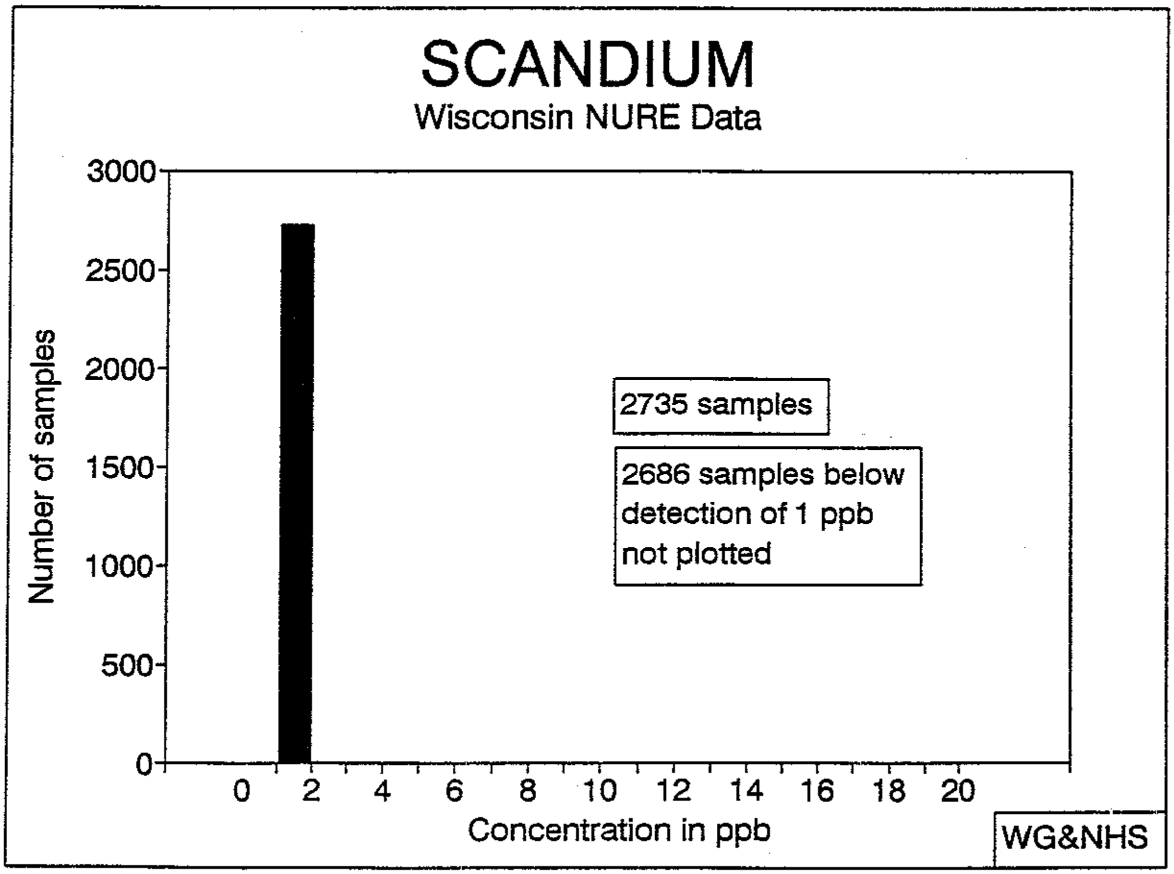
672 samples

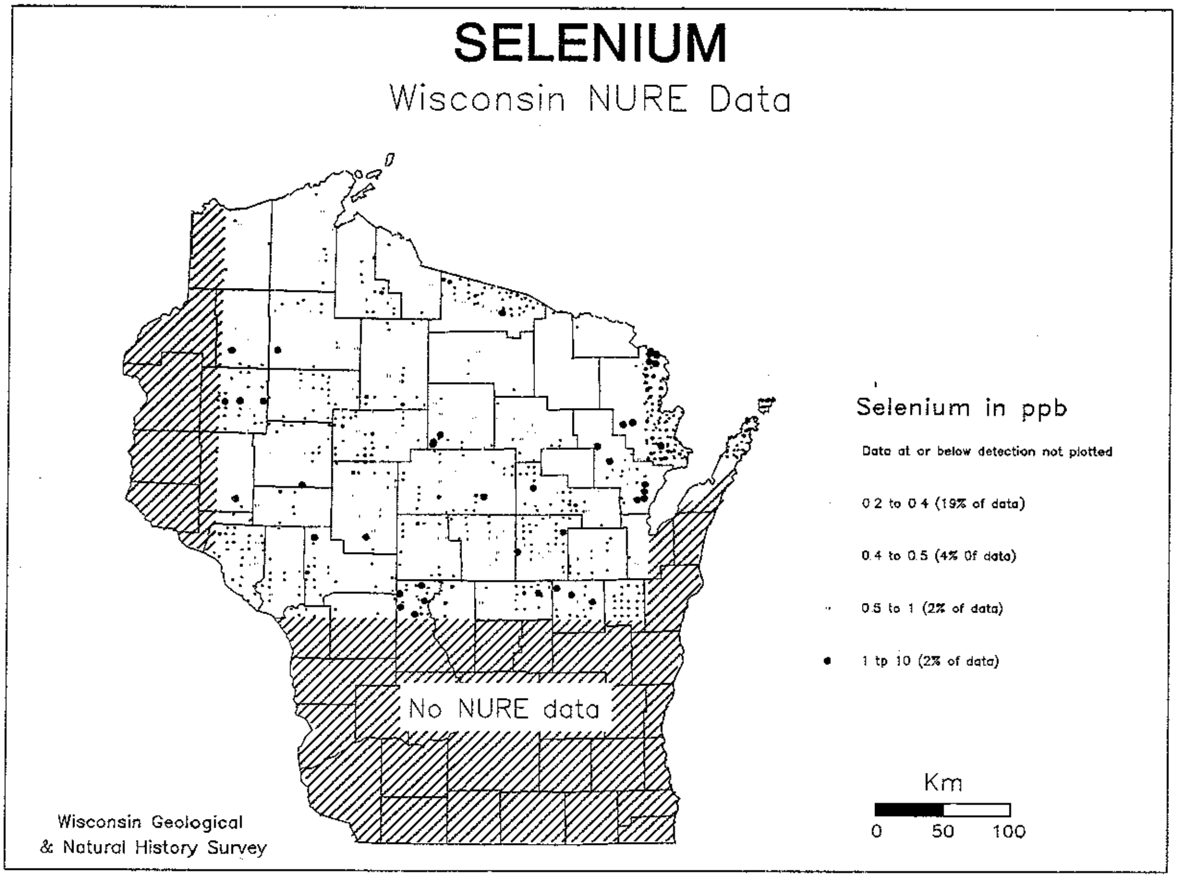
6 samples below detection of 0.1 ppm not plotted

8 samples above 20 ppm not plotted

WG&NHS

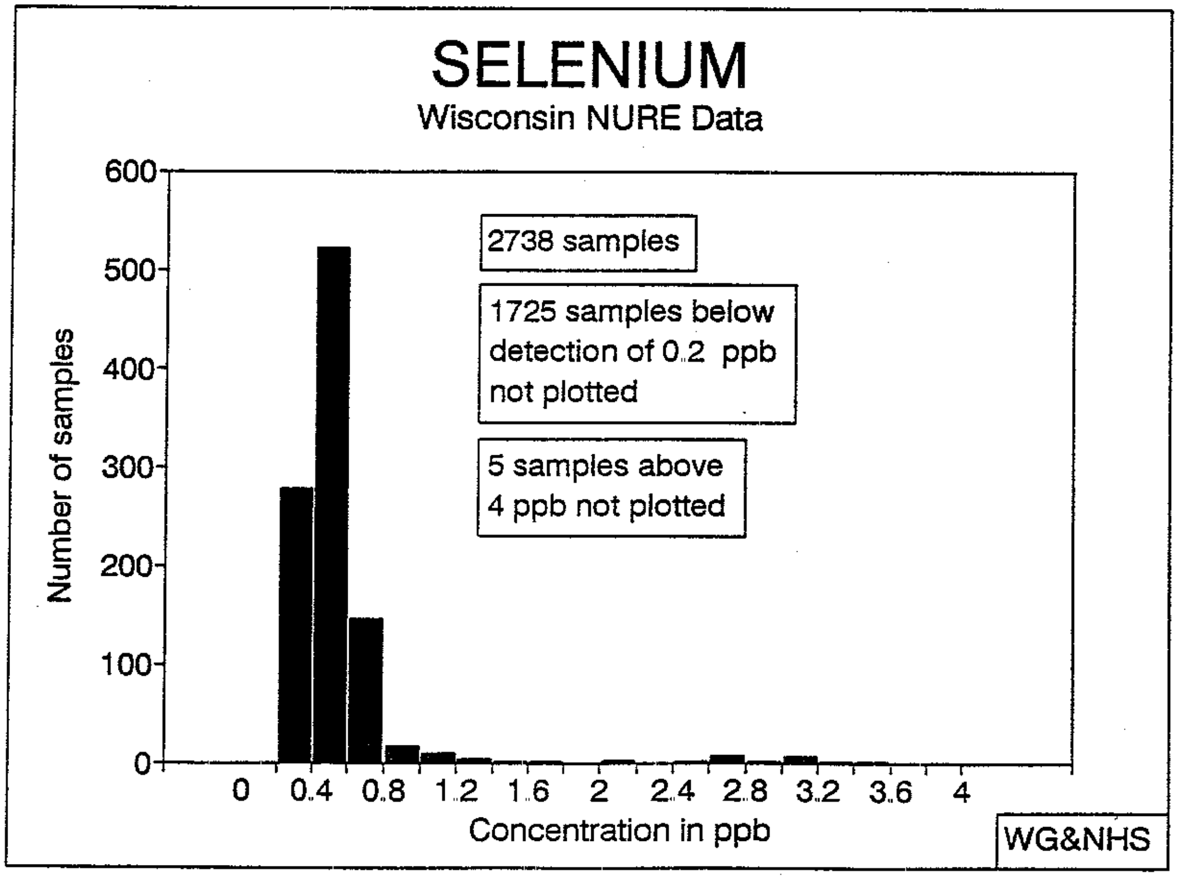

SCANDIUM
Wisconsin NURE Data
Scandium in ppb
Data at or below detection not plotted
1 to 8 (1% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


SCANDIUM
Wisconsin NURE Data
Number of samples
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
Concentration in ppb
2735 samples
2686 samples below detection of 1 ppb not plotted
WG&NHS



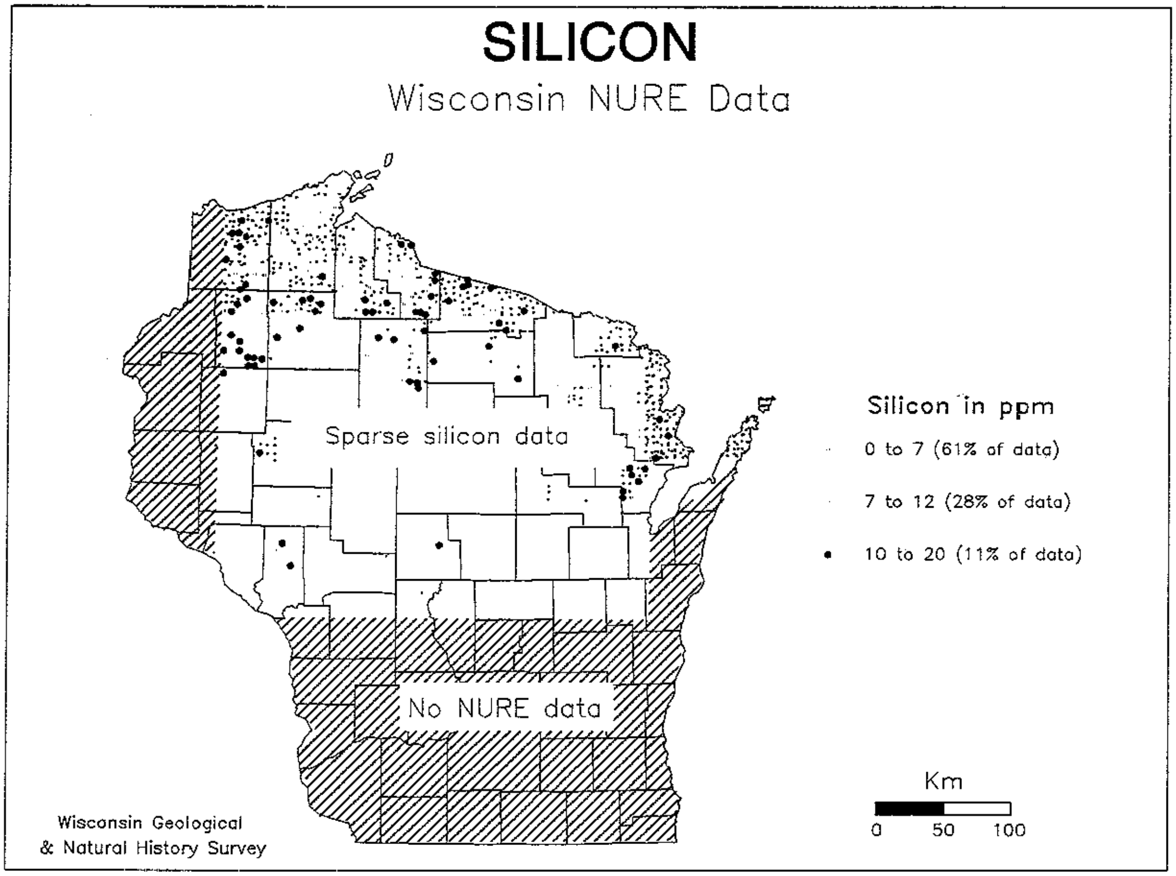
SELENIUM

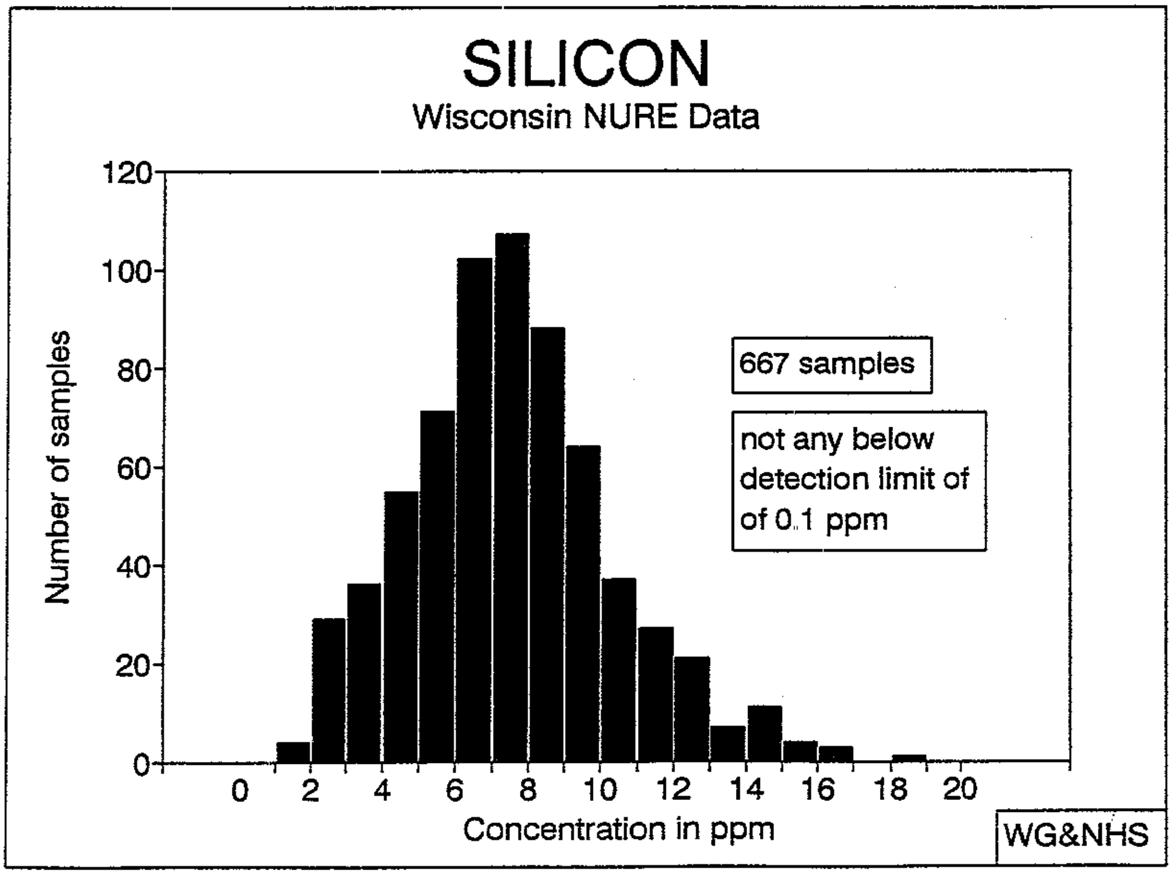
Wisconsin NURE Data

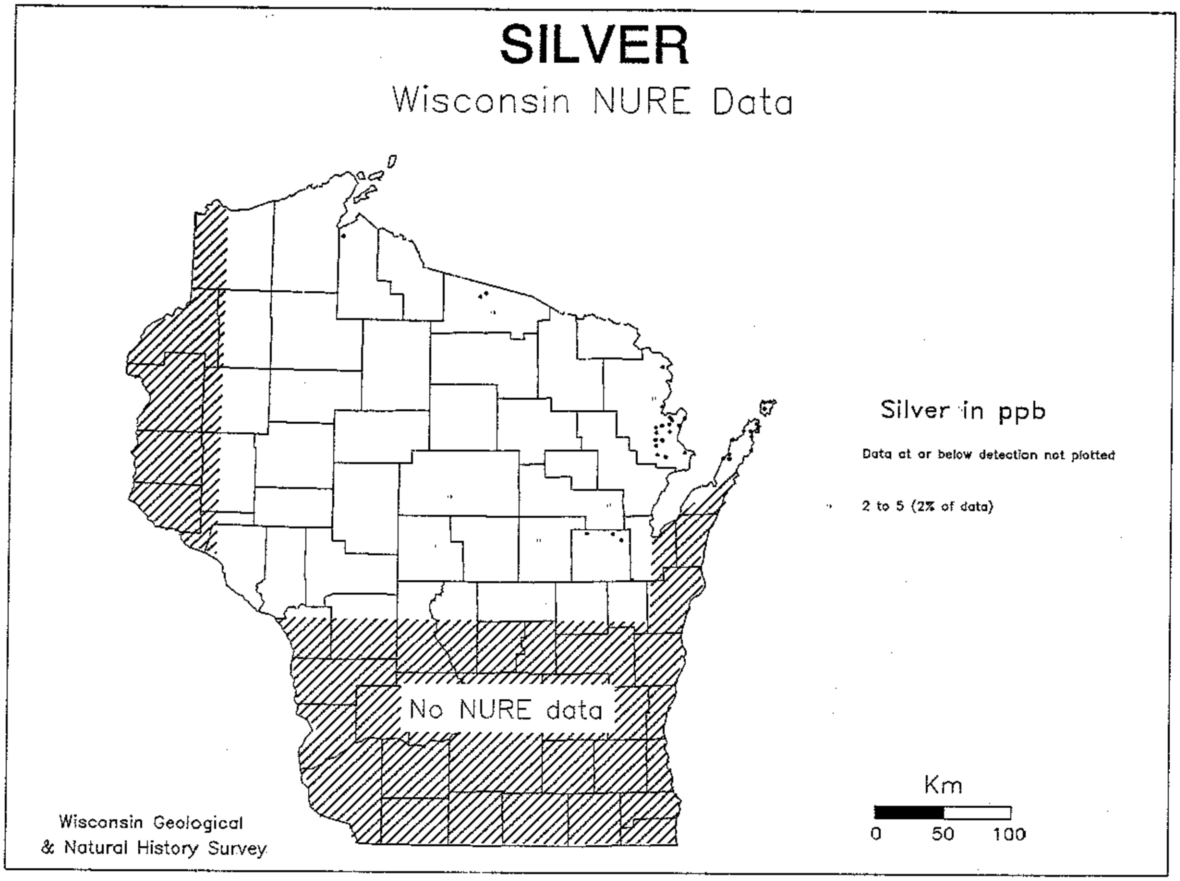


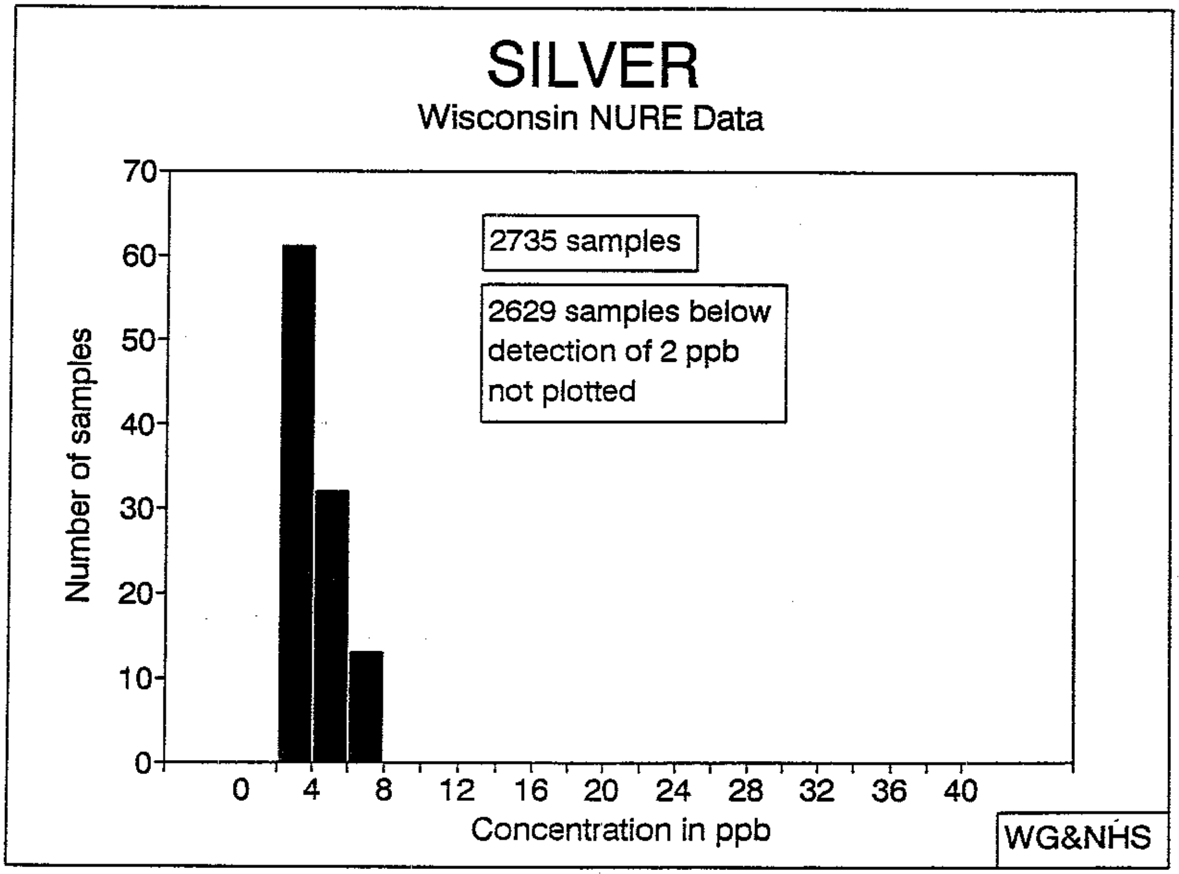
SELENIUM

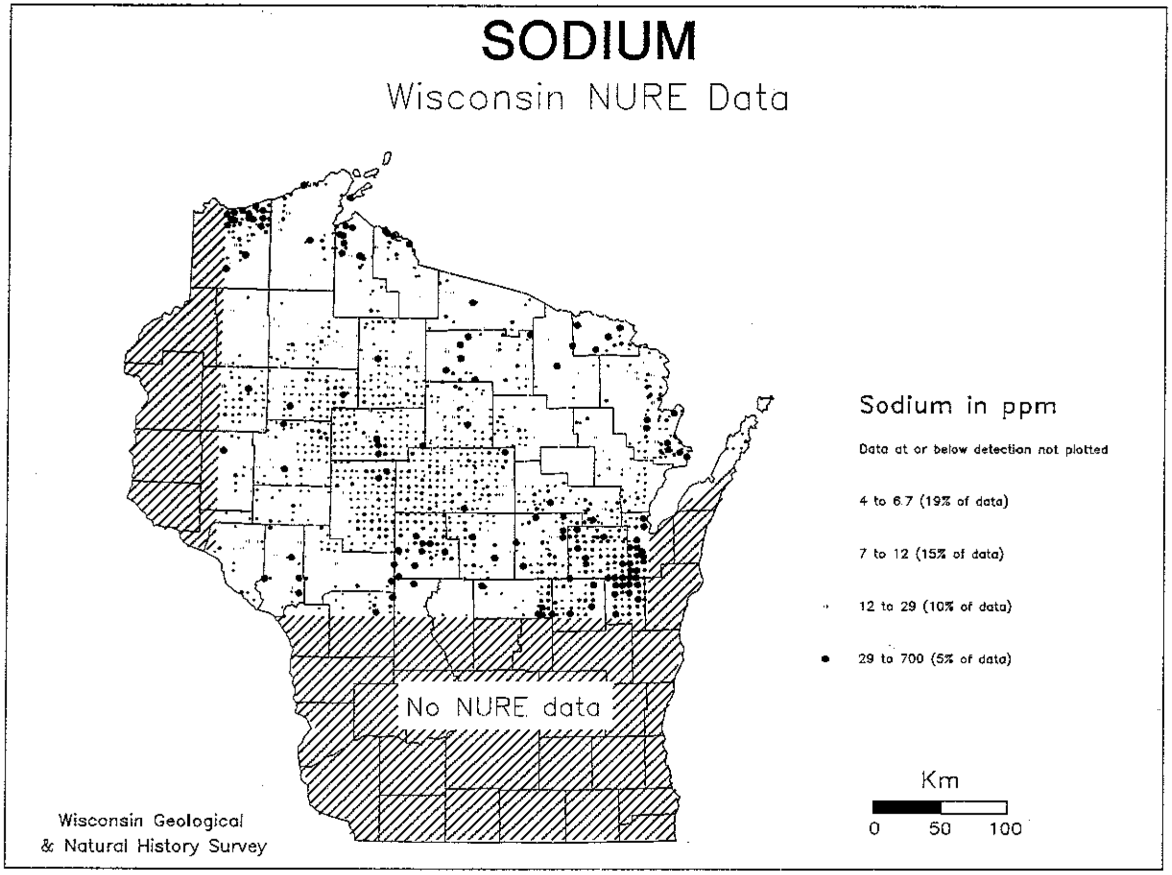
Wisconsin NURE Data


SILICON
Wisconsin NURE Data
Sparse silicon data
No NURE data
Silicon in ppm
· 0 to 7 (61% of data)
· 7 to 12 (28% of data)
● 10 to 20 (11% of data)
Km
0 50 100
Wisconsin Geological
& Natural History Survey


SILICON
Wisconsin NURE Data
Number of samples
0
20
40
60
80
100
120
0 2 4 6 8 10 12 14 16 18 20
Concentration in ppm
667 samples
not any below detection limit of of 0.1 ppm
WG&NHS

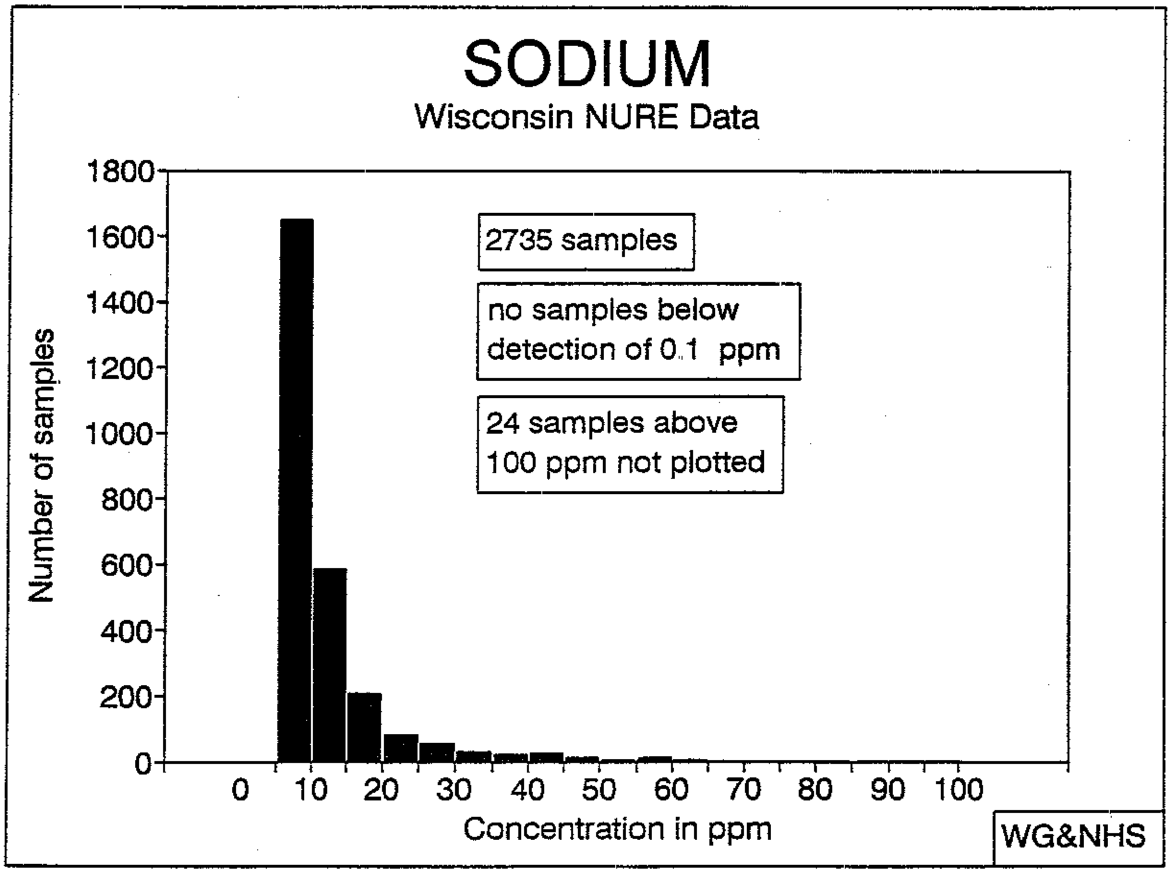

SILVER
Wisconsin NURE Data
No NURE data
Silver in ppb
Data at or below detection not plotted
2 to 5 (2% of data)
Km
0
50
100
Wisconsin Geological
& Natural History Survey


SILVER
Wisconsin NURE Data
2735 samples
2629 samples below detection of 2 ppb not plotted
Number of samples
0
10
20
30
40
50
60
70
0
4
8
12
16
20
24
28
32
36
40
Concentration in ppb
WG&NHS



SODIUM

Wisconsin NURE Data



SODIUM

Wisconsin NURE Data

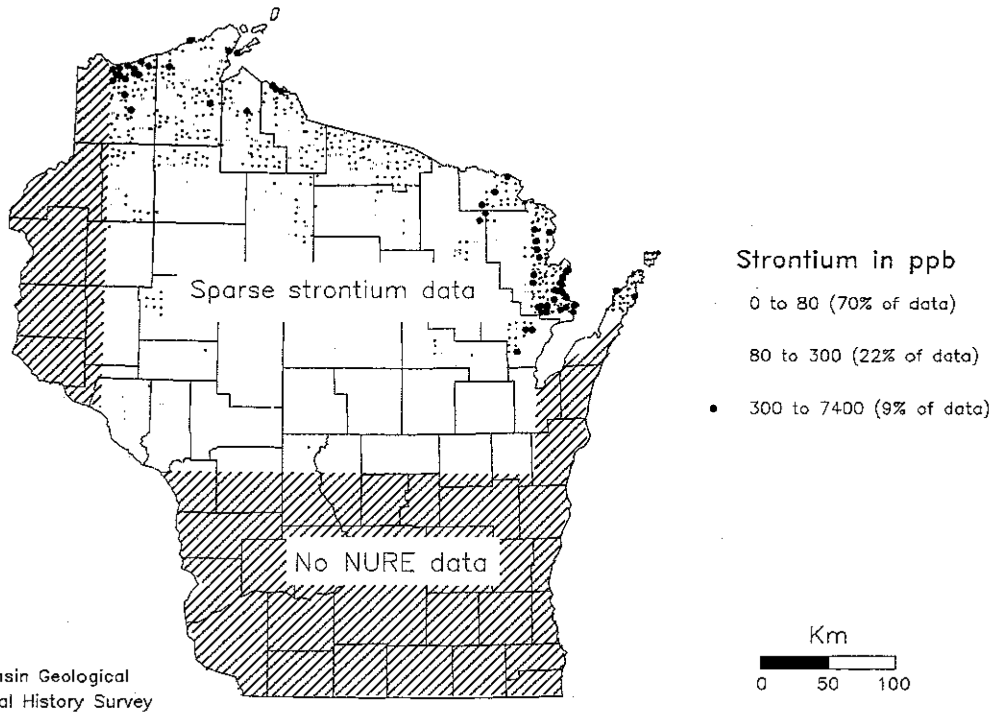
2735 samples

no samples below detection of 0.1 ppm

24 samples above 100 ppm not plotted

STRONTIUM

Wisconsin NURE Data



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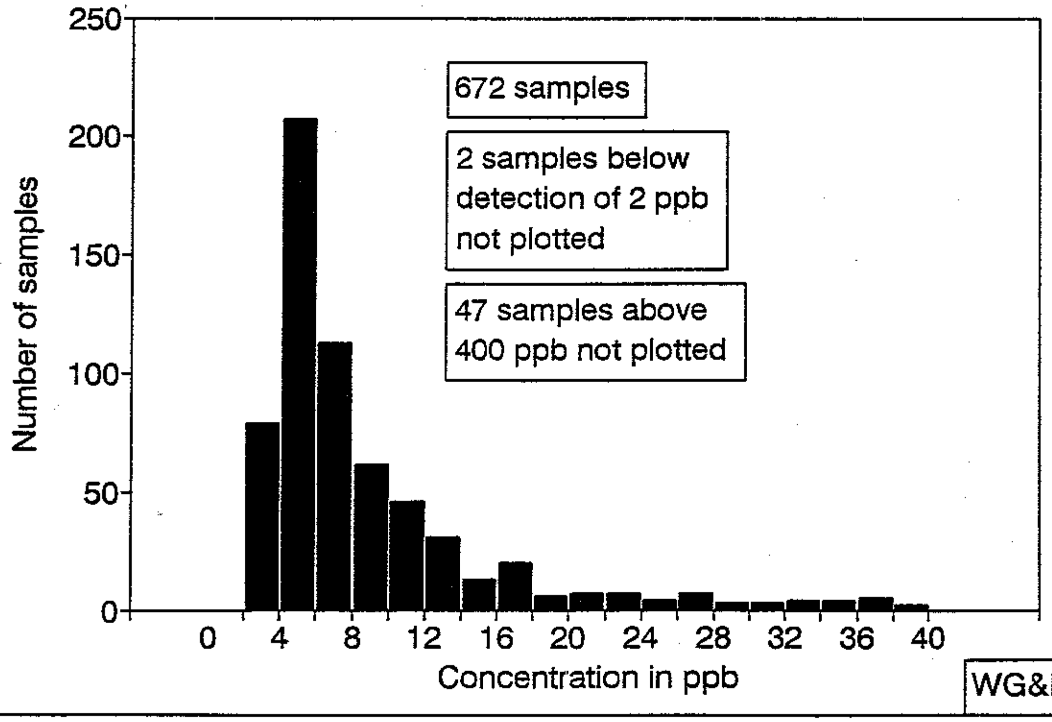
STRONTIUM

Wisconsin NURE Data

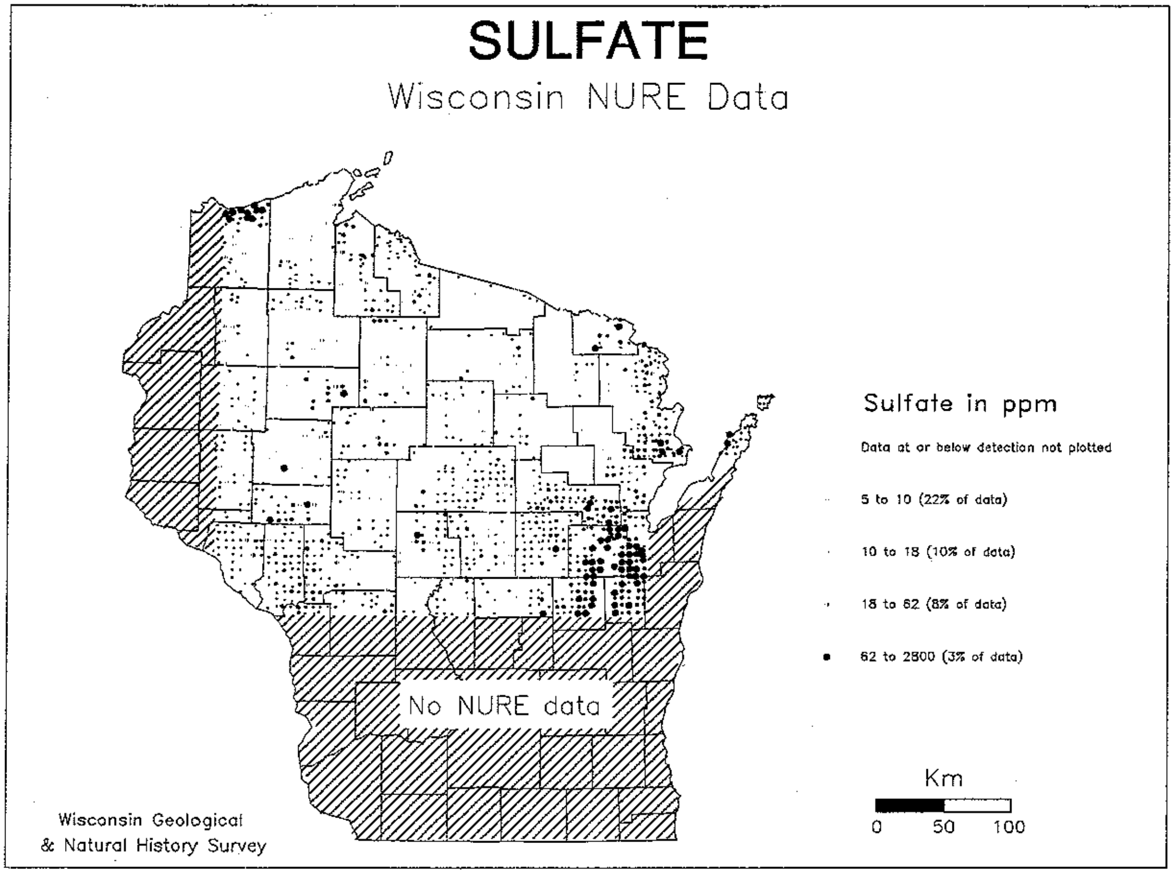


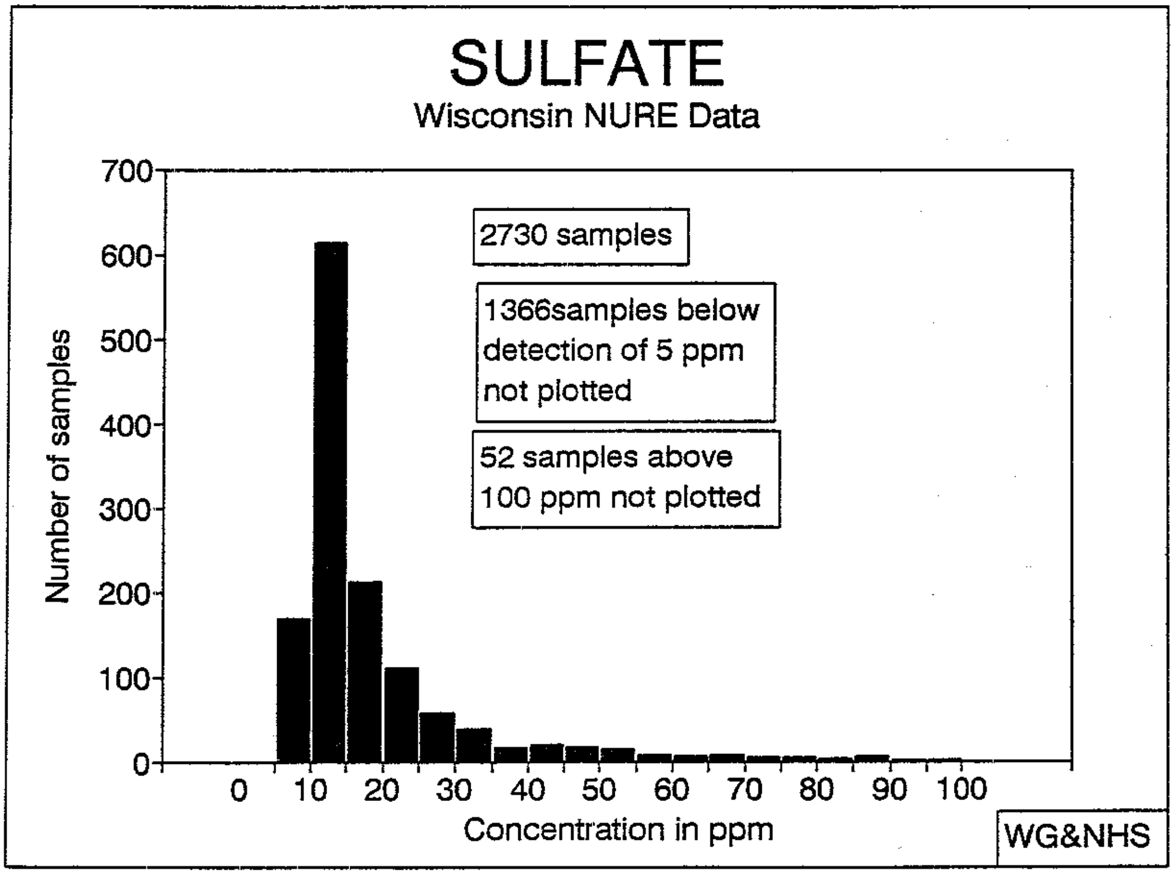
672 samples

2 samples below detection of 2 ppb not plotted

47 samples above 400 ppb not plotted

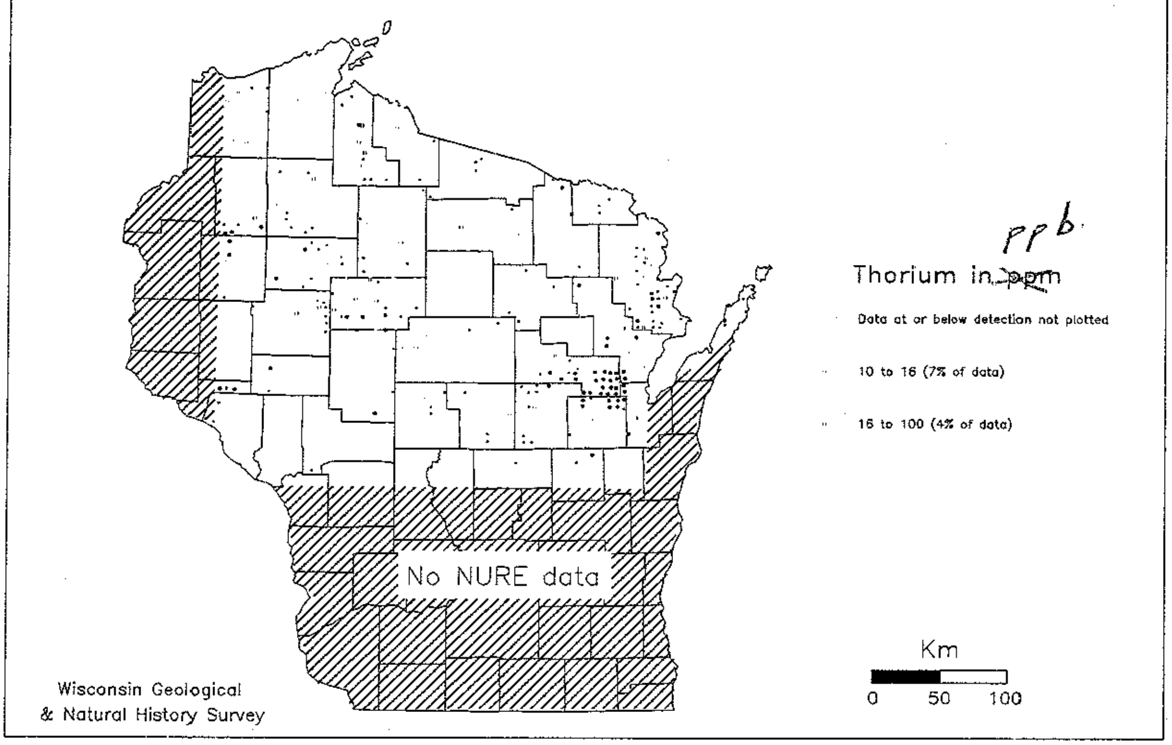
WG&NHS


SULFATE
Wisconsin NURE Data
Sulfate in ppm
Data at or below detection not plotted
5 to 10 (22% of data)
10 to 18 (10% of data)
18 to 62 (8% of data)
62 to 2800 (3% of data)
No NURE data
Km
0
50
100
Wisconsin Geological
& Natural History Survey


SULFATE
Wisconsin NURE Data
2730 samples
1366samples below detection of 5 ppm not plotted
52 samples above 100 ppm not plotted
Number of samples
0
100
200
300
400
500
600
700
Concentration in ppm
0
10
20
30
40
50
60
70
80
90
100
WG&NHS

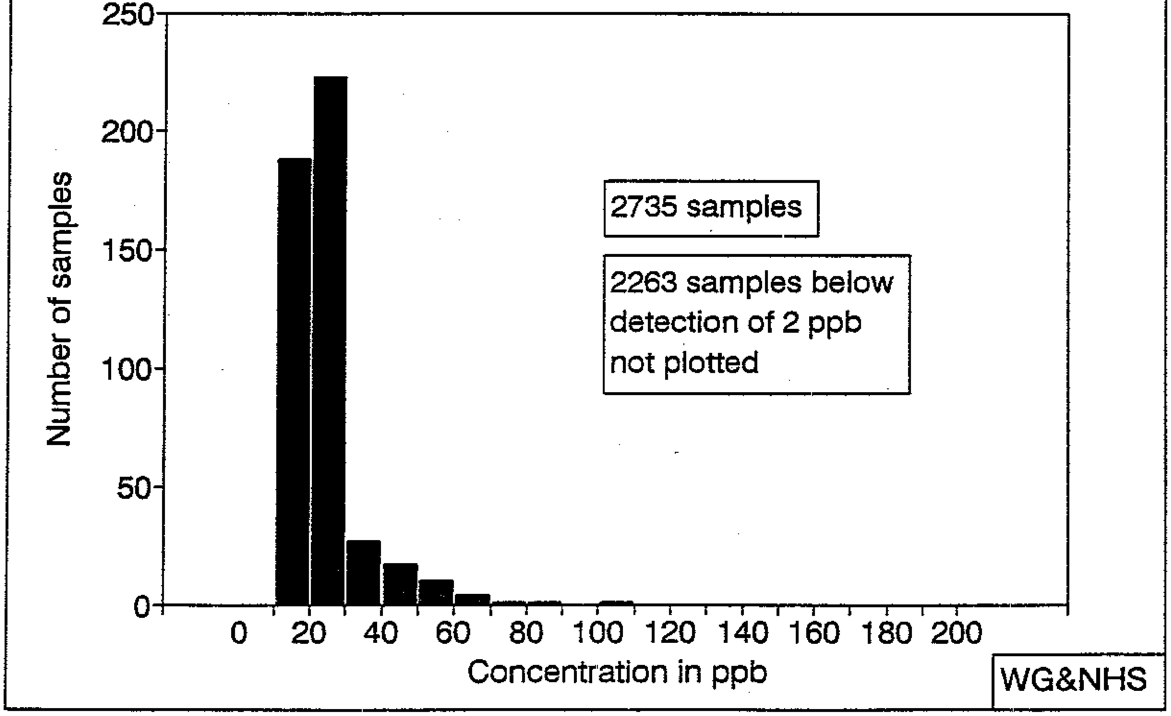
THORIUM

Wisconsin NURE Data



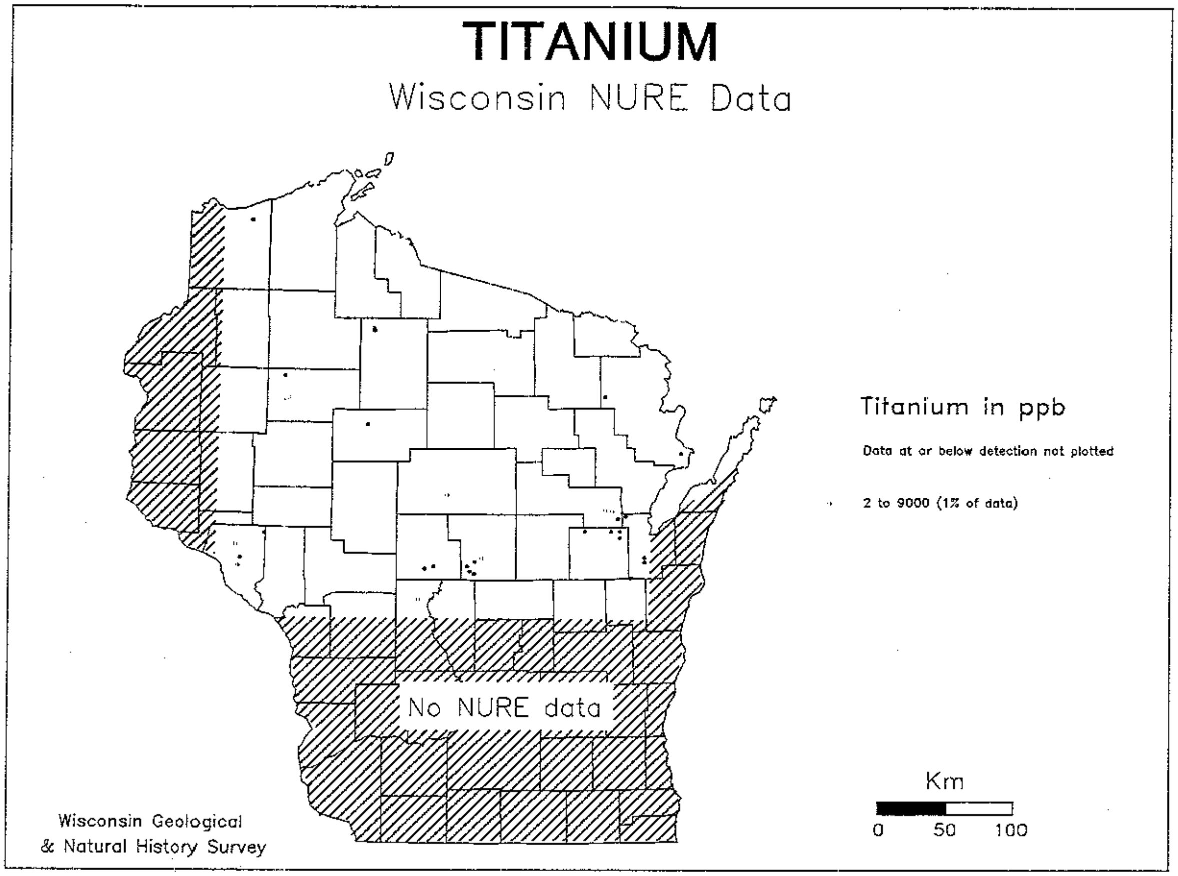
THORIUM

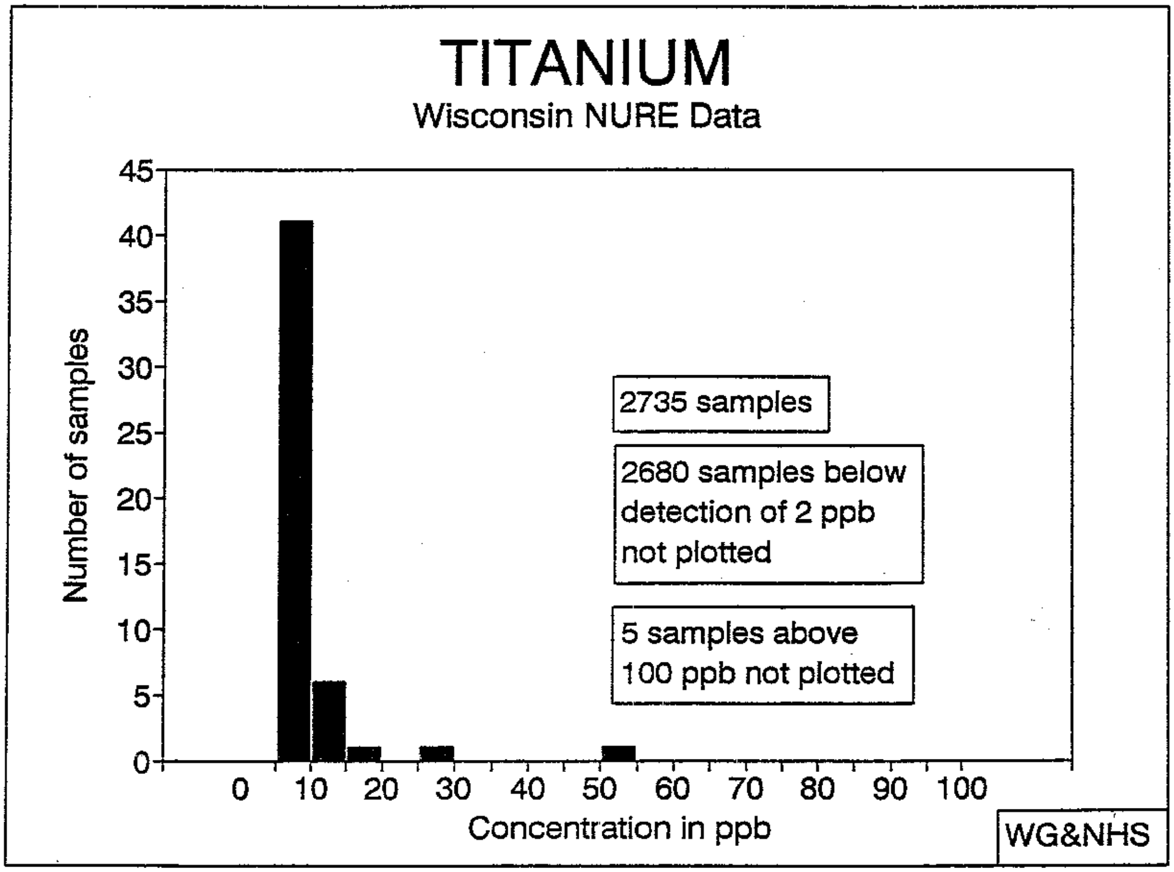
Wisconsin NURE Data



2735 samples

2263 samples below detection of 2 ppb not plotted





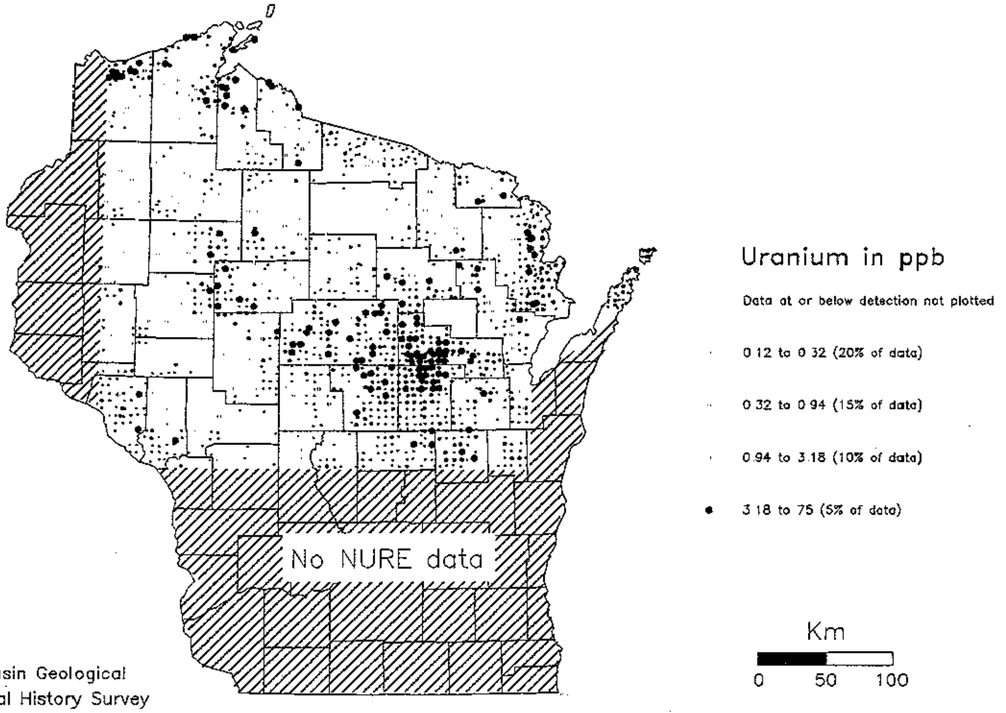
2735 samples

2680 samples below detection of 2 ppb not plotted

5 samples above 100 ppb not plotted

URANIUM

Wisconsin NURE Data



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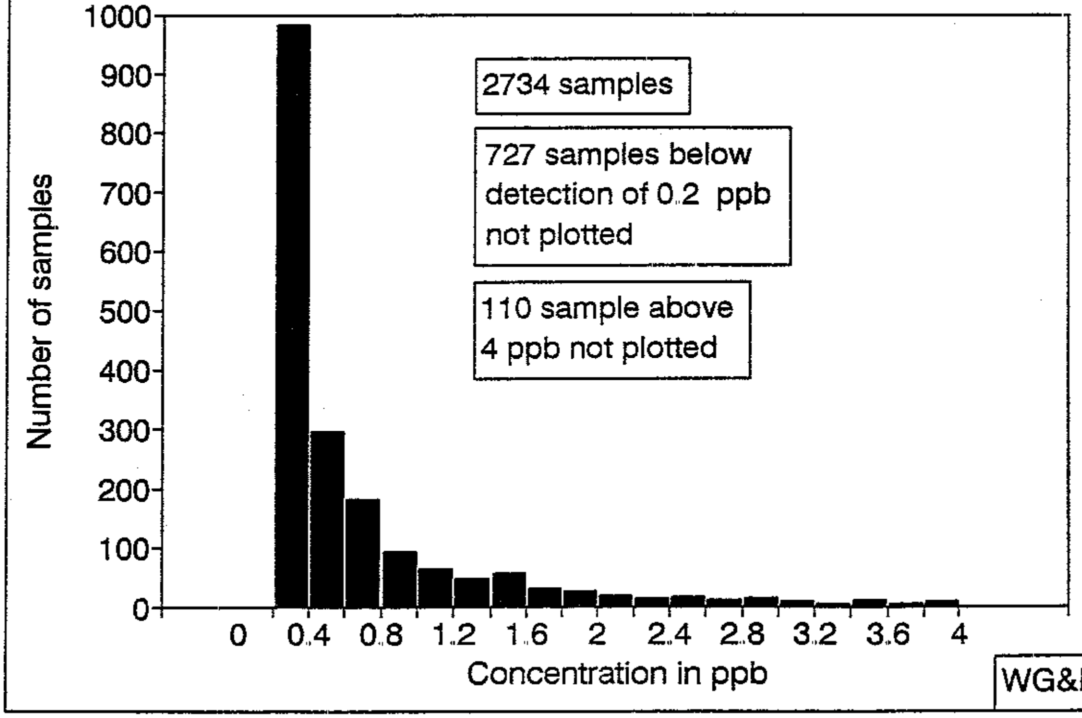
URANIUM

Wisconsin NURE Data

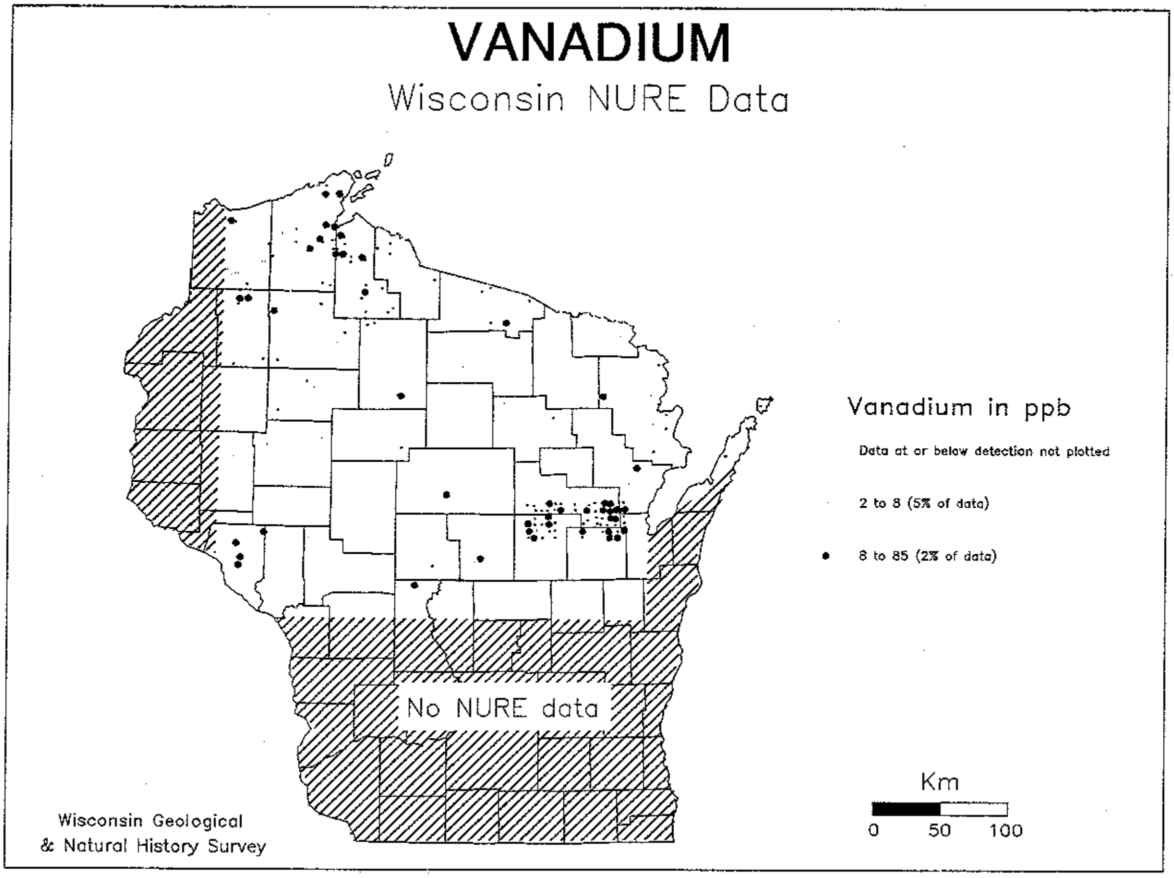


2734 samples

727 samples below detection of 0.2 ppb not plotted

110 sample above 4 ppb not plotted

WG&NHS


VANADIUM
Wisconsin NURE Data
Vanadium in ppb
Data at or below detection not plotted
2 to 8 (5% of data)
● 8 to 85 (2% of data)
No NURE data
Km
0 50 100
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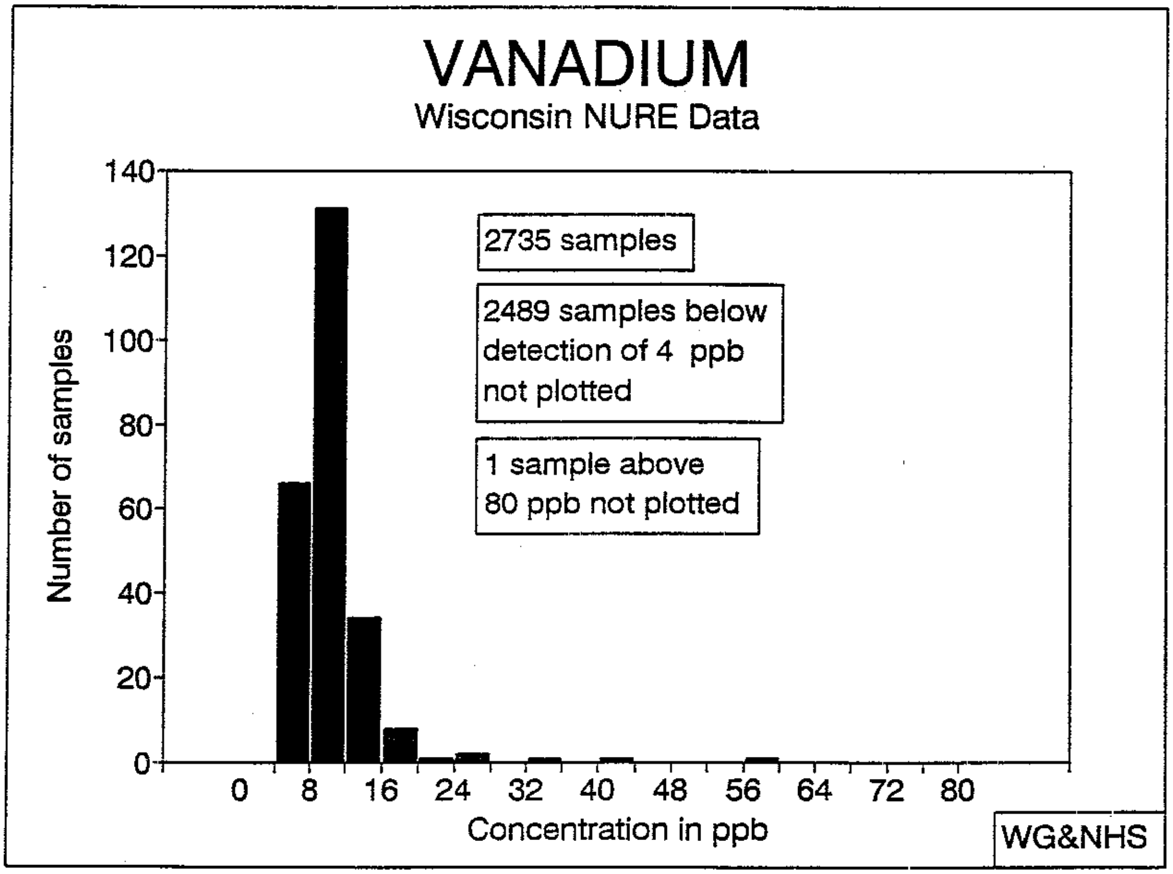
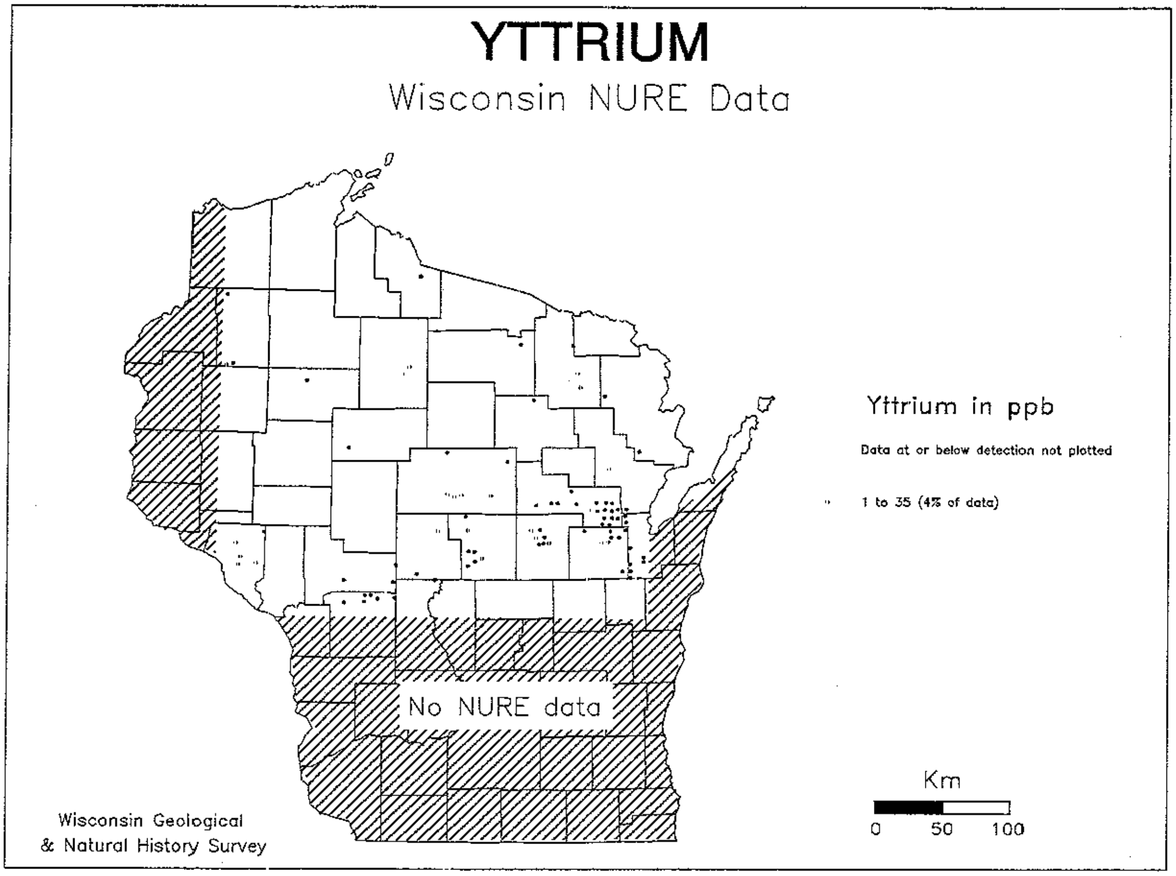

VANADIUM
Wisconsin NURE Data
Number of samples
0
20
40
60
80
100
120
140
0 8 16 24 32 40 48 56 64 72 80
Concentration in ppb
2735 samples
2489 samples below detection of 4 ppb not plotted
1 sample above 80 ppb not plotted
WG&NHS


YTTRIUM
Wisconsin NURE Data
Yttrium in ppb
Data at or below detection not plotted
1 to 35 (4% of data)
No NURE data
Km
0
50
100
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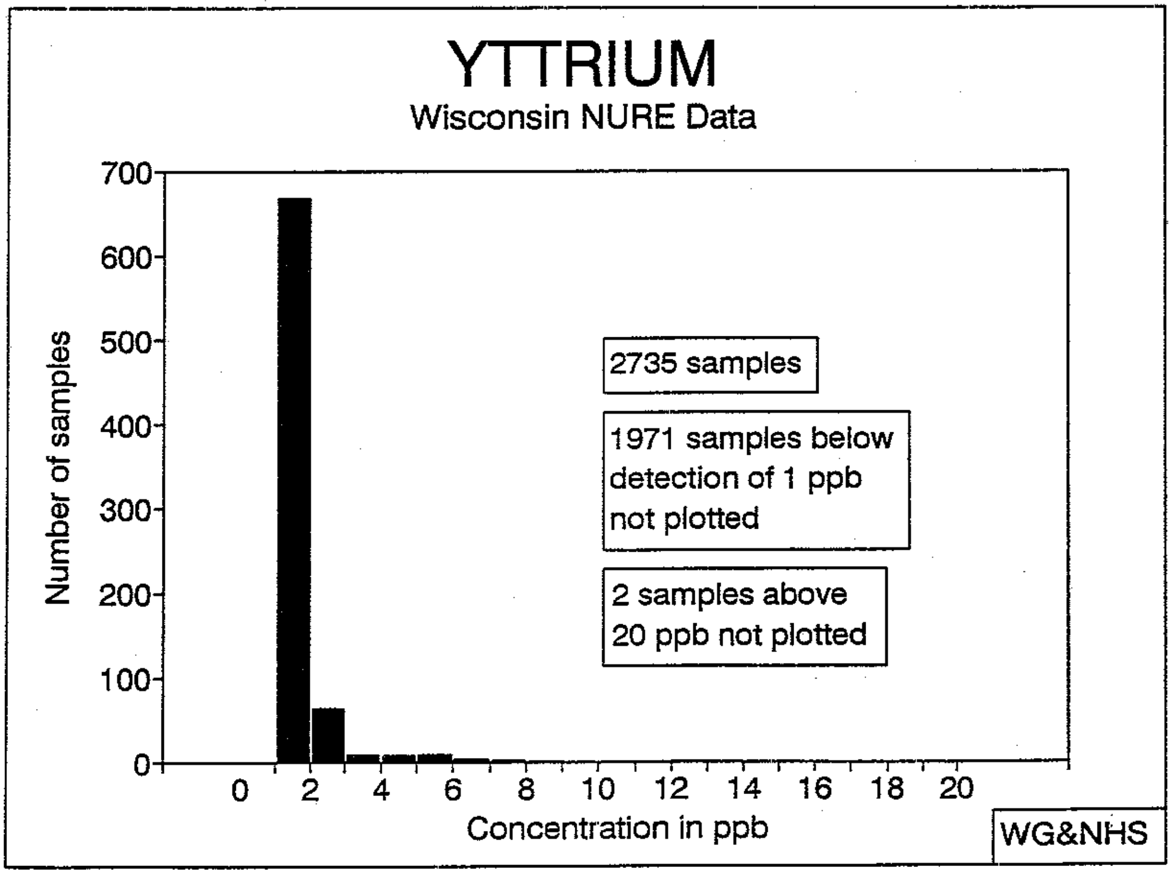
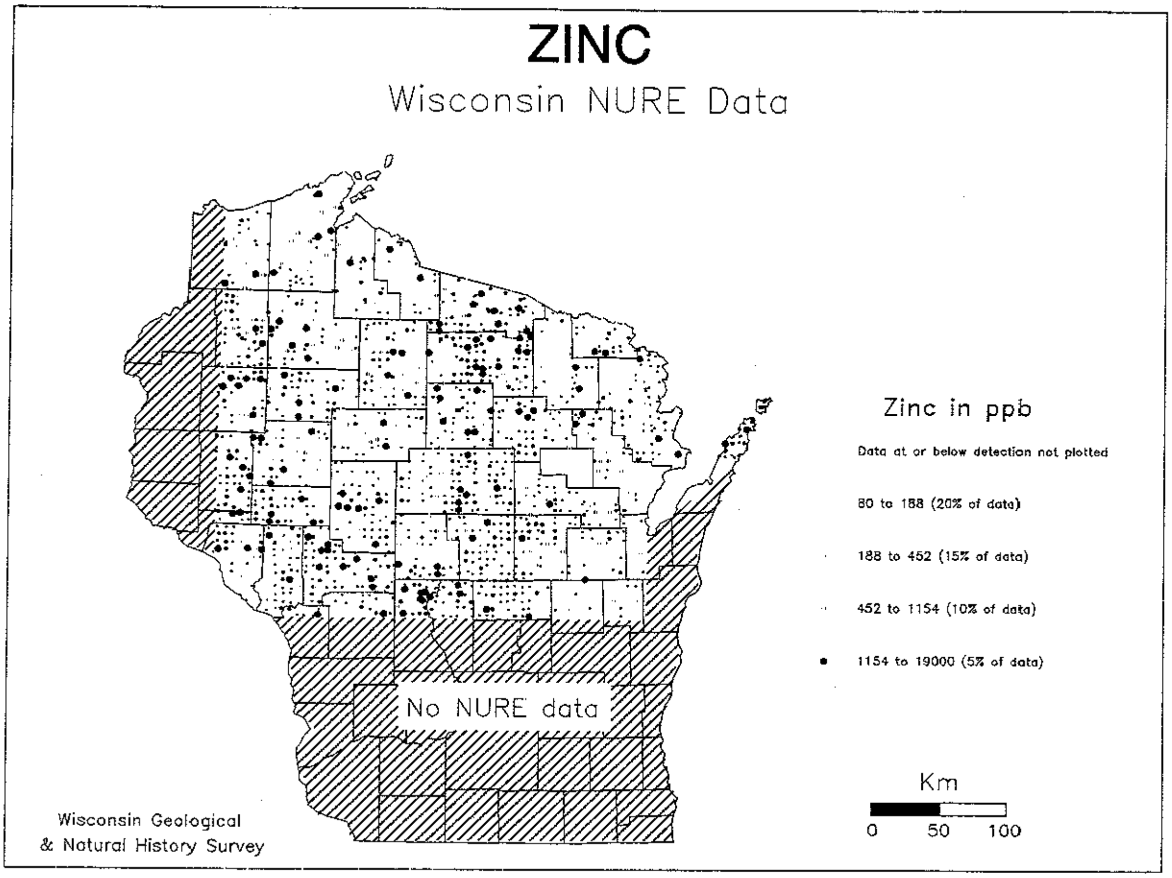

YTTRIUM
Wisconsin NURE Data
Number of samples
700
600
500
400
300
200
100
0
0
2
4
6
8
10
12
14
16
18
20
Concentration in ppb
2735 samples
1971 samples below detection of 1 ppb not plotted
2 samples above 20 ppb not plotted
WG&NHS


ZINC
Wisconsin NURE Data
Zinc in ppb
Data at or below detection not plotted
80 to 188 (20% of data)
· 188 to 452 (15% of data)
·· 452 to 1154 (10% of data)
● 1154 to 19000 (5% of data)
No NURE data
Km
0
50
100
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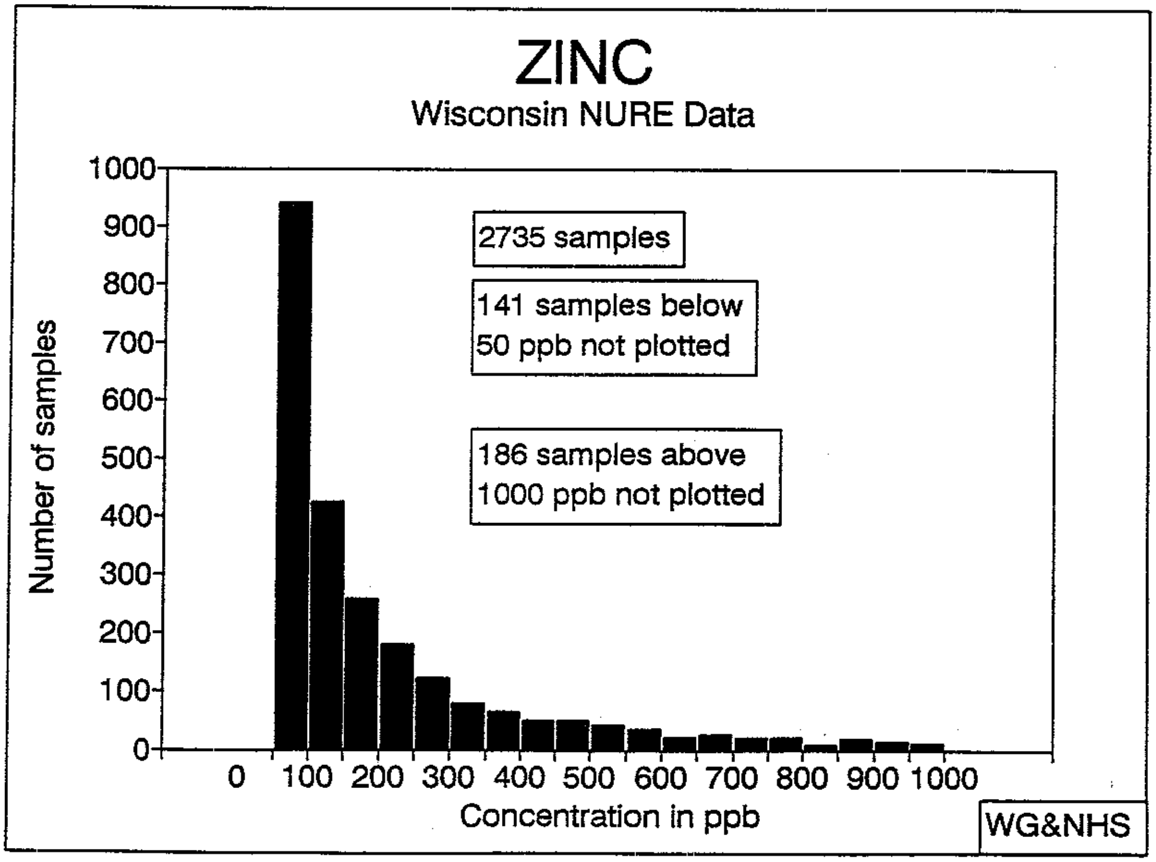
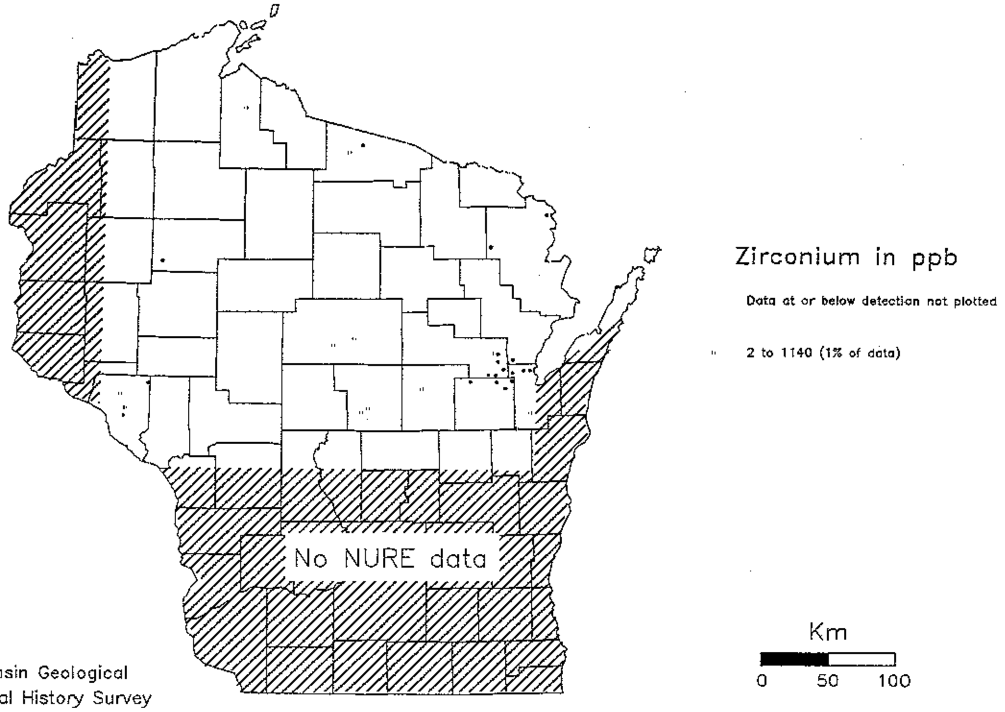

ZINC
Wisconsin NURE Data
2735 samples
141 samples below
50 ppb not plotted
186 samples above
1000 ppb not plotted
Number of samples
0
100
200
300
400
500
600
700
800
900
1000
Concentration in ppb
0
100
200
300
400
500
600
700
800
900
1000
WG&NHS

ZIRCONIUM

Wisconsin NURE Data



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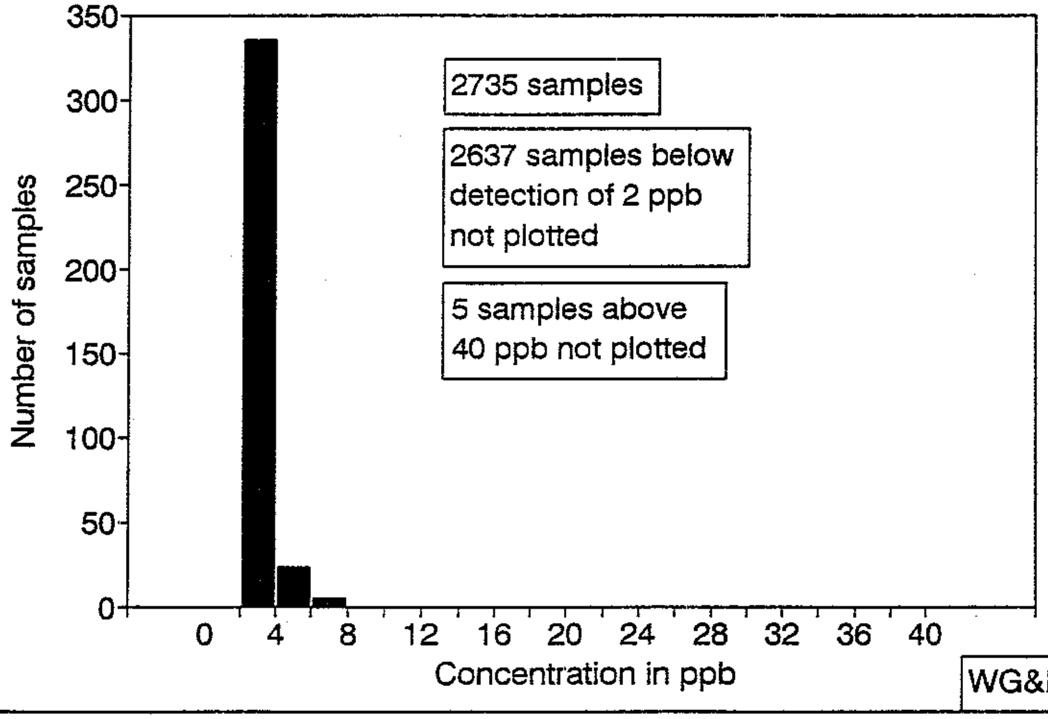
ZIRCONIUM

Wisconsin NURE Data



2735 samples

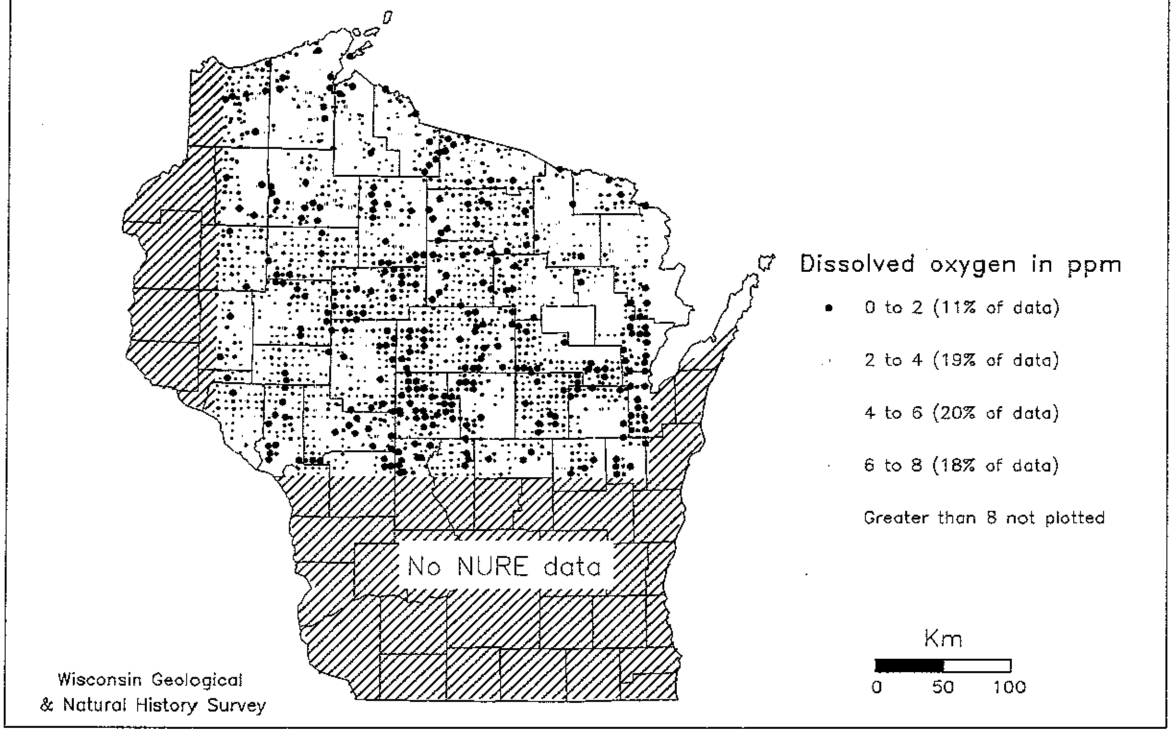
2637 samples below detection of 2 ppb not plotted

5 samples above 40 ppb not plotted

WG&NHS

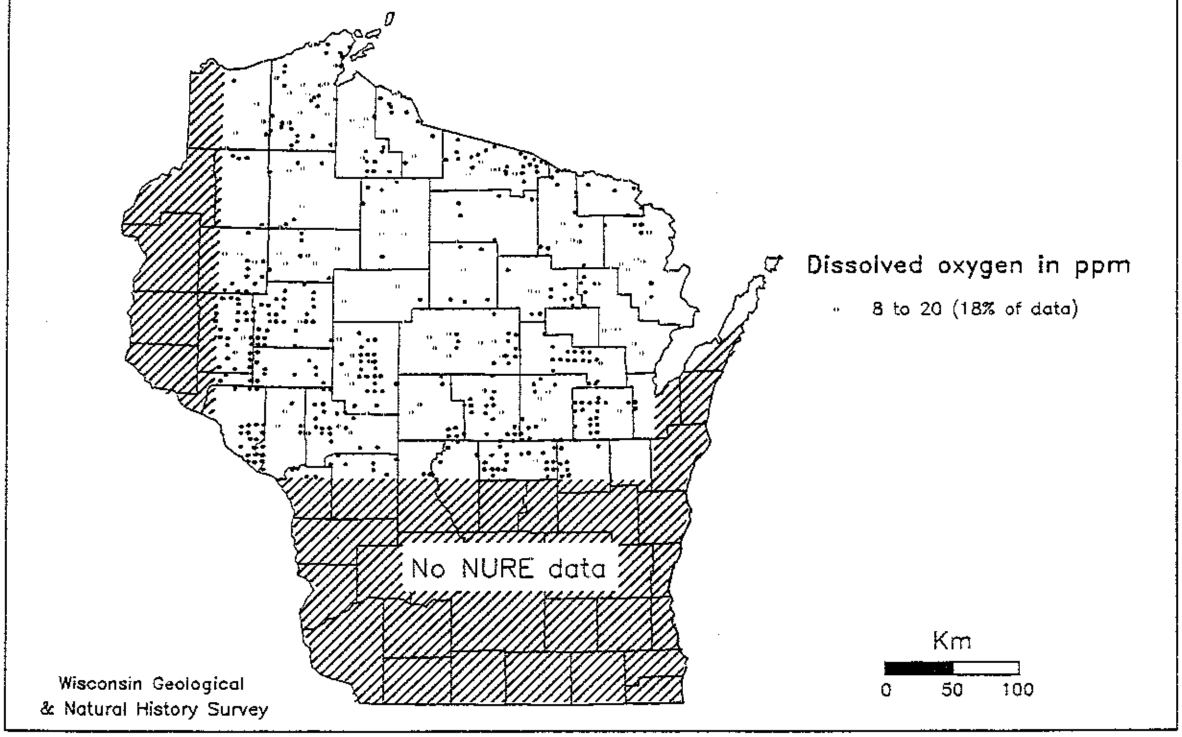
DISSOLVED OXYGEN - LOW VALUES

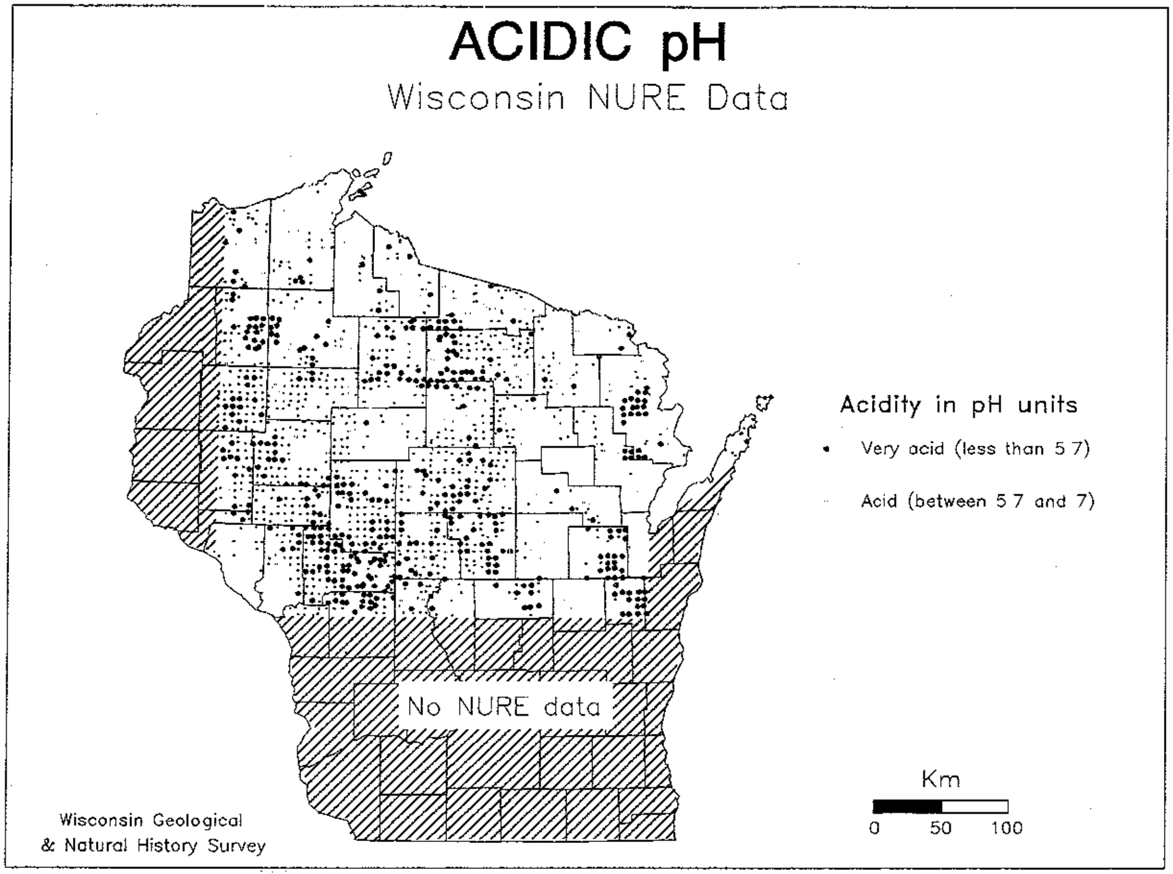
Wisconsin NURE Data



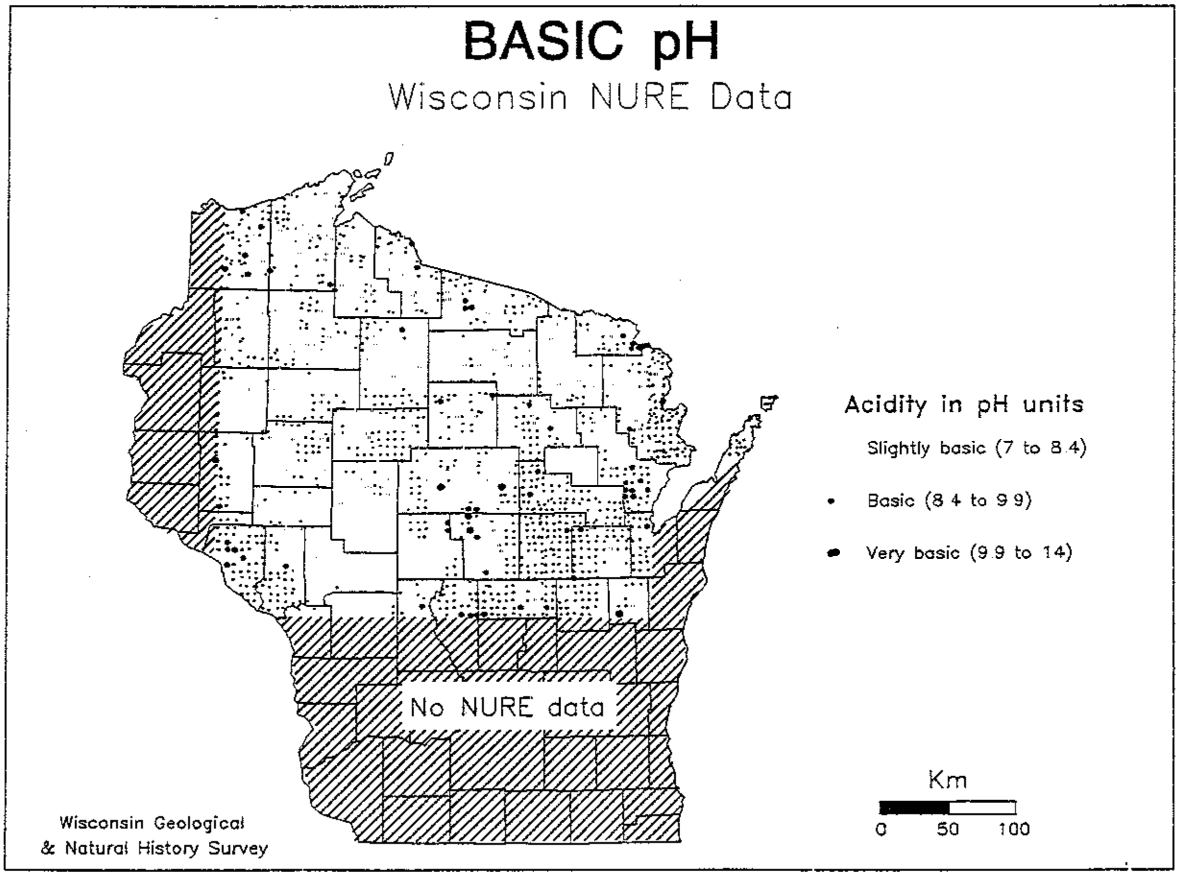
DISSOLVED OXYGEN - HIGH VALUES

Wisconsin NURE Data




ACIDIC pH

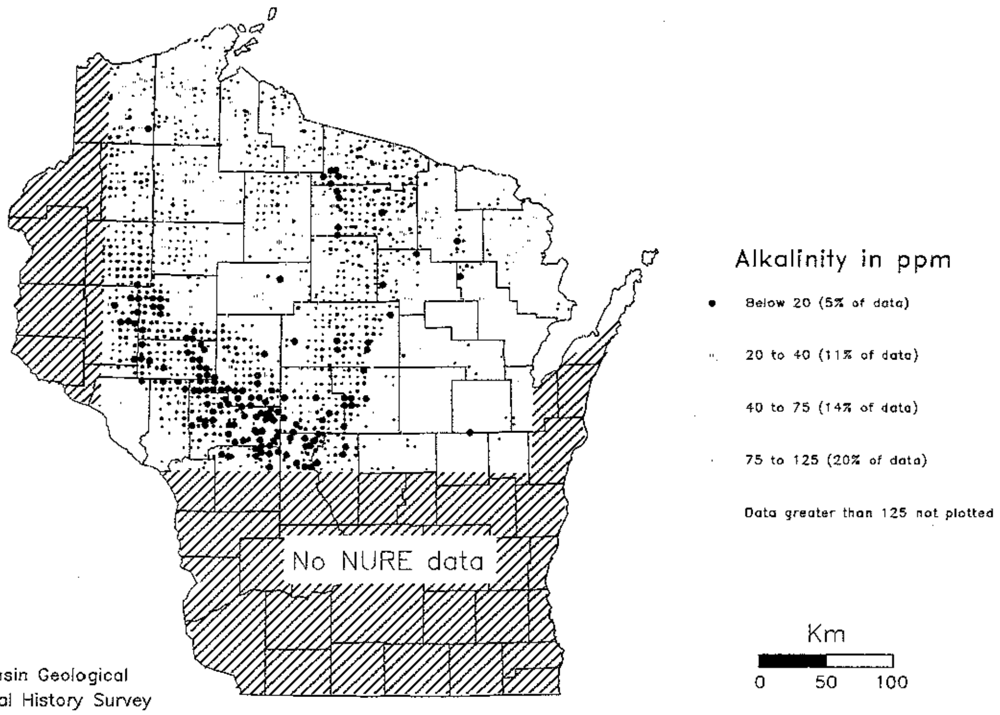
Wisconsin NURE Data


BASIC pH

Wisconsin NURE Data

TOTAL ALKALINITY - LOW VALUES

Wisconsin NURE Data



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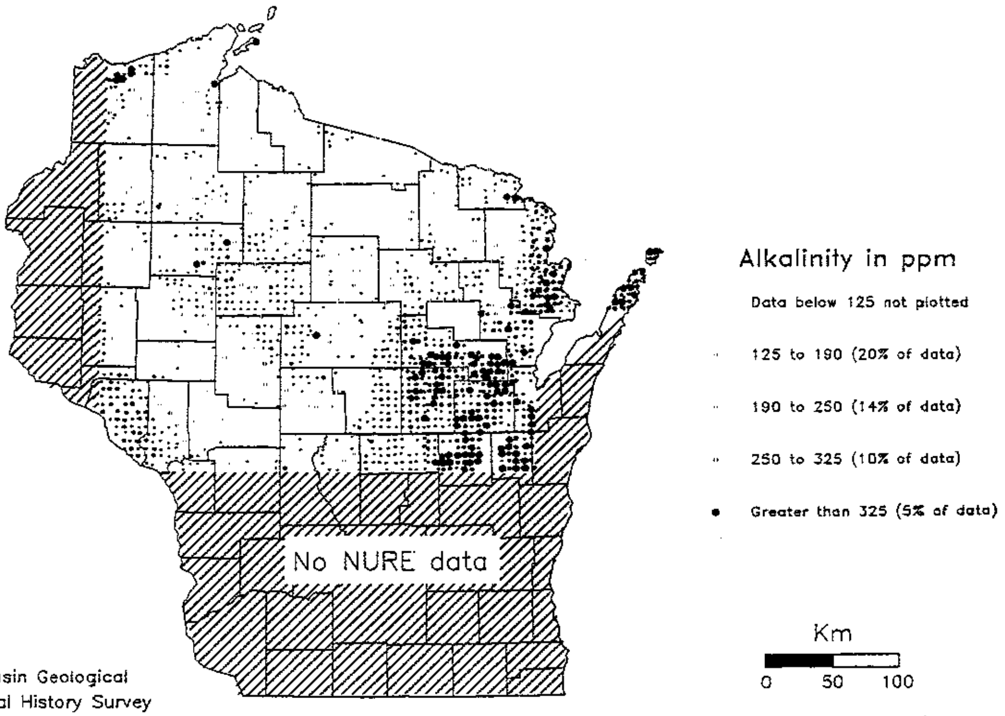
TOTAL ALKALINITY - HIGH VALUES

Wisconsin NURE Data



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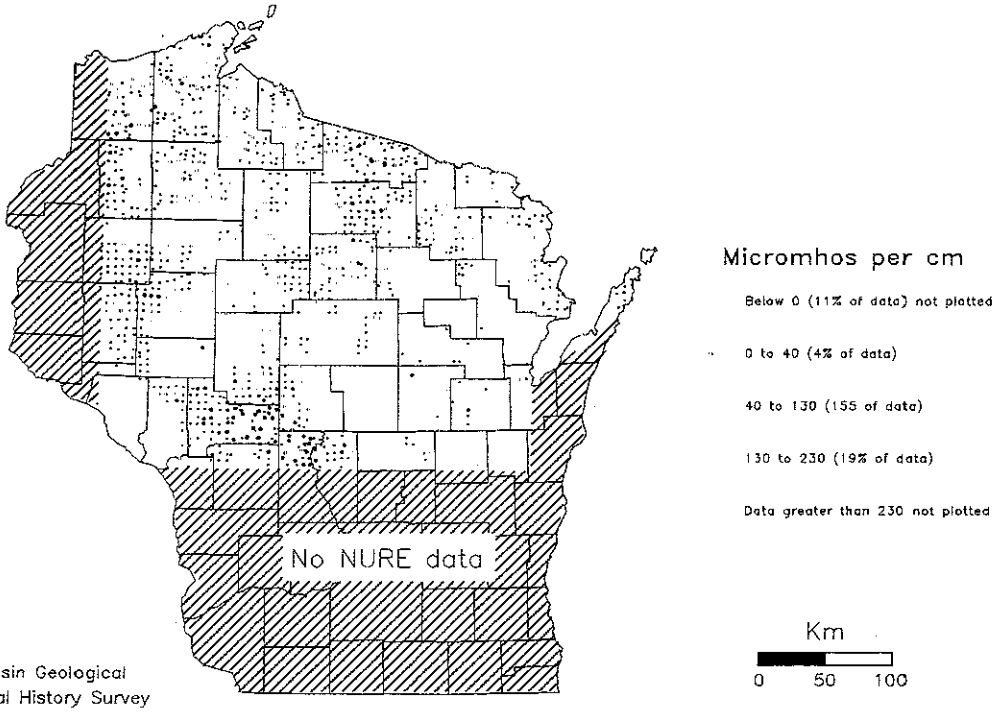
FIELD CONDUCTIVITY - LOW VALUES

Wisconsin NURE Data



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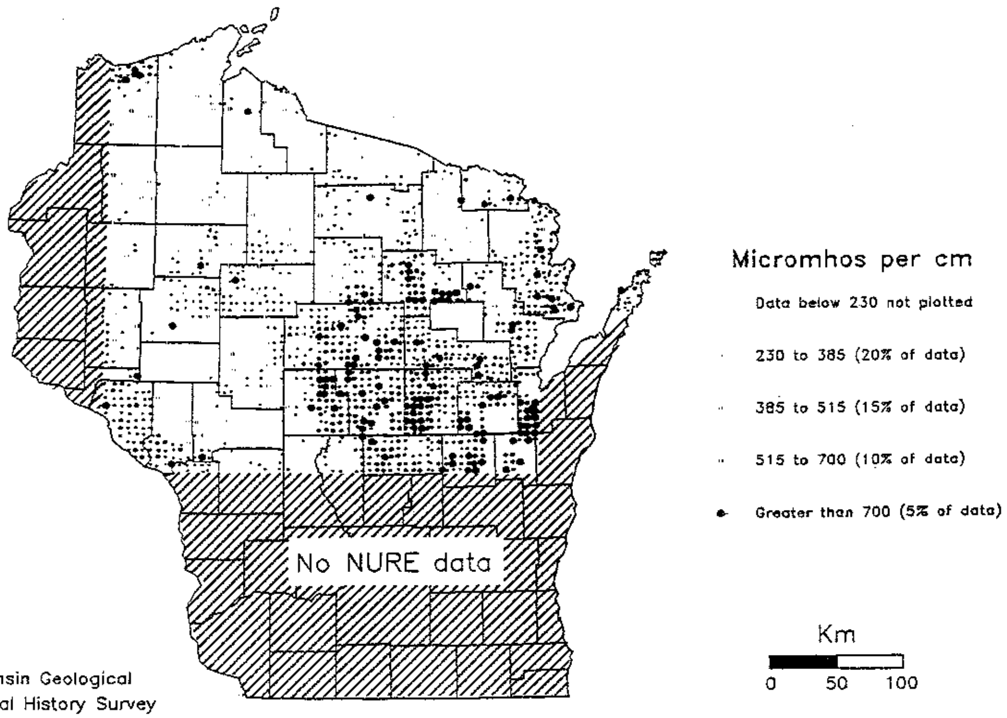
FIELD CONDUCTIVITY - HIGH VALUES

Wisconsin NURE Data



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