North Branch of the Chicago River SCS Curve Number Generation

This technical memorandum describes HDR's approach for generating SCS Curve Number data for the watersheds comprising the North Branch of the Chicago River (herein referred to as the "North Branch").

1. Approach

Previous approaches for Detailed Watershed Plan (DWP) SCS curve number generation are the "Calumet-Sag Watershed SCS Curve Number Generation" technical memorandum[a] authored by CH2M Hill (dated August 14, 2007 and herein referred to as the "CH2M Hill Memo") and "Comments on CH2MHill Curve Numbers"[b] email authored by CTE (dated September 14, 2007 and herein referred to as the "CTE email"). HDR will incorporate these approaches, with the following changes or refinements:

- The use of an additional Natural Resources Conservation Service (NRCS) soil survey for the City of Chicago;
- Analysis of the affects of minor soil types;
- Review and revisions of land use information;
- Use of existing remote sensing datasets to estimate impervious areas;
- GIS dataset preparation.

2. NRCS Soil Survey

The CH2M Hill Memo noted that NRCS soils datasets covered portions of the watersheds but did not include the City of Chicago. In place of this, the CH2M Hill Memo recommended assuming a uniform hydrologic soil group (HSG) of "C", representing moderately high runoff potential soils. The NRCS provides two types of soil datasets for the area. One type is the Soil Survey Geographic, or SSURGO, dataset[c]. The SSURGO dataset is available for select areas and is a detailed soil survey. The City of Chicago is not included in the SSURGO dataset, although portions of the North Branch upper basin are included.

A second type of soils dataset developed by the NRCS is the U.S. General Soil Map (formerly the State Soil Geographic dataset), also known as STATSGO or STATSGO2[d]. STATSGO is more general than SSURGO and is based on a wide range of available soil literature. The City of Chicago and portions of the North Branch lower basin are mapped in the STATSGO dataset. Figure 1 shows combined SSURGO and STATSGO soils information for the North Branch. The SSURGO dataset areas in the upper basin (the Skokie River, Upper North Branch, and a portion of the West Fork) are at a smaller, more refined scale than STATSGO. While SSURGO is the

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[a] pw://pwappoma001:NorthCentral_Omaha/Documents/D{6758c9b5-6371-46df-b1c9-ebcb8deb7223}

[b] pw://pwappoma001:NorthCentral_Omaha/Documents/D{8a9f643d-bd6c-496d-b4c7-c6e97ea73e08}

[c] http://soils.usda.gov/survey/geography/ssurgo/

[d] http://soils.usda.gov/survey/geography/statsgo/

preferred dataset, the additional use of STATSGO in the lower basin shows soils with HSG ranging from "A" (low runoff potential) to "C" (moderately high runoff potential). The STATSGO soil dataset will be used to supplement SSURGO data, rather than assuming a uniform soil type.

3. Minor Soil Types

The HSG designations of soils within the North Branch watershed are a key input to hydrologic modeling. Within each SSURGO or STATSGO GIS database, the NRCS has developed polygons (map units) that group soils. NRCS states:

> ***Map Unit Delineations are closed polygons that may be dominated by a single soil or miscellaneous area component plus allowable similar or dissimilar soils, or they can be geographic mixtures of groups of soils or soils and miscellaneous areas.***[e]

This does not mean that each map unit represents a homogenous (that is, the same) soil type. Instead, there may be multiple soil types (called soil components) occurring within a given map unit. The map unit is a common geographic feature that can potentially contain many different types of soils.

In most cases, each map unit will have a single HSG designation. This occurs when a single soil component is predominant (generally making up 90% or more of the map unit) or when the multiple soil components all have the same or similar HSG characteristic. The default soil database query will select this predominant HSG classification for use in hydrologic modeling. There can be cases where there are significant soil variations that require further examination to determine a proper HSG classification.

[e] Metadata for Soil Survey Geographic (SSURGO) database for Cook County, Illinois, March 2007.

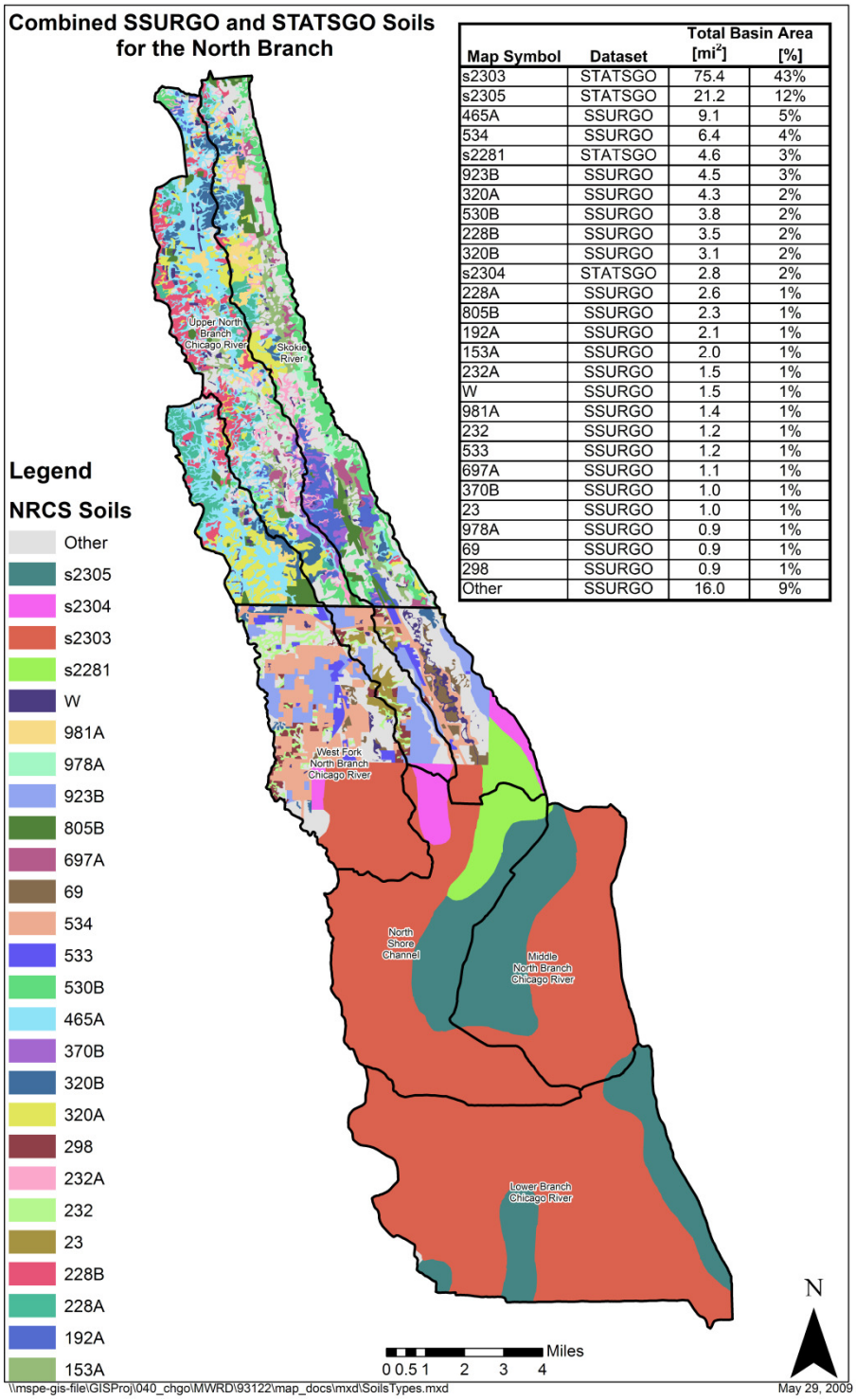

Figure 1. Combined SSURGO and STATSGO Soils for the North Branch

As an example, consider the soil report for map unit 989A in Figure 2. The Elliot soil component is HSG “C” and makes up 45% of the map unit, while the Mundelein soil is HSG “B” and makes up an additional 45% of the map unit. The remaining 10% of the map unit is split between two other soil components (Ashkum and Pellla) of HSG C and B respectively. As a map unit is the basic descriptive area, there is no further additional information within GIS that indicates the distribution of the B and C HSG soils. The default GIS query is to report the map unit as HSG C, only because the Elliot soil appears before the Mundelein soil in the database.

A technique is required to determine a single HSG for each map unit. The goal of the technique is to 1) improve hydrologic modeling accuracy by weighting the aggregate HSG in favor of a predominant value, and 2) to provide consistent and defensible HSG classifications.

RUSLE2 Related Attributes

Lake County, Illinois

Map symbol and soil name	Pct. of map unit	Hydrologic group	Kf	T factor	Representative value		
					% Sand	% Silt	% Clay
989A:							
Elliott	45	C	.24	4	8.1	66.9	25.0
Mundelein	45	B	.28	5	9.0	67.5	23.5
Ashkum	---	C	.20	5	8.0	55.0	37.0
Pella	---	B	.24	5	9.0	60.0	31.0

Figure 2. Example NRCS Soil Map Unit

In classifying a HSG for a given soil, the NRCS uses various soil parameters as documented in Chapter 7 of the Hydrology chapter in the National Engineering Handbook (NRCS, May 2007). Essentially, two parameters are used in HSG classification: 1) the depth to a water impermeable layer, such as clay or bedrock, or high water table; and 2) the most restrictive saturated hydraulic conductivity within the first 40 inches of the soil column. Figure 3 provides the decision matrix used in HSG classification.

The first step in the HSG assignment is to determine if the water impermeable layer or high water table is less than 40 inches from the surface. This information can be obtained from the NRCS soil database “Soil Features” and “Water Features” reports, or as a narrative from the “Map Unit Description” report. When the Map Description Report for map unit 989A is reviewed (Figure 4), the Elliot soil has root restrictive layer of approximately less than 40 inches.

The soil also has a water table for more than one month of the year at a depth of less than 40 inches. The Mundelein soil root restrictive depth is more than 60 inches but has a high water table of less than 40 inches. The NRCS Table 7-1 criteria are applied for both soils.

Table 7–1 Criteria for assignment of hydrologic soil groups when a water impermeable layer exists at a depth between 50 and 100 centimeters [20 and 40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 µm/s (>5.67 in/h)	≤40.0 to >10.0 µm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 µm/s (≤1.42 to >0.14 in/h)	≤1.0 µm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

Table 7–2 Criteria for assignment of hydrologic soil groups when any water impermeable layer exists at a depth greater than 100 centimeters [40 inches]

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>10 µm/s (>1.42 in/h)	≤10.0 to >4.0 µm/s (≤1.42 to >57 in/h)	≤4.0 to >0.40 µm/s (≤0.57 to >0.06 in/h)	≤0.40 µm/s (≤0.06 in/h)
	and	and	and	and/or
Depth to water impermeable layer	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]
	and	and	and	and/or
Depth to high water table	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]	>100 cm [>40 in]

Figure 3. NRCS HSG Classification Criteria

Map Unit Description (Brief, Generated)

Lake County, Illinois

[Minor map unit components are excluded from this report]

Map unit: 989A - Mundelein and Elliott silt loams, 0 to 2 percent slopes

Component: Elliott (45%)

The Elliott component makes up 45 percent of the map unit. Slopes are 0 to 2 percent. This component is on ground moraines. The parent material consists of Thin mantle of loess or other silty material and in the underlying till. Depth to a root restrictive layer, densic material, is 20 to 45 inches. The natural drainage class is somewhat poorly drained. Water movement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is moderate. Shrink-swell potential is moderate. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 16 inches during January, February, March, April, May. Organic matter content in the surface horizon is about 4 percent. Nonirrigated land capability classification is 2w. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 7 percent.

Component: Mundelein (45%)

The Mundelein component makes up 45 percent of the map unit. Slopes are 0 to 2 percent. This component is on lake plains. The parent material consists of Loess or other silty material and in the underlying outwash. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is somewhat poorly drained. Water movement in the most restrictive layer is moderately high. Available water to a depth of 60 inches is high. Shrink-swell potential is low. This soil is not flooded. It is not ponded. A seasonal zone of water saturation is at 18 inches during January, February, March, April, May. Organic matter content in the surface horizon is about 4 percent. Nonirrigated land capability classification is 1. This soil does not meet hydric criteria. The calcium carbonate equivalent within 40 inches, typically, does not exceed 10 percent.

Figure 4. Example NRCS Map Unit Description Report

Next, the range of most restrictive saturated hydraulic conductivity is determined. The most restricted layer is the layer having the lowest saturated hydraulic conductivity. Based on NRCS criteria only the first 40 inches of the soil profile are considered, regardless of the depth to the impermeable layer. This information is provided in the NRCS “Physical Soil Properties” report. Figure 5 shows an example report for map unit 989A. The most restricted saturated hydraulic conductivity for the Elliot soil is 0.42 to 4.23 µm/sec with a midpoint value of 2.32 µm/sec. For Mundelien it is 4.23 to 14.11 µm/sec, with a midpoint value of 9.17 µm/sec.

Physical Soil Properties

Lake County, Illinois

[Entries under "Erosion Factors--T" apply to the entire profile. Entries under "Wind Erodibility Group" and "Wind Erodibility Index" apply only to the surface layer. Absence of an entry indicates that data were not estimated]

Map symbol and soil name	Depth	Sand	Silt	Clay	Moist bulk density	Saturated hydraulic conductivity	Available water capacity	Linear extensibility	Organic matter	Erosion factors			Wind erodibility group	Wind erodibility index
										Kw	Kf	T		
	In	*Pct*	*Pct*	*Pct*	*g/cc*	*micro m/sec*	*In/In*	*Pct*	*Pct*					
989A:														
Elliott	0-6	2-15	58-78	20-27	1.25-1.45	4.23-14.11	0.22-0.24	0.0-2.9	3.5-5.0	.24	.24	4	6	48
	6-11	2-15	50-71	27-35	1.20-1.40	4.23-14.11	0.19-0.22	3.0-5.9	2.5-4.0	.20	.20			
	11-16	1-20	30-61	40-50	1.40-1.60	0.42-4.23	0.10-0.13	6.0-8.9	0.5-1.5	.32	.32			
	16-41	5-20	40-65	27-40	1.50-1.70	0.42-4.23	0.14-0.18	3.0-5.9	0.1-0.5	.37	.37			
	41-60	5-20	45-65	27-35	1.70-1.90	0.42-1.41	0.05-0.10	0.0-2.9	0.0-0.5	.43	.43			
Mundelein	0-17	0-15	58-80	20-27	1.15-1.30	4.23-14.11	0.22-0.24	0.0-2.9	3.0-5.0	.28	.28	5	6	48
	17-31	0-15	50-75	25-35	1.20-1.45	4.23-14.11	0.18-0.20	3.0-5.9	0.5-2.0	.37	.37			
	31-42	10-60	10-75	15-30	1.40-1.55	4.23-14.11	0.12-0.18	0.0-2.9	0.2-0.5	.32	.32			
	42-60	10-87	2-80	5-25	1.50-1.70	4.23-42.34	0.05-0.15	0.0-2.9	0.0-0.2	.28	.28			

Figure 5. Example NRCS Physical Soil Properties Report

Referring to NRCS Table 7-1, the saturated hydraulic conductivity of the Elliot soil partially falls into the HSG C and D range and Mundelien falls into HSG B and C. A weighted saturated hydraulic conductivity using each soils' midpoint values and the percent of map unit is calculated. For the map unit 989A example this is:

$$[(0.45 * 2.32\ \mu m/sec) + (0.45 * 9.17\ \mu m/sec)] / (0.45 + 0.45) = 5.74\ \mu m/sec$$

The weighted value in this case falls into HSG C. The map unit is characterized as HSG C indicating that under the high water table conditions both soils are closer to a HSG C than HSG B.

When a soil component is classified as a drained and undrained HSG[f], this approach will be applied to both cases. The first weighted average will include the drained component assuming that the water table and impermeable layer is more than 40 inches from the surface. The second weighted average will use the undrained component assuming that the water table and impermeable layer is less then 40 inches. This will produce a weighted HSG classification with drained and undrained elements.

Figure 6 provides a flowchart illustrating the weighting approach.

[f] For example, a B/D HSG classification indicates the soil acts as HSG B under drained conditions and HSG D under undrained conditions.

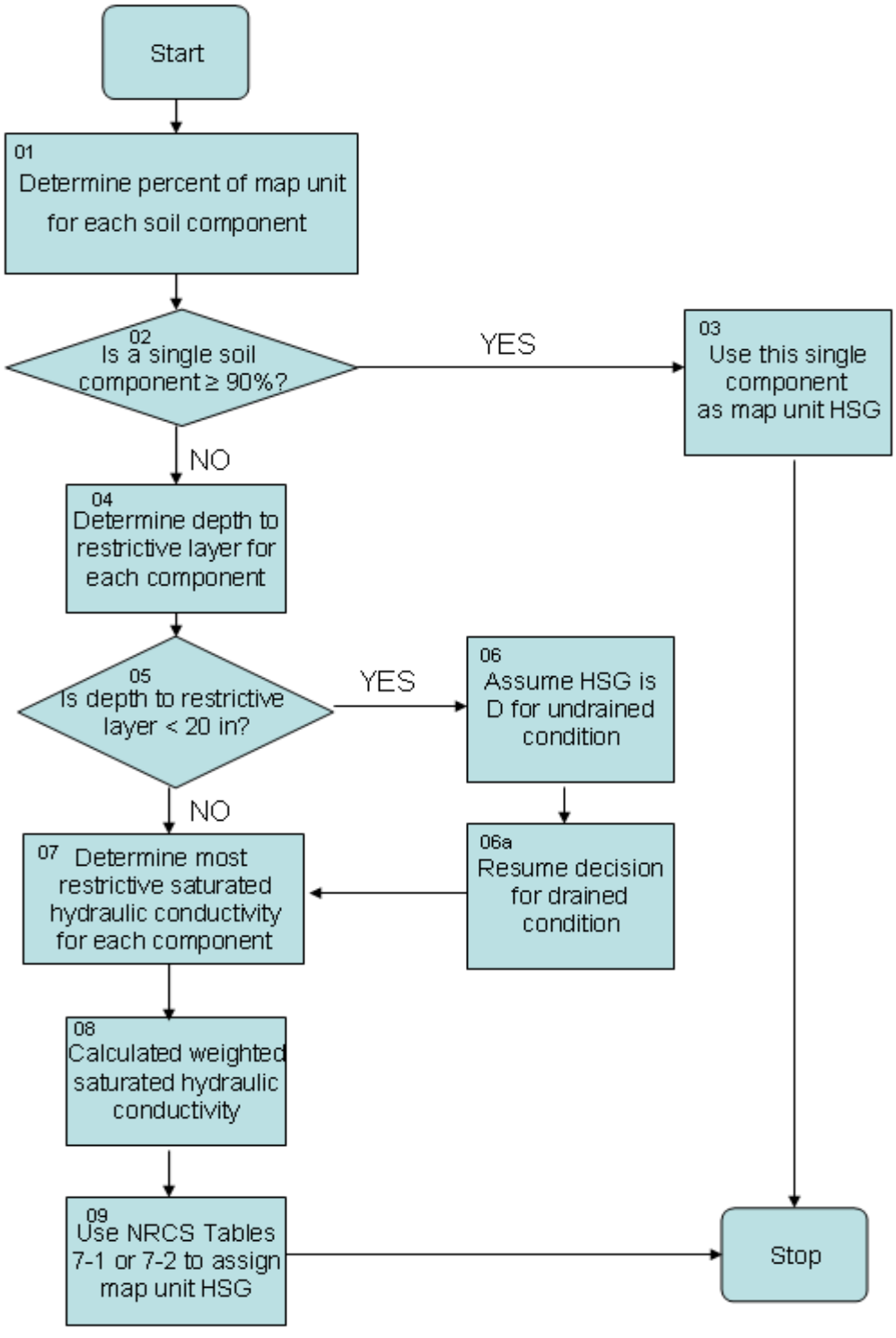

Figure 6 - HSG Weighting Flowchart

Based on this weighting approach, HDR reviewed and weighted the HSG for soil map units within the North Branch watershed. The NRCS map units in Table 1 were adjusted. Figure 7 and Figure 8 provide the HSG classifications over the North Branch basin for drained and undrained conditions, respectively.

Table 1. Adjusted Soil HSG Based on Multiple Soil Components

Map Unit	Original HSG	Adjusted based on Soil Components	
		Drained HSG	Undrained HSG
840B	B and C	C	C
840C2	C and B	C	C
923B	C and B/D	C	C
924	B/D and C	C	C
925B	C and D	D	D
926B	B/D and B	B	C
978A	C and B	C	C
978B	C and B	C	C
979A	B and C	C	C
979B	B and C	C	C
981A	B and D	C	C
981B	B and D	C	C
982A	B and D	C	C
982B	B and D	C	C
983B	B and D	C	C
989A	C and B	C	C
s2247	B/D and B	B	C
s2279	C and D	D	D
s2281	C and B/D	C	C
s2303	B/D and C	B	C
s2304	C and B/D	C	C
s2305	A and B/D	A	B

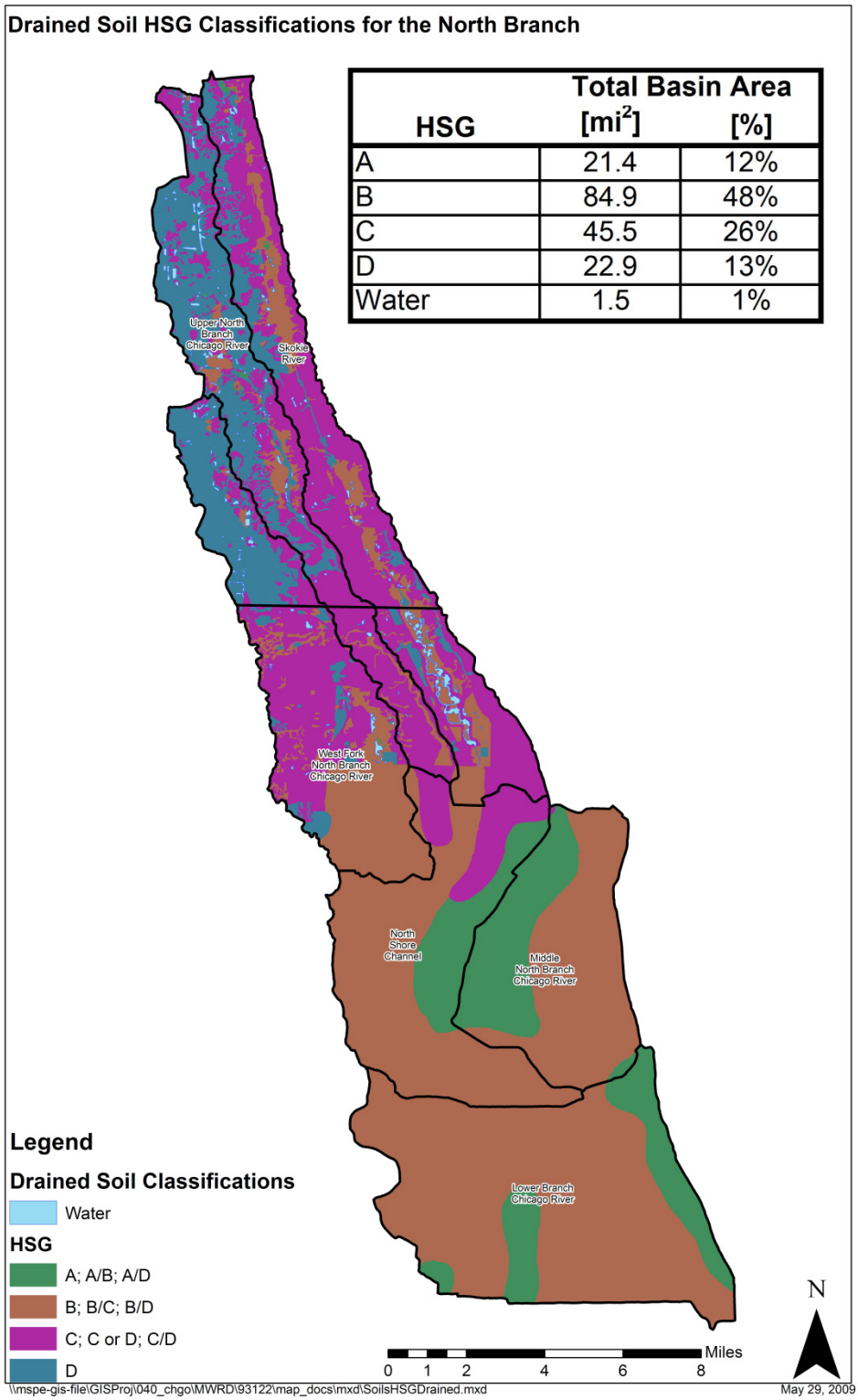

Figure 7. Drained Soil Classifications

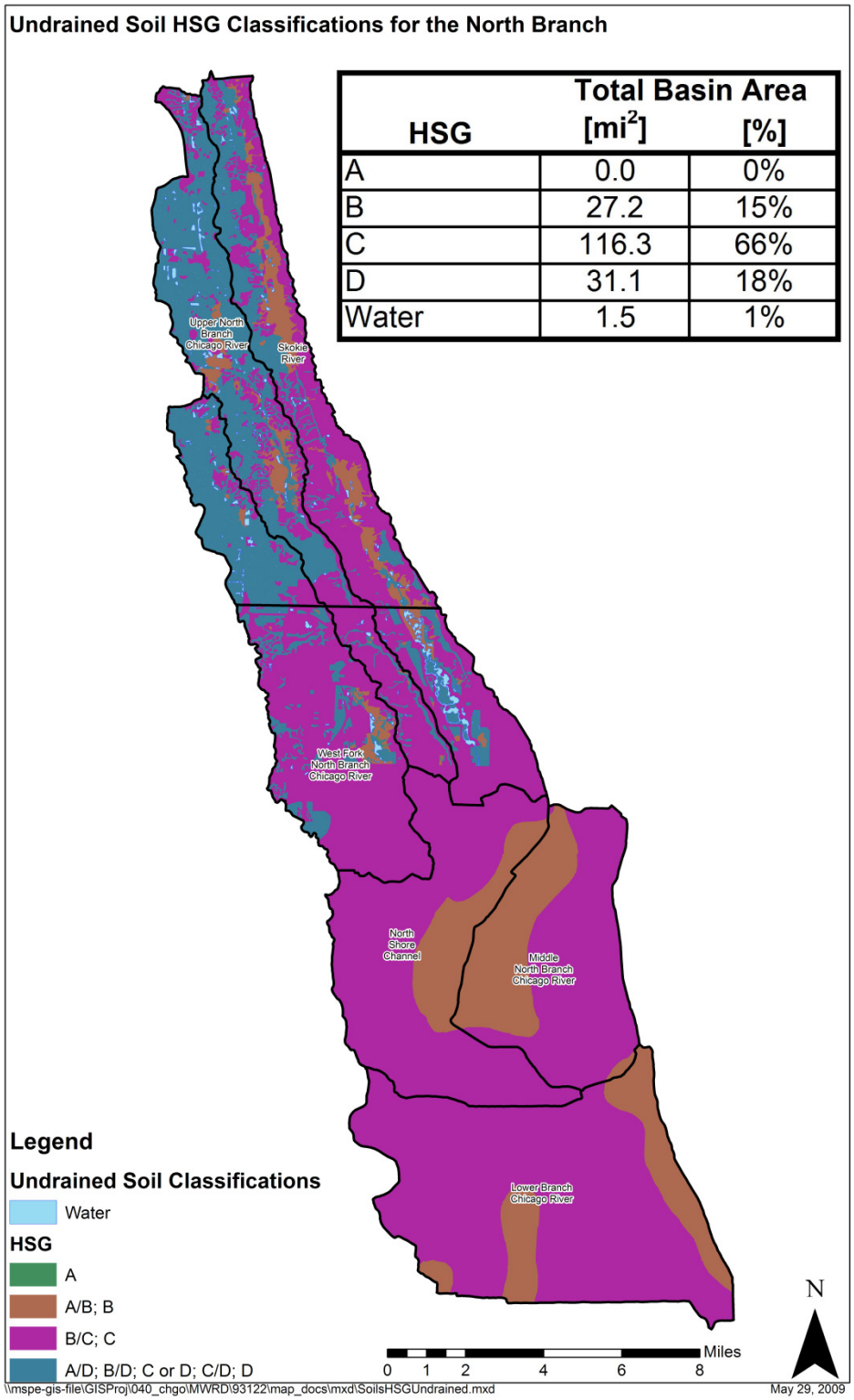

Figure 8. Undrained soil classifications

4. Land Use Information

The primary land use information used by HDR is the 2001 Land-use Inventory published by the Chicago Metropolitan Agency for Planning (CMAP), which was formerly the Northeastern Illinois Planning Commission (NIPC). CMAP publishes spatial land use information every five years, with the 2001 data (published May 2006) being the most recent at the time of this writing[g].

The CMAP dataset was developed at a scale of 1:24,000. The dataset was compiled using a variety of reference sources, including aerial photographs, georeferenced plat books, commercial datasets of shopping and manufacturing areas, and state, county, and city natural resources databases. Each area in this dataset is coded with a number representing type of land use. The overall classes of land use are:

- 1100 Series - Residential
- 1200 Series - Commercial and Services
- 1300 Series - Institutional
- 1400 Series - Industrial, Warehousing and Wholesale Trade
- 1500 Series - Transportation, Communication, and Utilities
- 2000 Series - Agricultural Land
- 3000 Series - Open Space
- 4000 Series - Vacant, Wetlands, or Under Construction
- 5000 Series - Water

A visual review of the CMAP dataset was performed by comparing the 2001 landuse data to 2007 aerial imagery[h]. Any land use data not matching the aerial information was revised to accurately represent land use conditions throughout the watershed. HDR found many parcels coded in the 4200 series (residential construction) that have since been developed to the 1100 series (residential). There were also some parcels in the 2000 series (agricultural) that appeared to be miscoded or subsequently developed. These were changed to various different land use types including residential, open space, retail center, and golf course. Table 2 summarizes the revised land uses made by HDR to the CMAP dataset. The total adjusted area amounts to 3.0 mi^2, or approximately 1.5% of the basin area. Table 3 summarizes the total land uses in the basin based on 2007 data, while Figure 9 maps this land use data.

[g] 2005 land use data was published by CMAP on January 2009. However, HDR had already updated the 2001 data to 2007 conditions by this time.

[h] USDA-FSA Aerial Photography Field Office, File "ortho_1-1_1n_il031_2007_1", Published August 23, 2007.

Table 2. HDR Revised Land Uses (Subset of CMAP dataset)

Revised Land Use		Revised Basin Area
As of 2001	**As of 2007**	**[mi^2]**
1110 (RES/SF)	3100 (OPENSP REC)	0.002
1350 (RELIGOUS)	1110 (RES/SF)	0.037
1520 (OTH LINEAR TRAN)	1223 (BUS. PARK)	0.008
2100 (CROP...)	1211 (MALL)	0.069
3100 (OPENSP REC)	1110 (RES/SF)	0.055
	1130 (RES/MF)	0.007
	1222 (SINGL OFFICE)	0.006
	1223 (BUS. PARK)	0.002
	3500 (OPENSP LINEAR)	0.019
3300 (OPENSP CONS)	1221 (OFFICE CMPS)	0.016
	1440 (INDUST PK)	0.011
4110 (VAC FOR/GRASS)	1110 (RES/SF)	0.184
	1130 (RES/MF)	0.011
	1212 (RETAIL CNTR)	0.026
	1221 (OFFICE CMPS)	0.220
	1222 (SINGL OFFICE)	0.003
	1223 (BUS. PARK)	0.033
	1231 URB MX W/PRKNG	0.003
	1430 (WAREH...)	0.044
	1440 (INDUST PK)	0.078
	1520 (OTH LINEAR TRAN)	0.011
	1540 (AUTO PRK)	0.016
	4210 (CONST RES)	0.049
4210 (CONST RES)	1110 (RES/SF)	0.599
	1130 (RES/MF)	0.222
	1222 (SINGL OFFICE)	0.079
	1232 (URB MX NO PRKNG)	0.006
4220 (CONST NONRES)	1130 (RES/MF)	0.048
	1221 (OFFICE CMPS)	0.215
	1222 (SINGL OFFICE)	0.066
	1223 (BUS. PARK)	0.191
	1231 (URB MX PRKNG)	0.255
	1232 (URB MX NO PRKNG)	0.006
	1440 (INDUST PK)	0.014
	3600 (OPENSP OTHER)	0.024
4300 (OTHER VACANT)	1110 (RES/SF)	0.018
	1130 (RES/MF)	0.072
	1211 (MALL)	0.060
	1212 (RETAIL CNTR)	0.028
	1221 (OFFICE CMPS)	0.012
	1222 (SINGL OFFICE)	0.045
	1223 (BUS. PARK)	0.020
	1231 (URB MX PRKNG)	0.014
	1232 (URB MX NO PRKNG)	0.006
	1320 EDUCATION	0.002
	1440 (INDUST PK)	0.087
	1540 (AUTO PRK)	0.014
	3600 (OPENSP OTHER)	0.030

Table 3. Land Uses (2007) in the North Branch Basin

Code	Description	Total Basin Area	
		[mi^2]	[%]
1100 Series	RESIDENTIAL		
1110	Single, Duplex and Townhouse Units	77.6	44%
1120	Farmhouse	<0.1	<1%
1130	Multi-Family	19.6	11%
1140	Mobile Home Parks and Trailer Courts	0.1	<1%
1200 Series	COMMERCIAL AND SERVICES		
1211	Shopping Malls	0.3	<1%
1212	Retail Centers	1.1	1%
1221	Office Campus/Research Park	1.8	1%
1222	Single-Structure Office Building	1.1	1%
1223	Business Park	1.2	1%
1231	Urban Mix With Dedicated Parking	10.0	6%
1232	Urban Mix, No Dedicated Parking	2.1	1%
1240	Cultural and Entertainment	0.8	<1%
1250	Hotel/Motel	0.2	<1%
1300 Series	INSTITUTIONAL		
1310	Medical and Health Care Facilities	1.0	1%
1320	Educational Facilities	5.2	3%
1330	Governmental Administration and Services	1.3	1%
1340	Prison and Correctional Facilities	n/a	n/a
1350	Religious Facilities	1.4	1%
1360	Cemeteries	2.1	1%
1370	Other Institutional	0.2	0%
1400 Series	INDUSTRIAL, WAREHOUSING AND WHOLESALE TRADE		
1410	Mineral Extraction	0.1	<1%
1420	Manufacturing and Processing	1.6	1%
1430	Warehousing/Distribution Center and Wholesale	0.7	<1%
1440	Industrial Park	7.7	4%
1500 Series	TRANSPORTATION, COMMUNICATION, AND UTILITIES		
1510 Series	Automotive Transportation	3.0	1%
1520	Other Linear Transportation with Associated Facilities	1.1	1%
1530	Aircraft Transportation		
1540	Independent Automobile Parking	0.2	<1%
1550	Communication	<0.1	<1%
1560	Utilities and Waste Facilities	1.1	1%
2000 Series	AGRICULTURAL LAND		
2100	Row Crops, Grains, And Grazing	1.4	1%

Code	Description	Total Basin Area	
		[mi^2]	[%]
2200	Nurseries, Greenhouses, Orchards, Tree Farms And Sod Farms	0.2	0%
2300	Agricultural, Other	n/a	n/a
3000 Series	OPEN SPACE		
3100	Open Space, Primarily Recreation	5.2	3%
3200	Golf Courses	9.0	5%
3300	Open Space, Primarily Conservation, Including Forest Preserves And Nature Preserves	9.8	6%
3400	Hunting Clubs, Scout Camps, And Private Campgrounds	0.1	<1%
3500	Linear Open-Space Corridors	0.2	<1%
3600	Other Open Space	0.1	<1%
4000 Series	VACANT, WETLANDS, OR UNDER CONSTRUCTION		
4110	Vacant Forest and Grassland	5.1	3%
4120	Wetlands Greater Than 2.5 Acres	0.9	1%
4210	Under Construction, Residential	0.1	<1%
4220	Under Construction, Non-Residential	<0.1	<1%
4300	Other Vacant	<0.1	<1%
5000 Series	WATER		
5100	Rivers, Streams, and Canals	0.4	<1%
5200	Lakes, Reservoirs, and Lagoons	1.3	1%
5300	Lake Michigan	<0.1	<1%

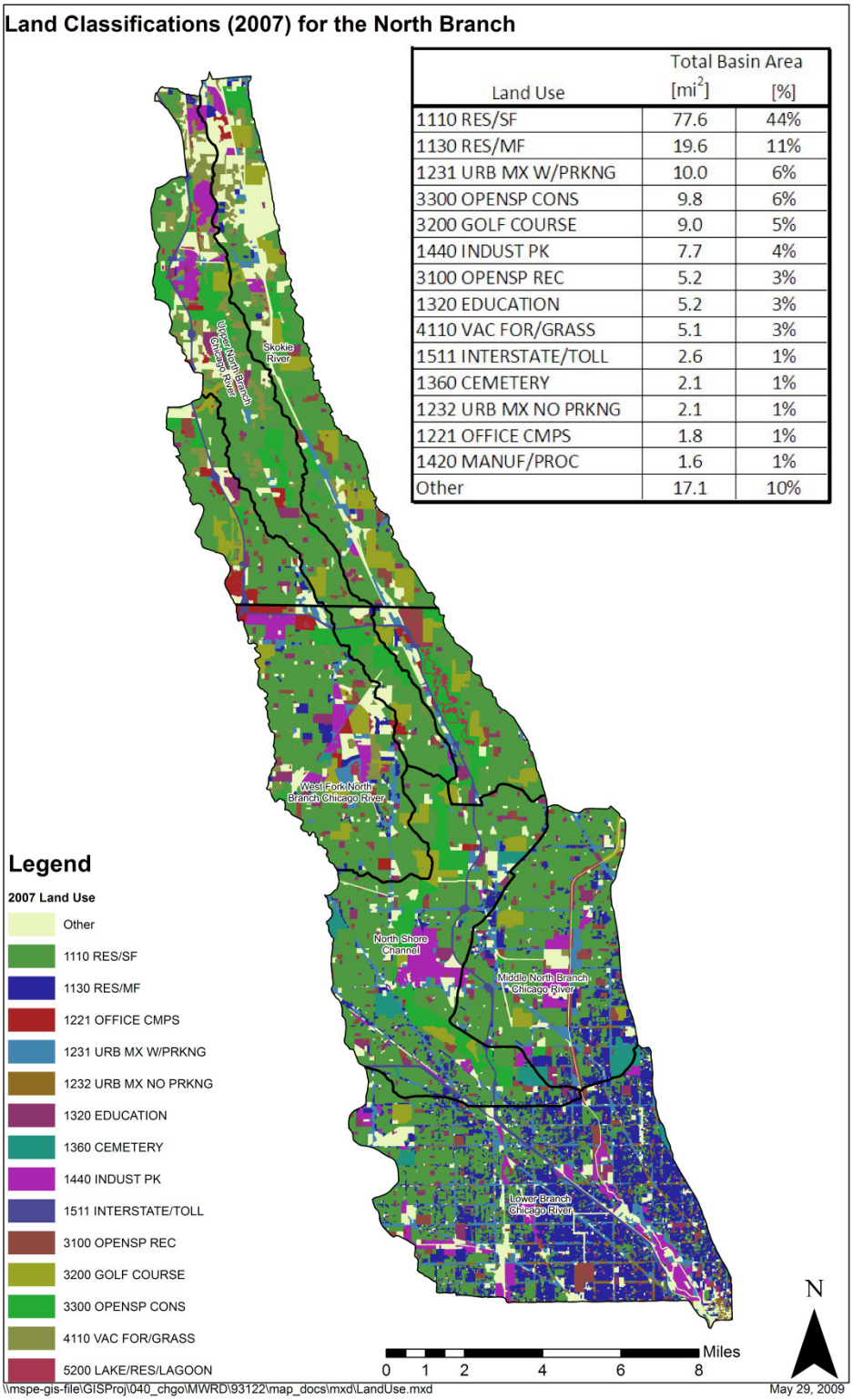

Figure 9. Map of Land Uses in the North Branch Basin

5. Imperviousness Estimate

Past storm-water management studies in the Chicago area have used remotely sensed data for estimating imperviousness.[i] An impervious dataset is available through the National Land Cover Database (NLCD)[j]. The impervious datasets use the LandSat ETM+ satellites with a classification algorithm to derive percent impervious data for a 30 meter size cell. Research has indicated that the correlation between the remotely sensed impervious data and measured is between 0.82 to 0.91 with a relative error of 8.8 to 11.4%[k].

HDR randomly selected nine parcels from the CMAP land use database to estimate the accuracy of the NLCD impervious data. Parcels were not selected if HDR identified a change in land use from 2001 to 2007. Parcels were selected based on two criteria: size and estimated imperviousness. The breakpoints between each classification were based on the statistical distribution of the parcels.

Parcels were grouped into the following sizes ranges:

- Small (less than 9 ac)
- Medium (9 to 62 ac)
- Large (more than 62 ac)

Impervious estimates were based on the NLCD data. Impervious criteria were:

- Low (less than 50% impervious area)
- Medium (between 50% and 80% impervious area)
- High (between 80% and 100% impervious area)

For each parcel, HDR estimated impervious area from the 2007 aerial image. Table 4 compares the measured and NLCD estimated impervious values. Figure 10 plots the measured errors for the sample parcels. The average error was -5% with a correlation of 0.88. The errors from the sample parcels appear to be random, with no apparent trend in errors as a function of parcel size or imperviousness.

The NLCD impervious dataset was intersected with the CMAP 2007 adjusted land use. Average and standard deviations of area-weighted imperviousness for each land use is provided in Table 5. Comparing these basin estimates with NRCS curve number guidance[l] shows a close fit. NRCS assumes 85% imperviousness for commercial and business district curve numbers; the GIS data

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[i] For example: The City of Chicago Green Infrastructure Mapping Program.

[j] USGS, "National Land Cover 2001 Database Zone 49 Imperviousness Layer", published September 2003. Online at: http://www.mrlc.gov/nlcd.php

[k] Yang,Limin et al, "An approach for mapping large-area impervious surfaces: Synergistic use of Landsat 7 ETM+ and high spatial resolution imagery", USGS/Canadian Journal of Remote Sensing, <<date>>

[l] See section 6 of this memo.

estimates Malls (land use 1211) as 81% ± 13%; Retail Centers (land use 1212) as 81% ± 11%; and Urban Mix with no Parking (land use 1232) as 85 % ± 9%. NRCS assumes industrial areas are 72% impervious; the GIS dataset estimates Industrial Parks (land use 1440) as 74% ± 19%; Warehouses (land use1430) as 66% ± 19%; Manufacturing (land use 1420) as 79% ± 15%; and Urban Mix with Parking (land use 1231) as 76% ± 13%. Other types of open space land use also appear reasonable, such as golf courses (land use 3200) at 15% ± 13%.

Figure 11 maps the NLCD impervious dataset for the North Branch basin.

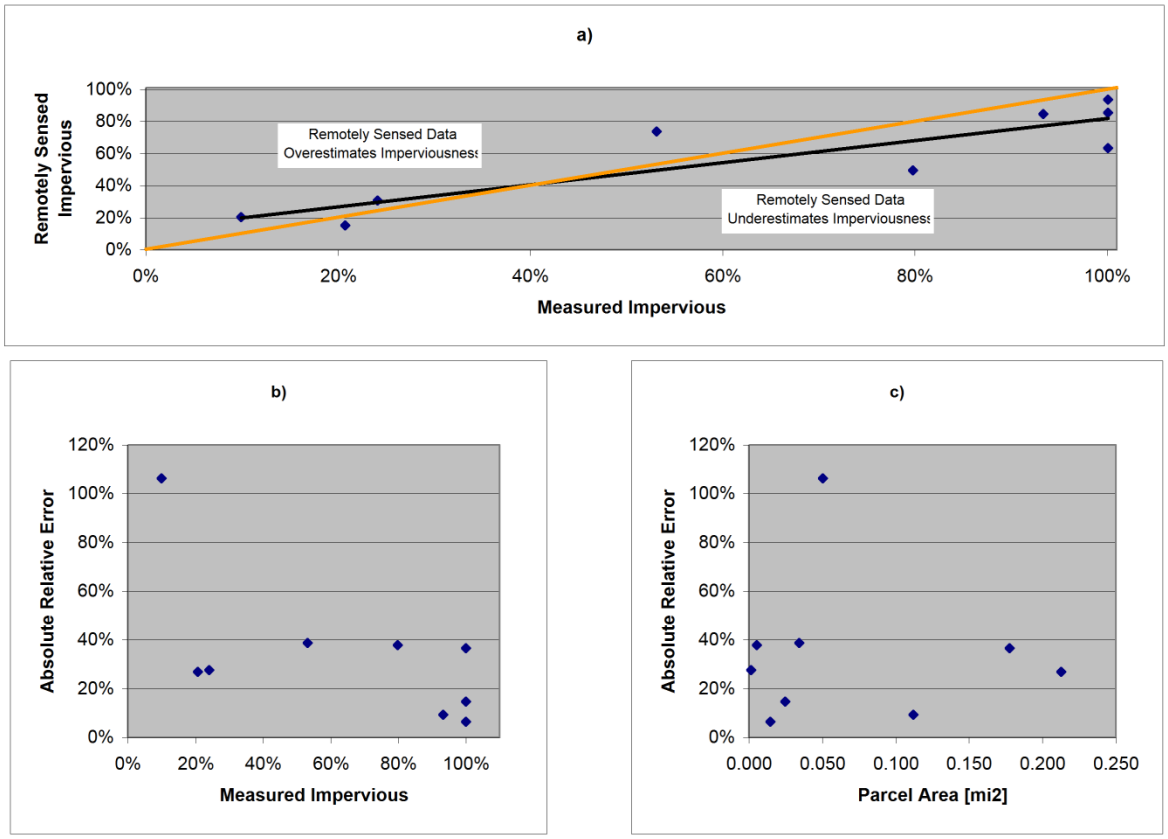

Figure 10. Impervious Measured versus Remotely Sensed Errors.

Notes:

Figure 10a. Measured versus Remotely Sensed Imperviousness

Figure 10b. Remotely Sensed Imperviousness error versus measured imperviousness.

Figure 10c. Remotely Sensed Imperviousness error versus parcel size.

Table 4. Measured and Remotely Sensed Imperviousness for Nine Parcels

Parcel		Categories		Impervious Area [%]		Error
ID	Description	Size	Imperviousness	Measured	NLCD	[%]
28303	Farm west of N Bradley Road and north of Indian Ridge Road	Small	Low	24%	31%	-28%
26334	Multifamily housing north of Dundee Rd and west of Pfingsten Rd	Small	Medium	80%	50%	38%
94604	Urban Mix south of W North Ave and east of W Grand Ave	Small	High	100%	94%	6%
24728	Vacant Grassland south of N Westmoreland Rd and east of N Waukegan Rd	Medium	Low	10%	21%	-106%
61875	Multifamily housing near N Claremount Ave and W Birchwood Ave	Medium	Medium	53%	74%	-39%
94854	Industrial Park near Hartland Ct and W Schubert Ave	Medium	High	100%	85%	15%
26480	Single family housing near E Onwentsia Rd and S Green Bay Rd	Large	Low	21%	15%	27%
56338	Single family housing near W Wellington Ave adn N Melvina Ave	Large	Medium	100%	63%	37%
44623	Industrial park near W Gross Point Rd and N Lehigh Ave	Large	High	93%	85%	9%

Notes:

Size: Small (less than 9 ac); Medium (9 to 62 ac); Large (more than 62 ac)

Impervious: Low (less than 50% impervious area); Medium (between 50% and 80% impervious area); High (between 80% and 100% impervious area)

Table 5. Area-Weighted Imperviousness by Land Use Category

Land Use	Total Area [mi^2]	Area-Weighted Imperviousness	
		Average [%]	StdDev [%]
1110 RES/SF	87.8	36	11
1120 RES/FARM	< 0.1	28	15
1130 RES/MF	24.0	65	14
1140 RES/MOBILE HM	0.1	55	17
1211 MALL	0.3	81	13
1212 RETAIL CNTR	1.2	81	11
1221 OFFICE CMPS	1.8	42	22
1222 SINGL OFFICE	1.2	62	18
1223 BUS. PARK	1.2	51	28
1231 URB MX W/PRKNG	11.2	76	13
1232 URB MX NO PRKNG	2.5	85	9
1240 CULT/ENT	1.1	46	19
1250 HOTEL/MOTEL	0.2	74	14
1310 MEDICAL	1.2	62	17
1320 EDUCATION	6.2	48	21
1330 GOVT	1.7	58	21
1350 RELIGOUS	1.7	50	14
1360 CEMETERY	2.5	26	14
1370 INST/OTHER	0.2	59	16
1410 MINERAL EXT	0.1	80	19
1420 MANUF/PROC	1.6	79	15
1430 WAREH/DIST/WHOL	0.7	66	19
1440 INDUST PK	7.8	74	19
1511 INTERSTATE/TOLL	2.6	63	19
1512 OTHER ROADWY	0.7	57	19
1520 OTH LINEAR TRAN	1.3	63	14
1540 INDEP AUTO PRK	0.3	79	10
1550 COMMUNICATION	<0.1	63	23
1560 UTILITIES/WASTE	1.1	53	23
2100 CROP/GRAIN/GRAZ	1.0	6	12
2200 NRSRY/GRNHS/ORC	0.2	22	18
3100 OPENSP REC	7.2	29	18
3200 GOLF COURSE	9.7	15	13
3300 OPENSP CONS	9.9	5	11
3400 OPENSP PRIVATE	0.2	20	13
3500 OPENSP LINEAR	0.3	38	12
3600 OPENSP OTHER	0.1	28	19
4110 VAC FOR/GRASS	5.2	15	14
4120 WETLAND	0.9	5	9
4210 CONST RES	<0.1	70	10
4300 OTHER VACANT	0.1	69	14

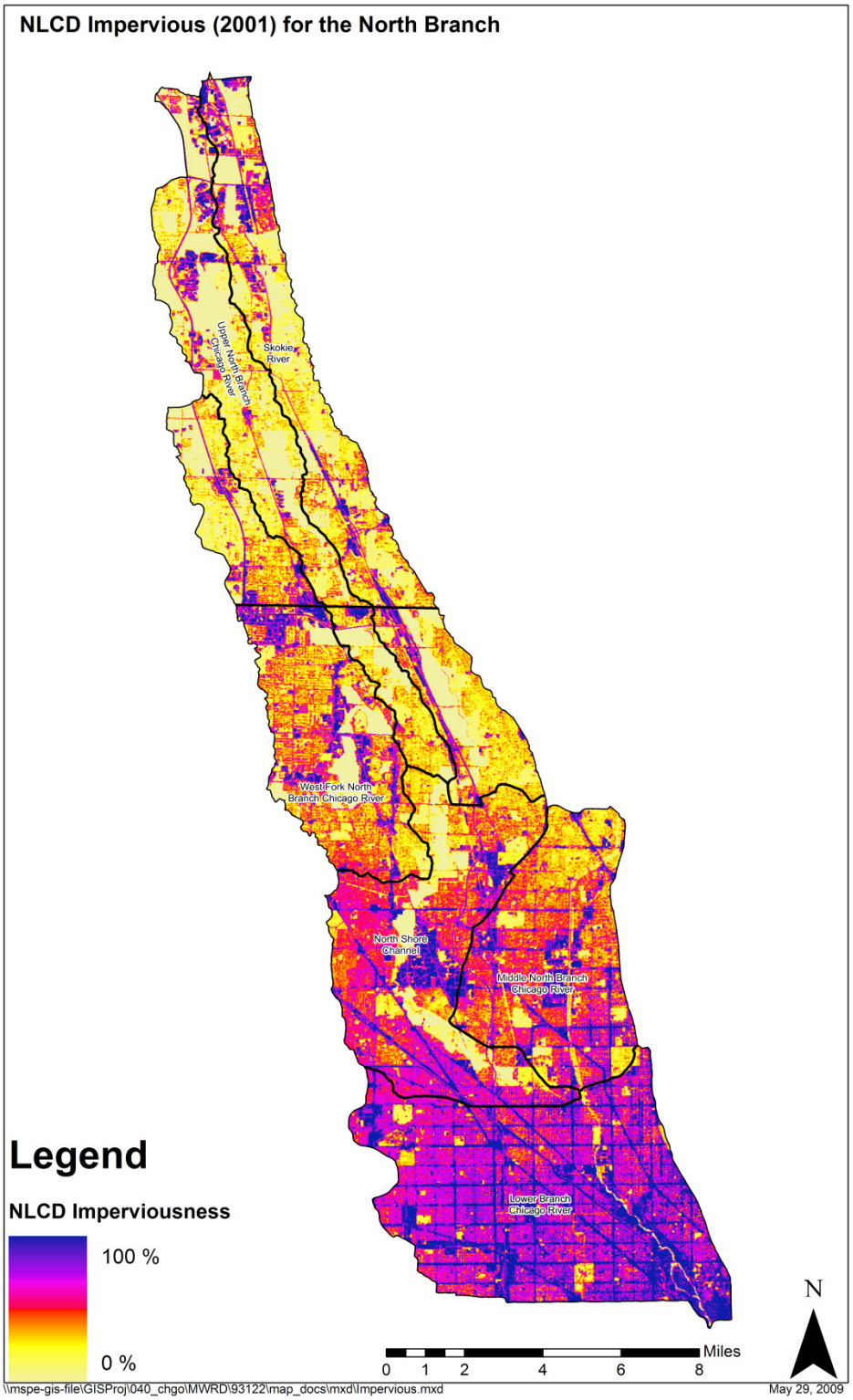

Figure 11. Impervious dataset for the North Branch

6. Curve Number Dataset Generation

NRCS has suggested curve numbers for a variety of land use types, hydrologic soil groups, and assumed conditions[m]. Figure 12 to Figure 14 shows the suggested curve numbers for agricultural and urban areas. Urban curve numbers are generally based on an adjustment of an open space condition based on the extent of impervious area. This adjustment given by:

$$CN_c = CN_p + \left(\frac{P}{100}\right)\left(98 - CN_p\right) \text{ (Equation 1)}$$

Where:

CN_c is the composite runoff curve number;
CN_p is the pervious runoff curve number, in this case the curve number for open space in a good hydrologic condition;
P is the percent imperviousness of an area.

For example, the curve number for a HSG C soil for open space (good condition) is 74. NRCS assumes that Commercial and Business land use has an average impervious area of 85%. To compute the curve number for this land use and a HSG C soil:

$$CN_c = 74 + \left(\frac{85}{100}\right)(98 - 74) = 94$$

This composite curve number is reported for the Commercial and Business land use for HSG C in Figure 14. As percent imperviousness approaches 100%, the curve number approaches 98.

HDR developed two GIS datasets of curve numbers based on either drained or undrained soil conditions shown in Figure 7 and Figure 8. The average impervious area for each type of land use (Table 5) was compared to NRCS assumed impervious areas to select a suggested set of curve numbers from Figure 14. Aerial photographs were also examined for assessing agricultural land uses or to refine hydrologic conditions for certain types of urban open space.

In some cases, land use types did not match a NRCS suggested set of curve numbers. A significant instance of this is residential land uses. The CMAP land use dataset generally defines residential areas on the basis of subdivisions and not individual homes. Further, a single family residential area could vary from a stand alone home with yard (with relatively low impervious area) to a condominium complex (with a relatively high impervious area). Institutional land uses, such as educational facilities, could vary from a relatively highly impervious single building and associated parking, to a campus containing open space, to a recreational facility mostly consisting of open space. In these cases, an open space condition with good grass cover was

[m] NRCS, "National Engineering Handbook, Part 630, Chapter 9 Hydrologic Soil-Cover Complexes", July 2004.

assumed. The curve number was then adjusted based on Equation 1 using the remotely sensed average impervious area taken over each specific parcel.

Table 6 lists the approach used to calculate curve number for each land use. Figure 15 and Figure 16 show the resulting curve numbers for drained and undrained soil conditions, respectively.

Based on guidance documents provided in the CH2M Hill Memo, the final curve numbers will be the average between drained and undrained soil conditions. Figure 17 provides the average drained and undrained soil condition curve numbers. An average curve number from this latter dataset will be computed for each subbasin drainage area previously delineated by HDR. The Geo-HMS software will create final HEC-HMS model code which incorporates the curve number information.

Table 9–1 Runoff curve numbers for agricultural lands [1/]

Cover description			CN for hydrologic soil group			
covertype	treatment [2/]	hydrologic condition [2/]	A	B	C	D
Fallow	Bare Soil	---	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C & T)	Poor	66	74	80	82
		Good	62	71	78	81
	C & T + CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C & T	Poor	61	72	79	82
		Good	59	70	78	81
	C & T + CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C & T	Poor	63	73	80	83
		Good	51	67	76	80

Figure 12. NRCS Suggested Curve Numbers for Cultivated Agricultural Lands

Table 9–1 Runoff curve numbers for agricultural lands [1/] — Continued

Cover description: cover type	treatment [2/]	hydrologic condition [3/]	CN for hydrologic soil group: A	B	C	D
Pasture, grassland, or range-continuous forage for grazing [4/]		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
Meadow-continuous grass, protected from grazing and generally mowed for hay		Good	30	58	71	78
Brush-brush-forbs-grass mixture with brush the major element [5/]		Poor	48	67	77	83
		Fair	35	56	70	77
		Good	30 [6/]	48	65	73
Woods-grass combination (orchard or tree farm) [7/]		Poor	57	73	82	86
		Fair	43	65	76	82
		Good	32	58	72	79
Woods [8/]		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Farmstead--buildings, lanes, driveways, and surrounding lots		---	59	74	82	86
Roads (including right-of-way):						
Dirt		---	72	82	87	89
Gravel		---	76	85	89	91

1/ Average runoff condition, and I_a=0.2s.

2/ Crop residue cover applies only if residue is on at least 5 percent of the surface throughout the year.

3/ Hydrologic condition is based on combinations of factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥20%), and (e) degree of surface toughness.
Poor: Factors impair infiltration and tend to increase runoff.
Good: Factors encourage average and better then average infiltration and tend to decrease runoff.
For conservation tillage poor hydrologic condition, 5 to 20 percent of the surface is covered with residue (less than 750 pounds per acre for row crops or 300 pounds per acre for small grain).
For conservation tillage good hydrologic condition, more than 20 percent of the surface is covered with residue (greater than 750 pounds per acre for row crops or 300 pounds per acre for small grain).

4/ Poor: < 50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

5/ Poor: < 50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

6/ If actual curve number is less than 30, use CN = 30 for runoff computation.

7/ CNs shown were computed for areas with 50 percent woods and 50 percent grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.

8/ Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed, but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Figure 13. NRCS Suggested Curve Numbers for Non-Cultivated Agricultural Lands

Table 9–5 Runoff curve numbers for urban areas [1/]

Cover description cover type and hydrologic condition	Average percent impervious area [2/]	-- CN for hydrologic soil group --			
		A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65 — 51.5	77	85	90	92
1/4 acre	38 — 34	61	75	83	87
1/3 acre	30 — 27.5	57	72	81	86
1/2 acre	25 — 22.5	54	70	80	85
1 acre	20 — 16	51	68	79	84
2 acres	12 — 0	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation)		77	86	91	94

1/ Average runoff condition, and $I_a = 0.2S$.

2/ The average percent impervious area shown was used to develop the composite CNs. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

3/ CNs shown are equivalent to those of pasture. Composite CNs may be computed for other combinations of open space type.

4/ Composite CNs for natural desert landscaping should be computed using figures 9–3 or 9–4 based on the impervious area percentage (CN=98) and the pervious area CN. The pervious area CNs are assumed equivalent to desert shrub in poor hydrologic condition.

Figure 14. NRCS Suggested Curve Numbers for Urban Areas

Table 6. Curve Number Calculation Method by Land Use

Land Use	Curve Number Data Source
1110 RES/SF	Impervious adjustment from open space, good condition
1120 RES/FARM	Impervious adjustment from open space, good condition
1130 RES/MF	Impervious adjustment from open space, good condition
1140 RES/MOBILE HM	Impervious adjustment from open space, good condition
1211 MALL	Commercial and business
1212 RETAIL CNTR	Commercial and business
1221 OFFICE CMPS	Impervious adjustment from open space, good condition
1222 SINGL OFFICE	Impervious adjustment from open space, good condition
1223 BUS. PARK	Impervious adjustment from open space, good condition
1231 URB MX W/PRKNG	Industrial
1232 URB MX NO PRKNG	Commercial and business
1240 CULT/ENT	Impervious adjustment from open space, good condition
1250 HOTEL/MOTEL	Industrial
1310 MEDICAL	Impervious adjustment from open space, good condition
1320 EDUCATION	Impervious adjustment from open space, good condition
1330 GOVT	Impervious adjustment from open space, good condition
1350 RELIGOUS	Impervious adjustment from open space, good condition
1360 CEMETERY	Impervious adjustment from open space, good condition
1370 INST/OTHER	Impervious adjustment from open space, good condition
1410 MINERAL EXT	Industrial
1420 MANUF/PROC	Industrial
1430 WAREH/DIST/WHOL	Industrial
1440 INDUST PK	Industrial
1511 INTERSTATE/TOLL	Streets and Roads; Paved; open ditches
1512 OTHER ROADWAY	Streets and Roads; Paved; open ditches
1520 OTH LINEAR TRAN	Streets and Roads; Paved; open ditches
1540 INDEP AUTO PRK	Paved parking lots
1550 COMMUNICATION	Impervious adjustment from open space, good condition
1560 UTILITIES/WASTE	Impervious adjustment from open space, good condition
2100 CROP/GRAIN/GRAZ	Row crops, straight rows
2200 NRSRY/GRNHS/ORC	Impervious adjustment from open space, good condition
3100 OPENSP REC	Impervious adjustment from open space, good condition
3200 GOLF COURSE	Open space, good condition
3300 OPENSP CONS	Open space, good condition
3400 OPENSP PRIVATE	Impervious adjustment from open space, good condition
3500 OPENSP LINEAR	Impervious adjustment from open space, good condition
3600 OPENSP OTHER	Impervious adjustment from open space, good condition
4110 VAC FOR/GRASS	Impervious adjustment from open space, good condition
4120 WETLAND	Woods, Good condition
4210 CONST RES	Impervious adjustment from open space, good condition
4300 OTHER VACANT	Open space, poor condition
5100 RIVERS/CANALS	CN=98
5200 LAKE/RES/LAGOON	CN=98
5300 LAKE MICHIGAN	CN=98

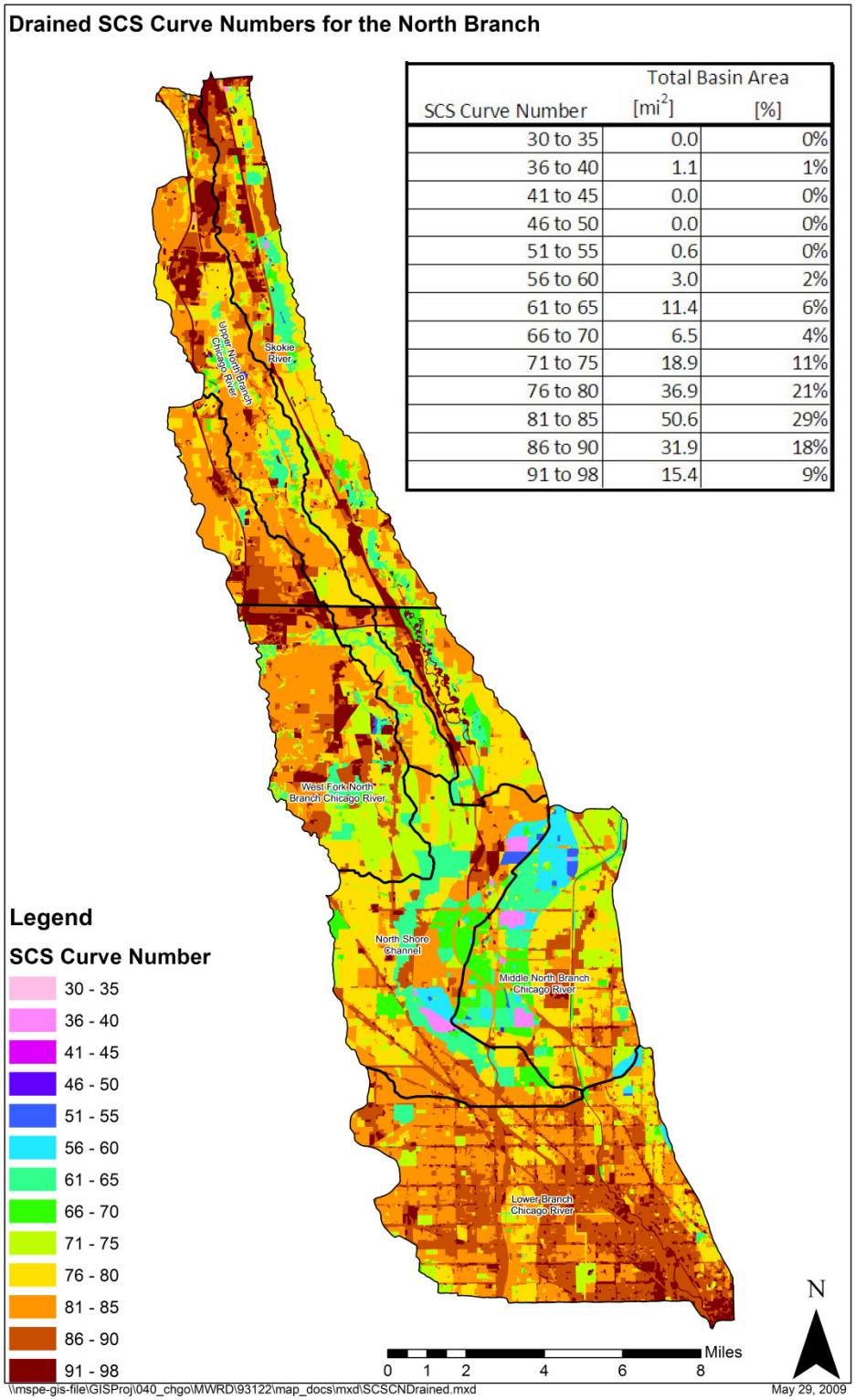

Figure 15. Curve Numbers based on Drained Soil Conditions

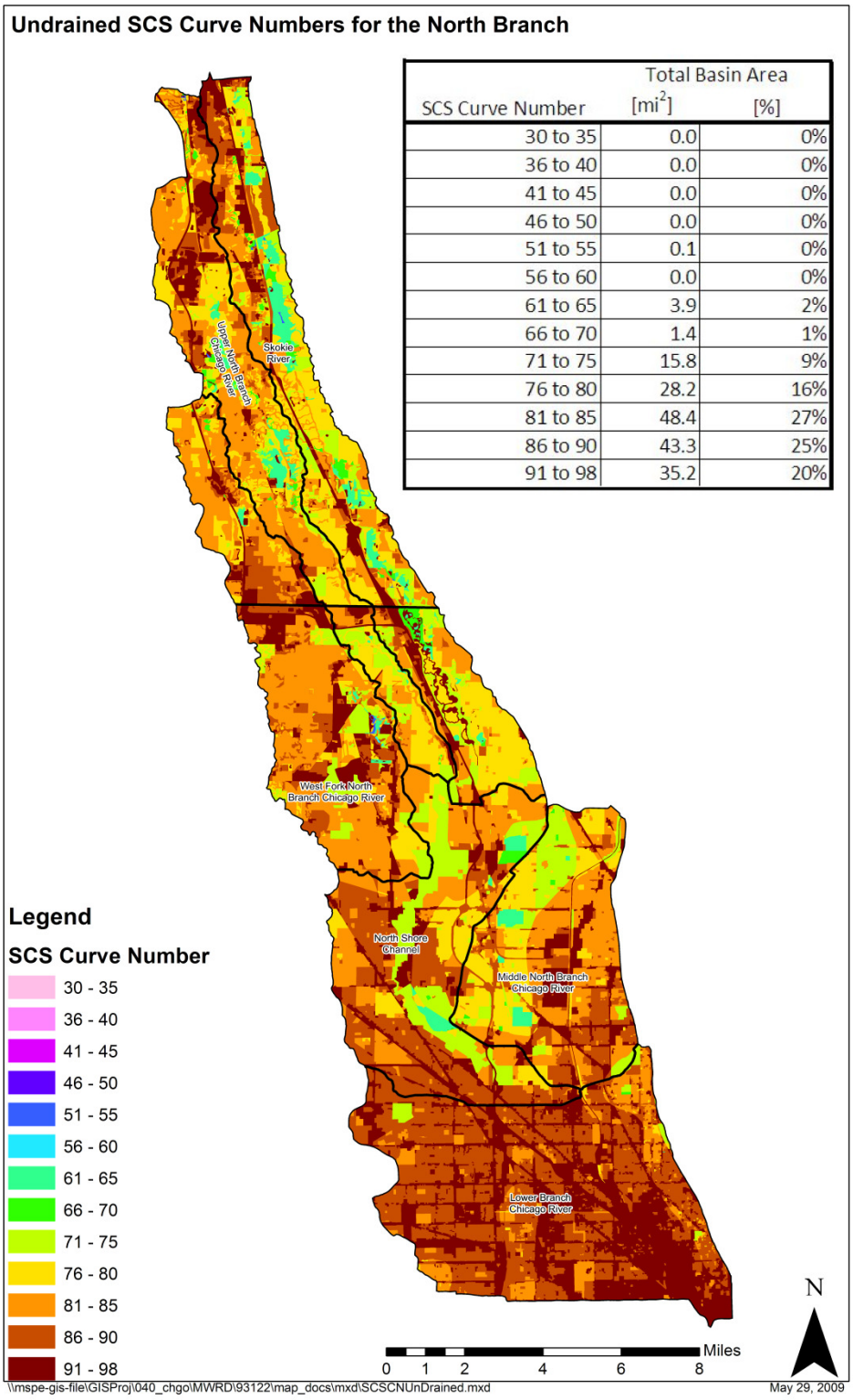

Figure 16. Curve Numbers based on Undrained Soil Conditions

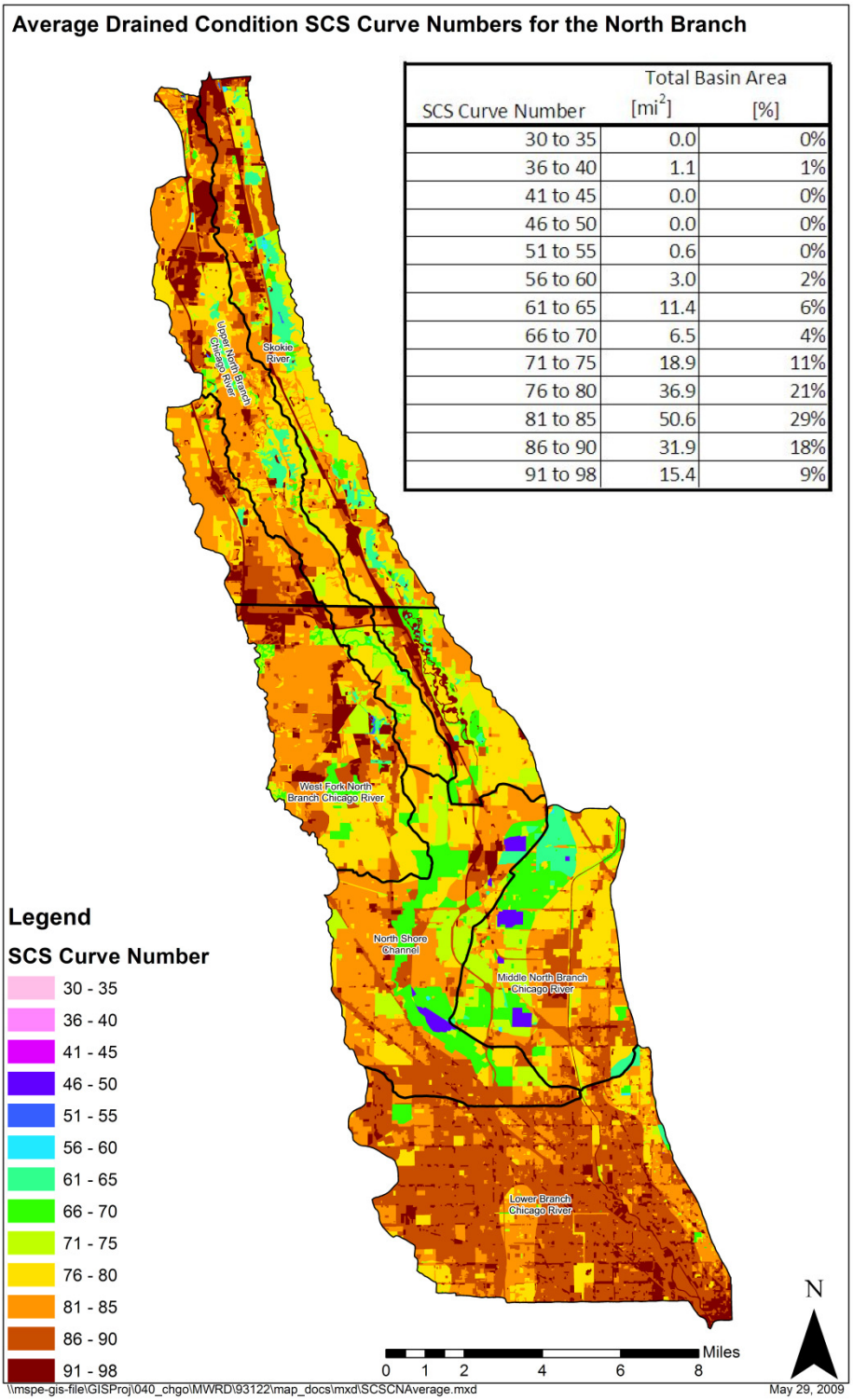

Figure 17. Curve Numbers based on Average Drained and Undrained Soil Conditions

Calumet-Sag Watershed SCS Curve Number Generation

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DATE: August 14, 2007

SCS hydrology uses the empirical curve number (CN) parameter as a part of calculating runoff volumes based on landscape characteristics such as soil type, land cover, imperviousness, and land-use development. Areas characterized by saturated or poorly infiltrating soils, or impervious development, have higher CN values, converting a greater portion of rainfall volume into runoff. The principle data sources used to develop CN values for the Calumet-Sag watershed are the Natural Resource Conversation Service (NRCS) soil data for Cook County and the 2001 Northeast Illinois Planning Commission (NIPC) land-use mapping for Cook County. This technical memorandum documents the procedure used to develop a CN grid for use in hydrologic modeling for the Calumet-Sag watershed and the assumptions inherent in this procedure.

Approach

CN values are dependent on a number of factors, including the soil infiltration characteristics and condition, as well as land cover characteristics such as directly connected impervious area and cover type. Therefore both soil data and land-use data are required to estimate CN. The best available soil and land-use data for Cook County are the NRCS soil data and NIPC land-use data. Table 1 lists curve numbers based on combinations of land-use data and soil data for small urban watersheds.

Table A.1 Curve Number Generation for Small Urban Watersheds

Cover description — Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group — A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5]		77	86	91	94

Table excerpted from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

A slightly modified version of this table will be used for curve number generation in the Calumet-Sag watershed, shown in table A.2. Both the NRCS soil data and the land use data require preprocessing before generating curve numbers using the lookup table.

Table A.2 Modified Curve Number Generation for Calumet-sag Watershed.

Description	Average % Impervious	Curve Number by Hydrologic Soil Group				Typical Land Uses
		A	B	C	D	
Residential (High Density)	65	77	85	90	92	Multi-family, Apartments, Condos, Trailer Parks
Residential (Med. Density)	30	57	72	81	86	Single-Family, Lot Size ¼ to 1 acre
Residential (Low Density)	15	48	66	78	83	Single-Family, Lot Size 1 acre and Greater
Commercial	85	89	92	94	95	Strip Commercial, Shopping Ctrs, Convenience Stores
Industrial	72	81	88	91	93	Light Industrial, Schools, Prisons, Treatment Plants
Disturbed/Transitional	5	76	85	89	91	Gravel Parking, Quarries, Land Under Development
Agricultural	5	67	77	83	87	Cultivated Land, Row crops, Broadcast Legumes
Open Land – Good	5	39	61	74	80	Parks, Golf Courses, Greenways, Grazed Pasture
Meadow	5	30	58	71	78	Hay Fields, Tall Grass, Ungrazed Pasture
Woods (Thick Cover)	5	30	55	70	77	Forest Litter and Brush adequately cover soil
Woods (Thin Cover)	5	43	65	76	82	Light Woods, Woods-Grass combination, Tree Farms
Impervious	95	98	98	98	98	Paved Parking, Shopping Malls, Major Roadways
Water	100	100	100	100	100	Water Bodies, Lakes, Ponds, Wetlands

Data from
http://gis2.esri.com/library/userconf/proc00/professional/papers/PAP657/p657.htm

Data is for average antecedent moisture condition II- dormant season (5-day) rainfall averaging from 0.5 to 1.1 inches and growing season rainfall from 1.4 to 2.1 inches

NRCS Soil data

Soil mapping for Cook County was downloaded from the NRCS website at http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/, representing 2002 conditions. The data downloaded includes a GIS shapefile of the soil groups and numerous text files that can be imported into an Access database and linked to the GIS data via a field called 'Mapunit Key.' The data field most relevant for SCS hydrology is the 'Hydrologic Group.' The hydrologic soil group (HSG) indicates the minimum infiltration of a specific soil group following wetting, and represented by four soil groups, shown in Table A.3.

TABLE A.3. HYDROLOGIC SOIL GROUPS

Hydrologic Soil Group	Description	Texture	Infiltration Rates (in/hr)
A	Low runoff potential and high infiltration rates even when wetted	Sand, loamy sand, or sandy loam	> 0.30
B	Moderate infiltration rates when wetted	Silt loam or loam	0.15 – 0.30
C	Low infiltration rates when wetted	Sandy clay loam	0.05 – 0.15
D	High runoff potential and very low infiltration when wetted	Clay loam, silty clay loam, sandy clay, silty clay, or clay clay, or clay	0 – 0.05

All data from Technical Release 55, Urban Hydrology for Small Watersheds, June 1986

Soil groups with drainage characteristics impacted by a high water table are indicated with a '/D' designation, where the letter preceding the slash indicates the hydrologic group of the soil under drained conditions. Thus an 'A/D' indicates that the soil has characteristics of the A soil group if drained, but the D soil group if not drained. 'A/D', 'B/D', or 'C/D', occur throughout the Calumet-Sag study area and represent a cumulative area of 9.11 mi^2 of the 152 square-mile watershed. Due to the difficulty of establishing the extent of drainage of these soils for each mapped soil polygon, it was assumed that 50% (by area) of these soil types were drained.

The City of Chicago is not mapped within the NRCS data set and thus does not have an assigned HSG. Based on previous studies, a minimum infiltration rate of 0.1 in/hr is reasonable in much of Chicago which corresponds to a 'C' HSG. In addition, a number of other soil features lacked HSG data, however these were generally open water or unmapped areas, for which CN values would not be stratified by HSG. When intersected with land-use data, the CN values are averaged across A, B , C and D values for the specified land-use type to estimate CN.

NIPC Land Use Data

NIPC land-use data contains delineation of land-use categories at an average scale of 0.10 acres for features in the Calumet-Sag watershed. To generate CN values, these land-use categories must be converted to analogous land-use categories for which CN data has previously been developed. Table A.4 demonstrates the field mapping used to convert NIPC land-use categories into categories for which CN data exists.

Table A.4. NIPC field mapping to land use field.

NIPC Code	NIPC Land USE	SCS Land Use	A	B	C	D	A/D	B/D	C/D	NULL
1110	1110 RES/SF	Residential (High Density)	77	85	90	92	84.5	88.5	91	86
1120	1120 RES/FARM	Residential (Low Density)	48	66	78	83	65.5	74.5	80.5	68.75
1130	1130 RES/MF	Residential (Med. Density)	57	72	81	86	71.5	79	83.5	74
1140	1140 RES/MOBILE HM	Residential (High Density)	77	85	90	92	84.5	88.5	91	86
1211	1211 MALL	Commercial	89	92	94	95	92	93.5	94.5	92.5
1212	1212 RETAIL CNTR	Commercial	89	92	94	95	92	93.5	94.5	92.5
1221	1221 OFFICE CMPS	Commercial	89	92	94	95	92	93.5	94.5	92.5
1222	1222 SINGL OFFICE	Commercial	89	92	94	95	92	93.5	94.5	92.5
1223	1223 BUS. PARK	Commercial	89	92	94	95	92	93.5	94.5	92.5
1231	1231 URB MX W/PRKNG	Commercial	89	92	94	95	92	93.5	94.5	92.5
1232	1232 URB MX NO PRKNG	Industrial	81	88	91	93	87	90.5	92	88.25
1240	1240 CULT/ENT	Commercial	89	92	94	95	92	93.5	94.5	92.5
1250	1250 HOTEL/MOTEL	Commercial	89	92	94	95	92	93.5	94.5	92.5
1310	1310 MEDICAL	Industrial	81	88	91	93	87	90.5	92	88.25
1320	1320 EDUCATION	Industrial	81	88	91	93	87	90.5	92	88.25
1330	1330 GOVT	Commercial	89	92	94	95	92	93.5	94.5	92.5
1340	1340 PRISON	Industrial	81	88	91	93	87	90.5	92	88.25
1350	1350 RELIGOUS	Commercial	89	92	94	95	92	93.5	94.5	92.5
1360	1360 CEMETERY	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
1370	1370 INST/OTHER	Residential (Low Density)	48	66	78	83	65.5	74.5	80.5	68.75
1410	1410 MINERAL EXT	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
1420	1420 MANUF/PROC	Industrial	81	88	91	93	87	90.5	92	88.25
1430	1430 WAREH/DIST/WHOL	Industrial	81	88	91	93	87	90.5	92	88.25
1440	1440 INDUST PK	Industrial	81	88	91	93	87	90.5	92	88.25

NIPC Code	NIPC Land USE	SCS Land Use	A	B	C	D	A/D	B/D	C/D	NULL
1511	1511 INTERSTATE/TOLL	75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1512	1512 OTHER ROADWY	75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1520	1520 OTH LINEAR TRAN	I75 % Impervious/25 % Open Land	83.25	88.75	92.00	93.50	88.38	91.13	92.75	89.38
1530	1530 AIR TRANSPORT	50 % Impervious/ 50% Open Lands	68.50	79.50	86.00	89.00	78.75	84.25	87.50	80.75
1540	1540 INDEP AUTO PRK	Commercial	89	92	94	95	92	93.5	94.5	92.5
1550	1550 COMMUNICATION	Agricultural	67	77	83	87	77	82	85	78.5
1560	1560 UTILITIES/WASTE	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
2100	CROP/GRAIN/GRAZ	Agricultural	67	77	83	87	77	82	85	78.5
2200	NRSRY/GRNHS/ORC	Agricultural	67	77	83	87	77	82	85	78.5
2300	2300 AG/OTHER	Agricultural	67	77	83	87	77	82	85	78.5
3100	3100 OPENSP REC	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3200	3200 GOLF COURSE	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3300	3300 OPENSP CONS	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3400	3400 OPENSP PRIVATE	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3500	3500 OPENSP LINEAR	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
3600	3600 OPENSP OTHER	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
4110	4110 VAC FOR/GRASS	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
4120	4120 WETLAND	Meadow	30	58	71	78	54	68	74.5	59.25
4210	4210 CONST RES	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
4220	4220 CONST NONRES	Disturbed/Transitional	76	85	89	91	83.5	88	90	85.25
4300	4300 OTHER VACANT	Open Land – Good	39	61	74	80	59.5	70.5	77	63.5
5100	5100 RIVERS/CANALS	Water	100	100	100	100	100	100	100	100
5200	LAKE/RES/LAGOON	Water	100	100	100	100	100	100	100	100
5300	5300 LAKE MICHIGAN	Water	100	100	100	100	100	100	100	100
9999	9999 OUT OF REGION	Water	100	100	100	100	100	100	100	100

Note: not all NIPC land use types exist within the Calumet-Sag watershed.

Steps for Generating Curve Number Grid

Following the preparation of the land-use and soil data is described in the preceding two sections, three steps are followed to generate the CN Grid

1) Perform an intersection of the NRCS soil mapping polygon feature class with the NIPC land use polygon feature class. This produces a polygon feature class that has both land-use type and HSG. This feature class was output into a personal geodatabase so that Access queries could be performed on it.
2) Add a field called CurveNumber to the intersected feature class
3) Assign a CN value to each intersected polygon feature based upon HSG and land use. This was performed using an Access update query on the CurveNumber field. The soil groups impacted by high water table (e.g. 'A/D') were estimated to be 50% drained, using the average of the D CN and the drained (e.g. A) CN.
4) Use the "feature to raster" function in ArcToolbox to create a CN grid based on the CurveNumber value at the center of each grid pixel. A 20 ft x 20 ft grid, the same resolution as digital terrain model uses for watershed delineation, was used for this purpose.

The included figure shows the final CN grid for the Calumet-Sag watershed.