Calumet-Sag Watershed SCS Curve Number Generation

PREPARED FOR: Jonathan Grabowy \ MWRDGC

PREPARED BY: Mason Throneburg \ CH2M HILL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL

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.

COPYRIGHT 2008 BY CH2M HILL, INC. • COMPANY CONFIDENTIAL