Spatial database development, web mapping application design, and ArcSLAMM-WinSLAMM urban stormwater modeling for planning purposes in Dry Run Creek Watershed

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Final Report

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Background/Scope of Work:

The GeoTREE Center has previously worked with Dry Run Creek Watershed coordinator to develop spatial databases and to carry out urban stormwater modeling in the Dry Run Creek watershed. That work occurred over a couple different phases in which the GeoTREE Center developed a comprehensive Geographic Information Systems database which included the representation of very detailed source areas (land use) for all urban areas of the watershed. This database was in a custom ArcSLAMM geodatabase format which along with ArcSLAMM tools allowed the GeoTREE Center to use WinSLAMM to model runoff and pollutant loads across all urban sub-watersheds. In addition to this modeling the GeoTREE Center developed sub-watershed boundaries for approximately 10 Best Management Practices (BMPs) in the DRC watershed and used the ArcSLAMM/WinSLAMM modeling system to model reductions in runoff volume and pollutant resulting from the BMPs. Although this was a significant accomplishment the DRC Watershed Coordinator and the DRC Advisory Board and Commissioners desired to have a more complete modeling effort for the multitude of BMPs that are in the DRC Watershed.

The present project has attempted to more comprehensively model the benefits of BMPs in the watershed. This was accomplished by using the ArcSLAMM toolset and databases to derive sub-watershed or drainage area boundaries for 67 separate BMPs in the watershed, creating WinSLAMM compliant database files for each of those 67 sub-watersheds, parameterized individual BMPs in the WinSLAMM model for those 67 databases, and carried out WinSLAMM modeling for each of the databases resulting in modeled improvements due to the BMP. The results from the project include this report, all modeled data in GIS and Excel format, and a web mapping application (https://arcg.is/1TqTj8) for easy interrogation of the result. In addition to the BMP modeling results, the base modeling for the entire urban area of the DRC Watershed are delivered and presented in this report. This is an update to what was delivered in previous project. The GeoTREE Center updated the underlying detailed source area and have rerun the ArcSLAMM/WinSLAMM process to produce modeled results for all sub-watersheds in the DRC watershed.

WinSLAMM and ArcSLAMM

The WinSLAMM model (http://www.winslamm.com/default.html) is a relatively widely used urban stormwater planning model which has been used in various areas throughout North America. Developed over several decades, and based on extensive field monitoring activities, the model is continually updated and calibrated using field monitoring data to generate relatively accurate predicted water quality and quantity results. Although characterizing urban watersheds is an inherently geospatial activity, WinSLAMM had not previously leveraged GIS software for developing land use input information or for visualizing results back in GIS software. Initially funded by a grant from the Iowa Water Center, a preliminary ArcSLAMM package was developed to couple ArcGIS to WinSLAMM by the UNI GeoTREE Center. Further funding from both PV&Associates, developer of WinSLAMM, and the Iowa Department of Agriculture and Land Stewardship (IDALS) allowed the continued development of ArcSLAMM. The ArcSLAMM package, which consists of a customized geodatabase and a set of custom ArcGIS tools, greatly extends the capabilities for applying WinSLAMM to modeling small to moderate urban watersheds.

This project represents a large effort to apply the coupled ArcSLAMM/WinSLAMM system to an urban watershed such as Dry Run Creek Watershed including modeling a significant number of BMPs. The overall objectives of the project were to:

- Quantify annual stormwater pollution discharged in the urban area of Dry RunCreek based on a representative annual rainfall file
- Develop maps and database that can be used to identify areas that produce the most stormwater pollution
- Assess the pollution control effectiveness of previously installed BMPs
- Develop a web mapping application (https://arcg.is/1TqTj8) which displays BMPs in the Dry Run Creek Watershed

Detailed source areas database development

Using ArcGIS and the ArcSLAMM customized geodatabase, several UNI GeoTREE Center student research assistants participated in the digitization and quality control checking that led to the development of a comprehensive coverage of the urban areas of DRC watershed. The customized ArcSLAMM geodatabase is designed to greatly improve the efficiency in digitizing detailed source areas (land use). The student research assistants used high resolution imagery provided by Blackhawk County to digitize approximately 5805 acres of detailed source areas in the urban part of the watershed.

The entire digitized geodatabase source area feature class contains 46,133 polygons. Figures 2 and 3 show the final digitized urban area in the Dry Run Creek watershed. The geodatabase allows the user to draw polygons and then enter the relevant characteristics of each polygon that WinSLAMM requires. WinSLAMM requires that each polygon have a land use type (residential, institutional, industrial, commercial, other urban, freeway) and a source area type (roofs, driveways, parking lots, sidewalks, landscaped areas, etc.) along with other information that WinSLAMM requires (such as whether a roof is pitched or flat, whether a parking lot drains to a pervious/impervious area). As far as the land use type, residential area has the majority for both the total number of polygons (~87.4%) and the area (3115 acres). There were 1458, 364, 784, 6, and 76 acres of institutional, commercial, industrial, other urban, and freeway land uses in the digitized geodatabase. Table 1 indicates the area falling in general source area types.

Table 1: The area by major land use (source area types) in the Dry Run Creek watershed.

Area by Source Area		
Source Area	Total area (acres)	Area (percentage)
Landscape Areas	3651.26	62.9%
Rooftops	619.49	10.67%
Paved Parking	434.33	7.48%
Streets	529.33	9.12%
Driveways	185.75	3.2%
Sidewalks	164.87	2.84%
Water Body Areas	32.04	0.55%
Other Impervious Areas	0.93	0.02%
Undeveloped Areas	61.24	1.05%
Paved Playground	6.32	0.11%
Other Pervious Areas	5.07	0.09%
Unpaved Parking	38.15	0.66%
High Traffic Urban Freeway	53.53	0.92%
High Traffic Urban Pervious	22.91	0.39%
Total	5805.24	100%

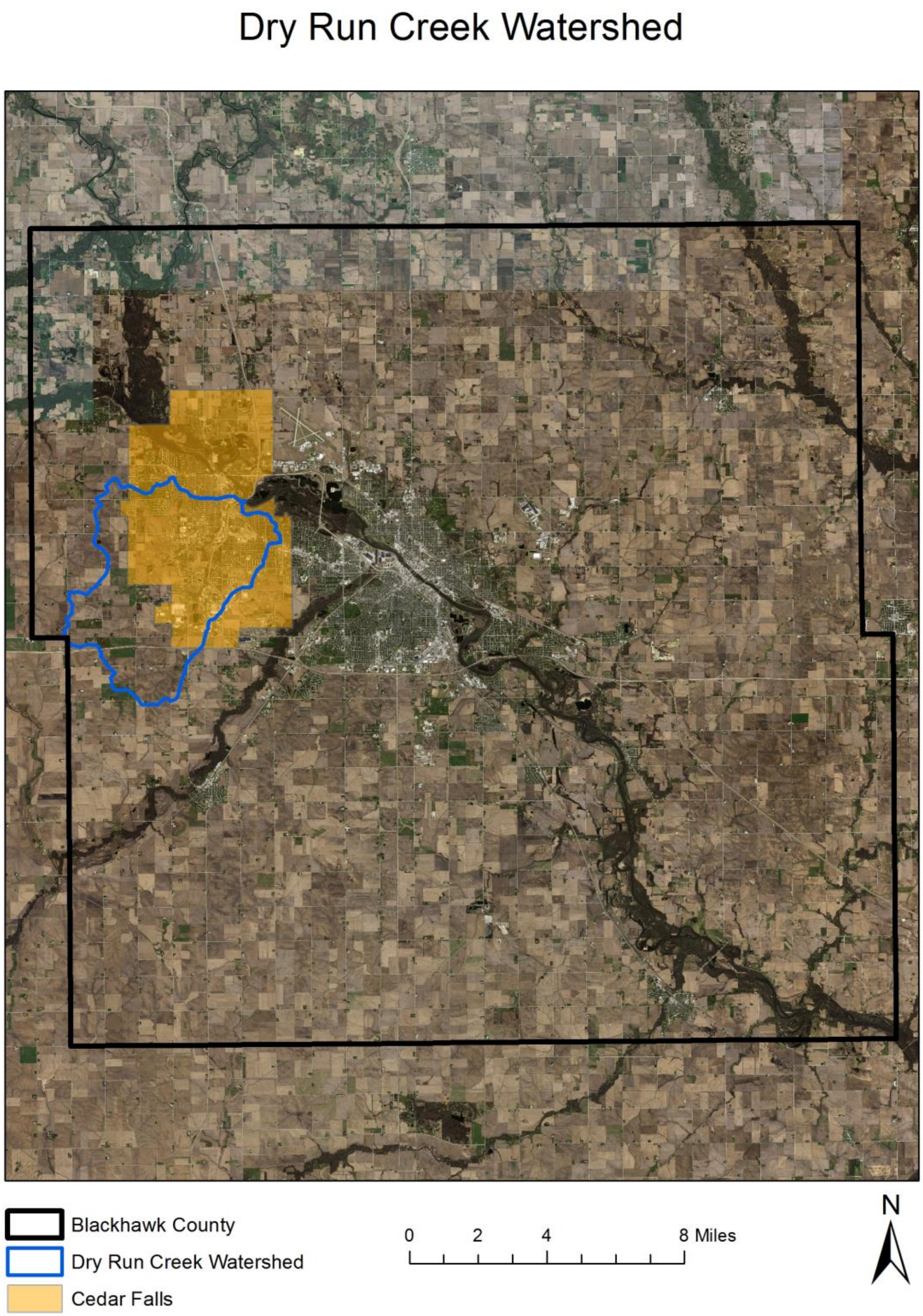

Figure 1: Map of the Dry Run Creek watershed in relation to Blackhawk County and the city Cedar Falls, Iowa.

Dry Run Creek Watershed

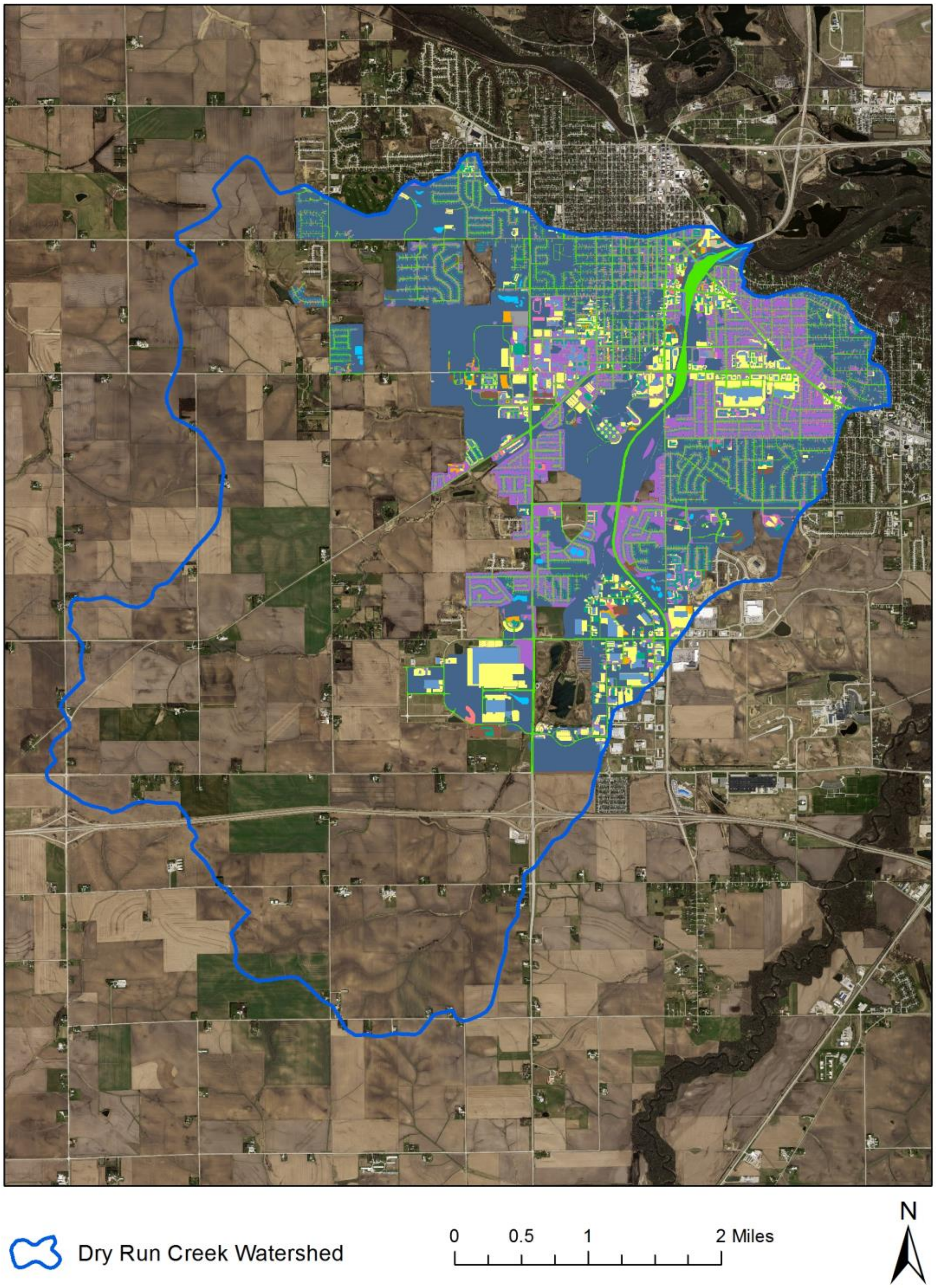

Figure 2: The digitized urban areas of Cedar Falls in the Dry Run Creek watershed storing WinSLAMM source areas.

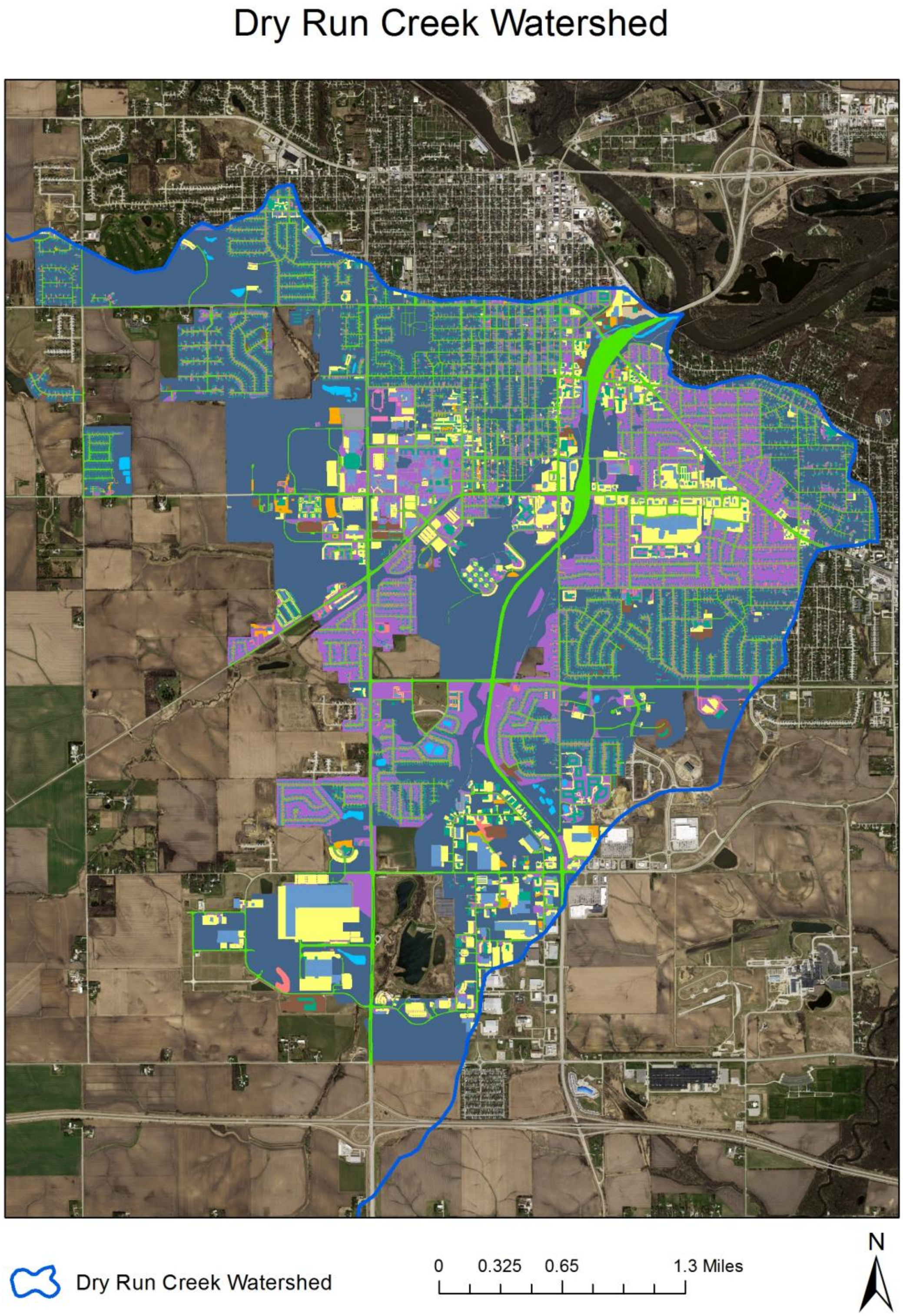

Figure 3: Zoomed in view of digitized urban areas of Cedar Falls in the Dry Run Creek watershed.

Sub-watershed Delineation

ArcSLAMM tools were used to derive several sets of sub-watersheds that fall in the Dry Run Creek watershed based on the topography of the area as defined by the Iowa Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM) which was downloaded from the Iowa Department of Natural Resources GIS Library (https://programs.iowadnr.gov/nrgislibx/). Before delineating the sub-watersheds, the DEM was hydrologically enforced using the Hydrologically Enforce Digital Elevation Model (DEM) ArcSLAMM tool using the detailed stream lines produced by the Iowa DNR and Flood Center as part of their statewide floodplain mapping project (http://iowafloodcenter.org/projects/floodplain-mapping/ and http://www.iihr.uiowa.edu/iowafloodmaps). Using the hydrologically enforced DEM and the ArcSLAMM Catchment Delineation tools, sub-watersheds for the entire urban area of the Dry Run Creek watershed were derived and are shown in Figure 4. The sub-watersheds (N = 398) for the urban area of DRC were defined by entering a parameter for the tool indicating the approximate size, or upstream drainage area, to use to define the sub-watersheds. This was set to 5000 cells (approximately 10-15 acres).

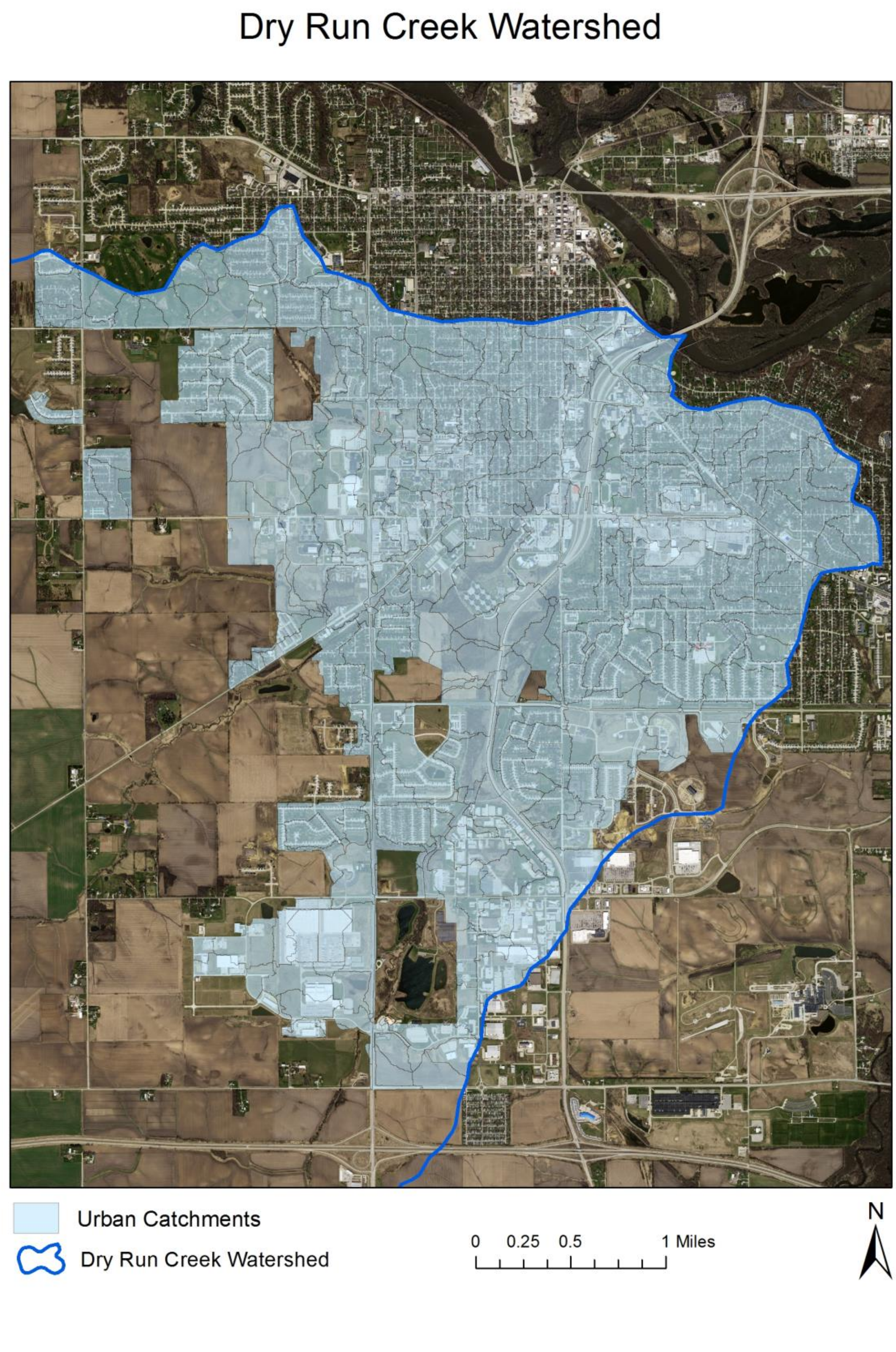

Figure 4: The sub-watersheds used for generating WinSLAMM compliant databases in Cedar Falls.

WinSLAMM File Generation

Two further tools in the ArcSLAMM package allow the completion of the pre-processing steps which result in the creation of one WinSLAMM compliant database file per sub-watershed. In the first instance, the Intersect Catchments with WinSLAMM Detailed Source Areas ArcSLAMM tool was used to prepare GIS feature classes that is an intersection of the sub-watersheds with their unique identifier and all detailed WinSLAMM source areas. There were 398 urban sub-watersheds delineated for the Dry Run Creek watershed in areas with detailed source areas (i.e urban areas). The final preprocessing step was to run the Create WinSLAMM Compliant Databases ArcSLAMM tool to create one WinSLAMM compliant database for each unique sub-watershed. WinSLAMM uses the Microsoft Access .mdb file format to store a wide variety of information in approximately 20 separate tables. The Create WinSLAMM Compliant Databases ArcSLAMM tool reads data from the intersected sub-watershed/source area feature class and translates this data into the necessary file format that WinSLAMM can read. At this point there was one unique file for each sub-watershed. Figure 3 illustrates an example screenshot of these files Windows Explorer.

Name	Date modified	Type	Size
catchment162.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment168.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment171.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment172.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment177.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment179.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment186.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment194.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment197.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment199.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment203.mdb	11/7/2016 2:05 PM	Microsoft Access ...	1,152 KB
catchment217.mdb	11/7/2016 2:06 PM	Microsoft Access ...	1,152 KB
catchment221.mdb	11/7/2016 2:06 PM	Microsoft Access ...	1,152 KB
catchment222.mdb	11/7/2016 2:06 PM	Microsoft Access ...	1,152 KB
catchment232.mdb	11/7/2016 2:06 PM	Microsoft Access ...	1,152 KB

Figure 5: A screenshot demonstrating WinSLAMM compliant databases.

WinSLAMM Base Modeling

The WinSLAMM model was used to carry out simulations for all urban sub-watersheds in the Dry Run Creek watershed. The purpose of this modeling was to meet the first two objectives mentioned above: to quantify stormwater runoff per sub-watershed thereby providing data and to indicate higher contributing areas (hot-spots). This modeling was carried out using WinSLAMM and the files created as described above using the ArcSLAMM – i.e. one simulation per sub-watershed. Figure 6 demonstrates a file opened in WinSLAMM. So in this example, the source areas from industrial, institutional, and residential areas of a sub-watershed have been translated from the ArcSLAMM geodatabase land use and source area types to the WinSLAMM format which can be used for carrying out a simulation. The WinSLAMM model can be run for a single file or batch processing can be carried out for a set of files.

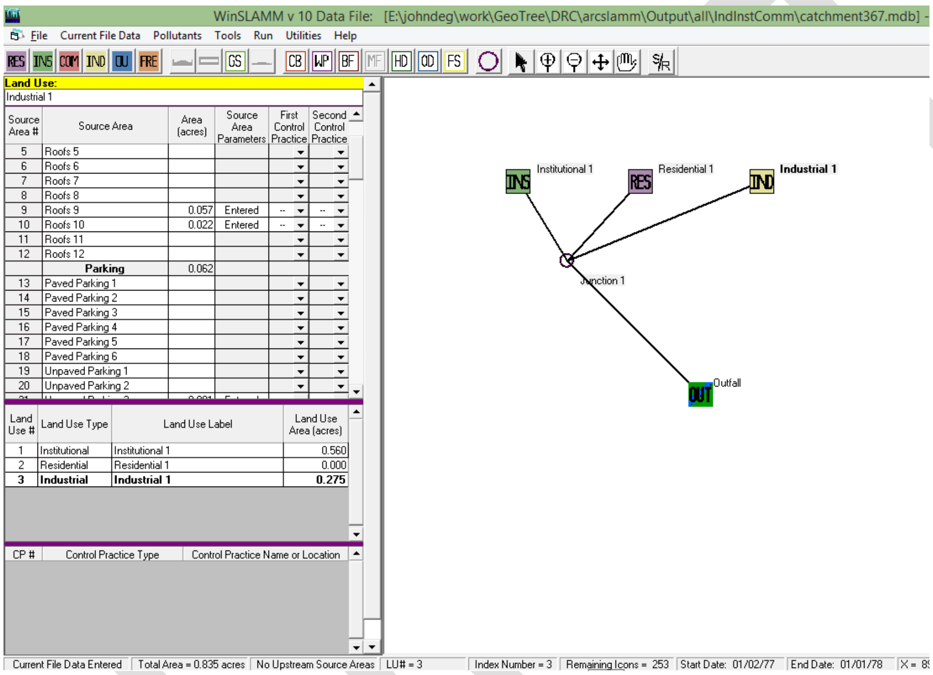

Figure 6: A single sub-watershed WinSLAMM database open in the WinSLAMM software.

The base modeling carried out represents a single year of simulation utilizing a rainfall file from Waterloo, Iowa from 1977 which represents an average rainfall year (total rainfall = 34 inches). The rainfall file contains the rain start and end date and time as well as the total rainfall depth occurring in that year and WinSLAMM models the runoff and pollutant loads for each rainfall event.

The WinSLAMM model requires several other files that are used to model estimates of particulate solids concentrations by source areas and land use, other pollutant concentrations, and runoff volumes from different source areas. Table 2 indicates the files used in the base WinSLAMM modeling. The same files were used for all of these simulations except for the Street Delivery File which is varied by WinSLAMM depending on the type of land use for a given source area. The model also can use a Winter Season Range which in our case was set to dates (12/01 to 03/12) recommended for Madison, Wisconsin. (http://wi.water.usgs.gov/slamm/readme10.0.html).

Table 2: The files used in WinSLAMM base modeling.

File Name	Description
IA Waterloo 1977.RAN	Start/end time and date of all rainfall events in typical year – an example file from Waterloo, IA was used
WI_AVG01.pscx	Particulate solids concentration file. Varies based on source area, land use, and rainfall depth. Based on numerous stormwater monitoring studies in Wisconsin by USGS and Wisconsin DNR
WI_GE003.ppdx	Pollutant probability distribution file for all pollutants besides sediments. Varies per source area/land use combination. Based on numerous stormwater monitoring studies in Wisconsin by USGS and Wisconsin DNR
WI_SL06 Dec06.rsvx	Runoff coefficient file used to calculate runoff volume for each different source area as a function of rainfall depth. Based on numerous stormwater monitoring studies by the USGS and Wisconsin DNR from various urban land uses and source areas in Wisconsin
WI_Com Inst Indust Dec06.std or WI_Res and Other Urban Dec06.std	Street delivery file which describe the fraction of total particulates that are washed from the streets during rain events but are subsequently redeposited due to lack of energy in the flowing water. WinSLAMM adjusts the file used based on the land use being modeled for individual source areas.

Figure 7-10 shows the WinSLAMM base (no BMPs included) modeled results by sub-watershed in the urban areas of the Dry Run Creek watershed. There are several sub-watersheds that were delineated only for small segments of roads which have the highest loading rates but are difficult to distinguish on the map.

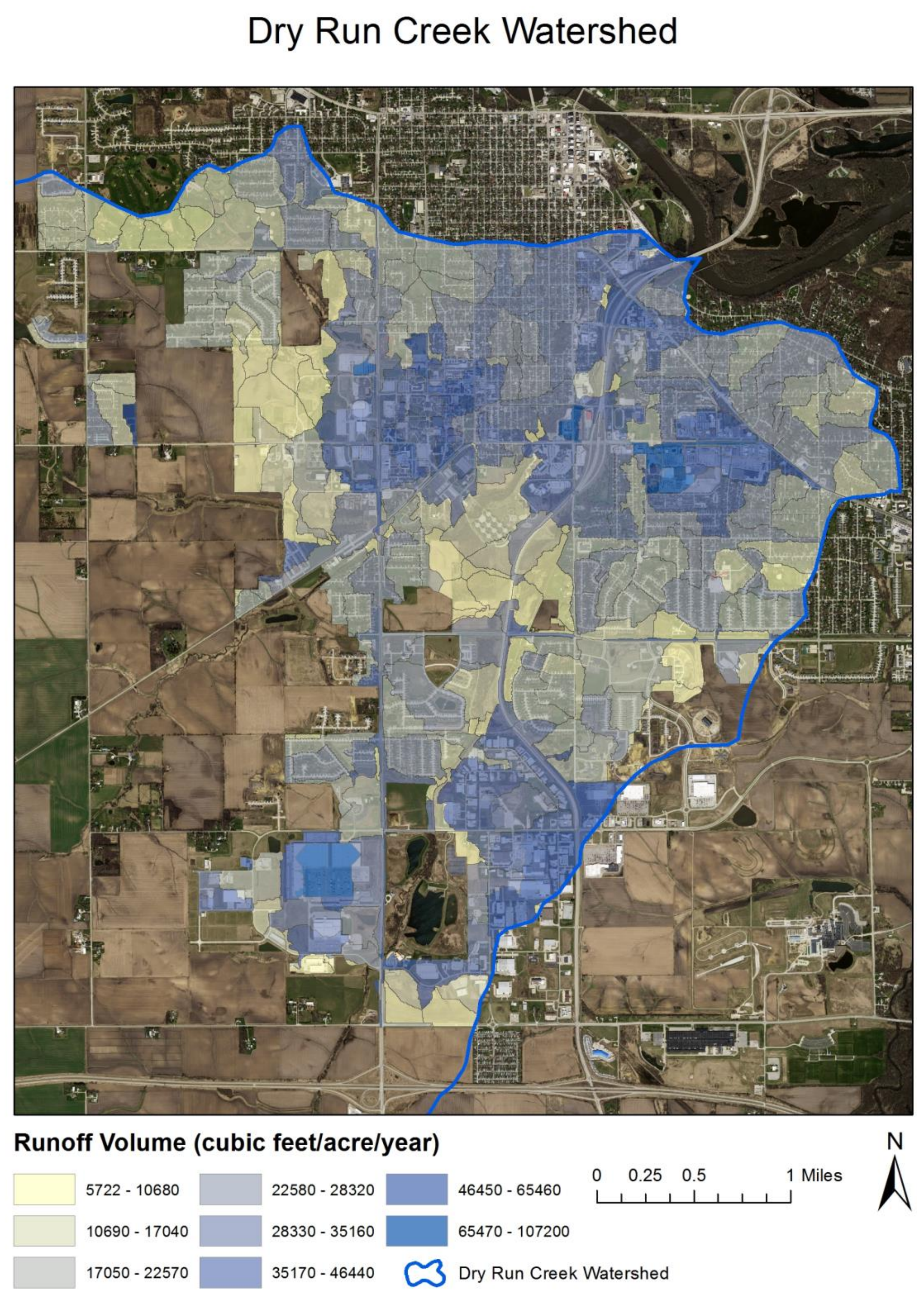

Figure 7: WinSLAMM modeled total runoff for all sub-watersheds normalized by the area (acres) of the catchment.

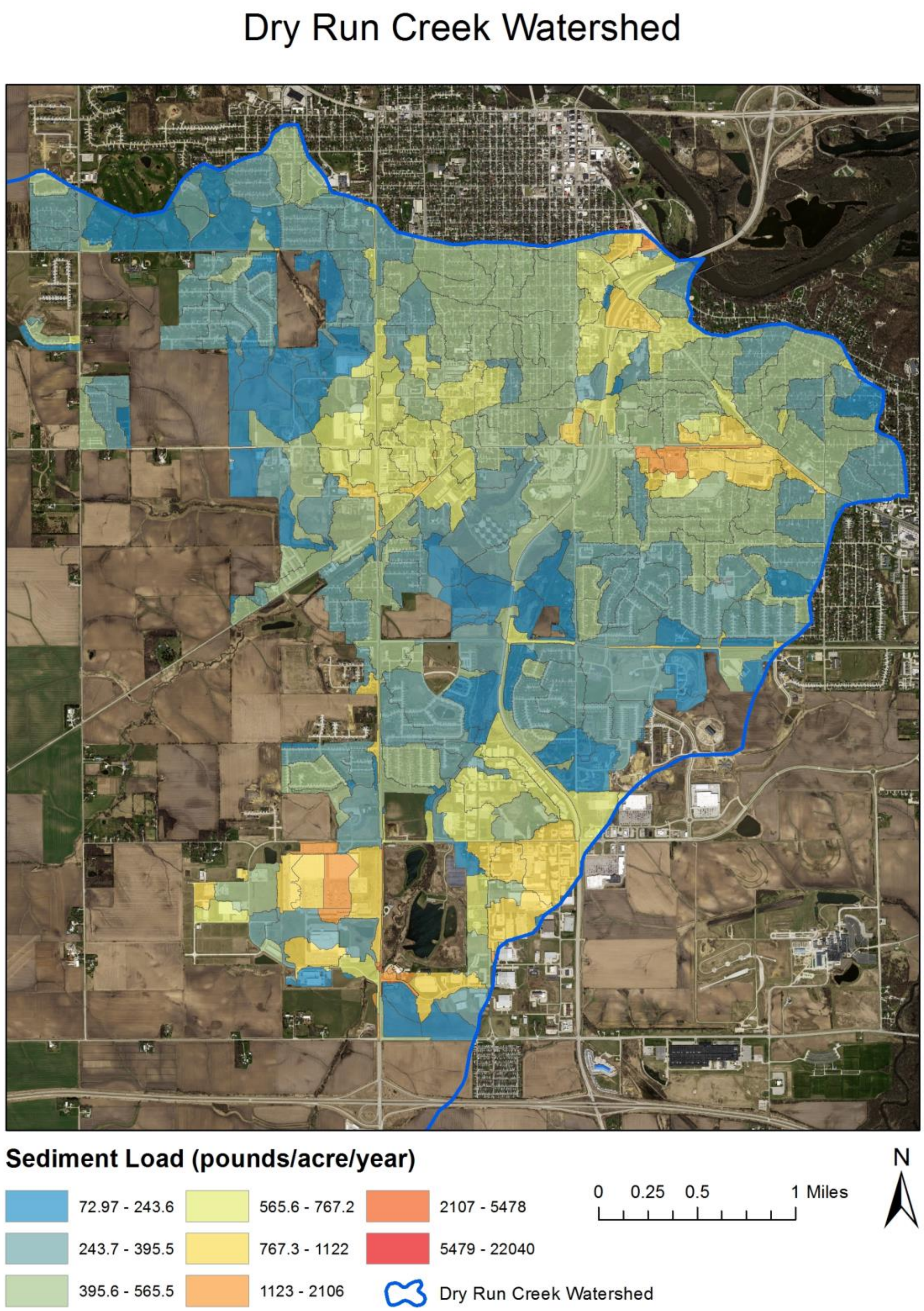

Figure 8: WinSLAMM modeled total sediment load for all sub-watersheds.

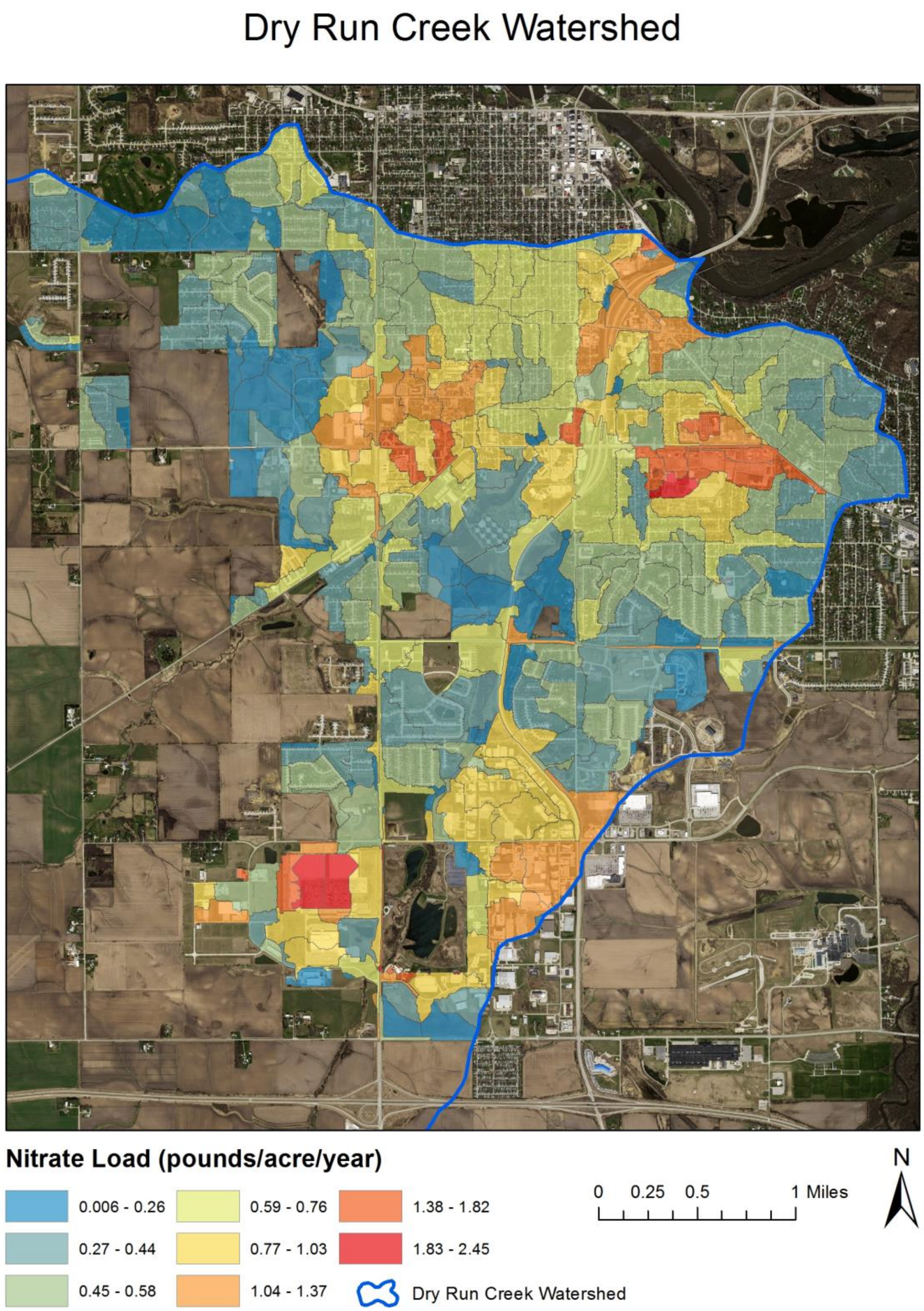

Figure 9: WinSLAMM modeled total nitrate load for all sub-watersheds normalized by the area (acres) of the catchments.

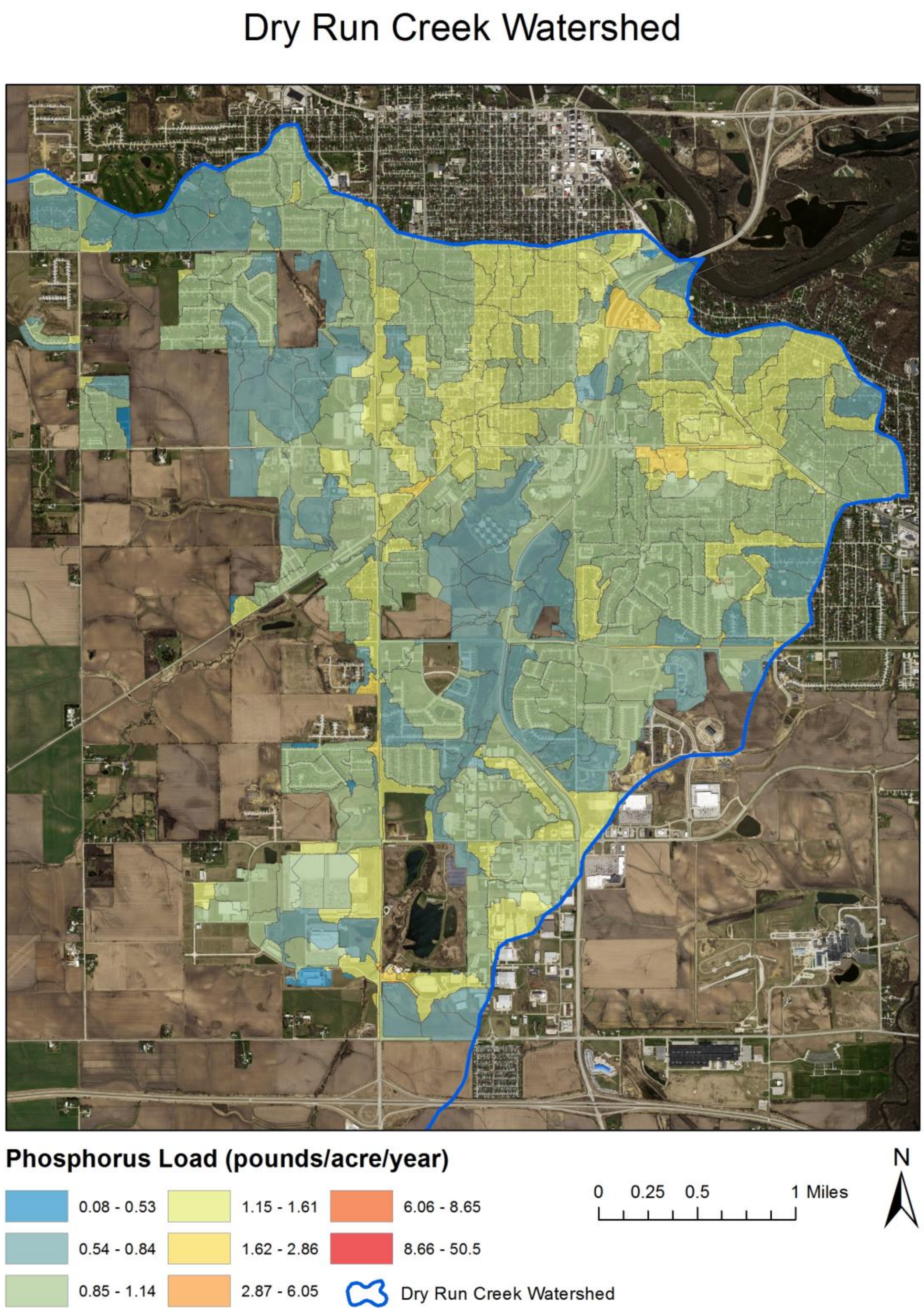

Figure 10: WinSLAMM modeled total phosphorus load for all sub-watersheds.

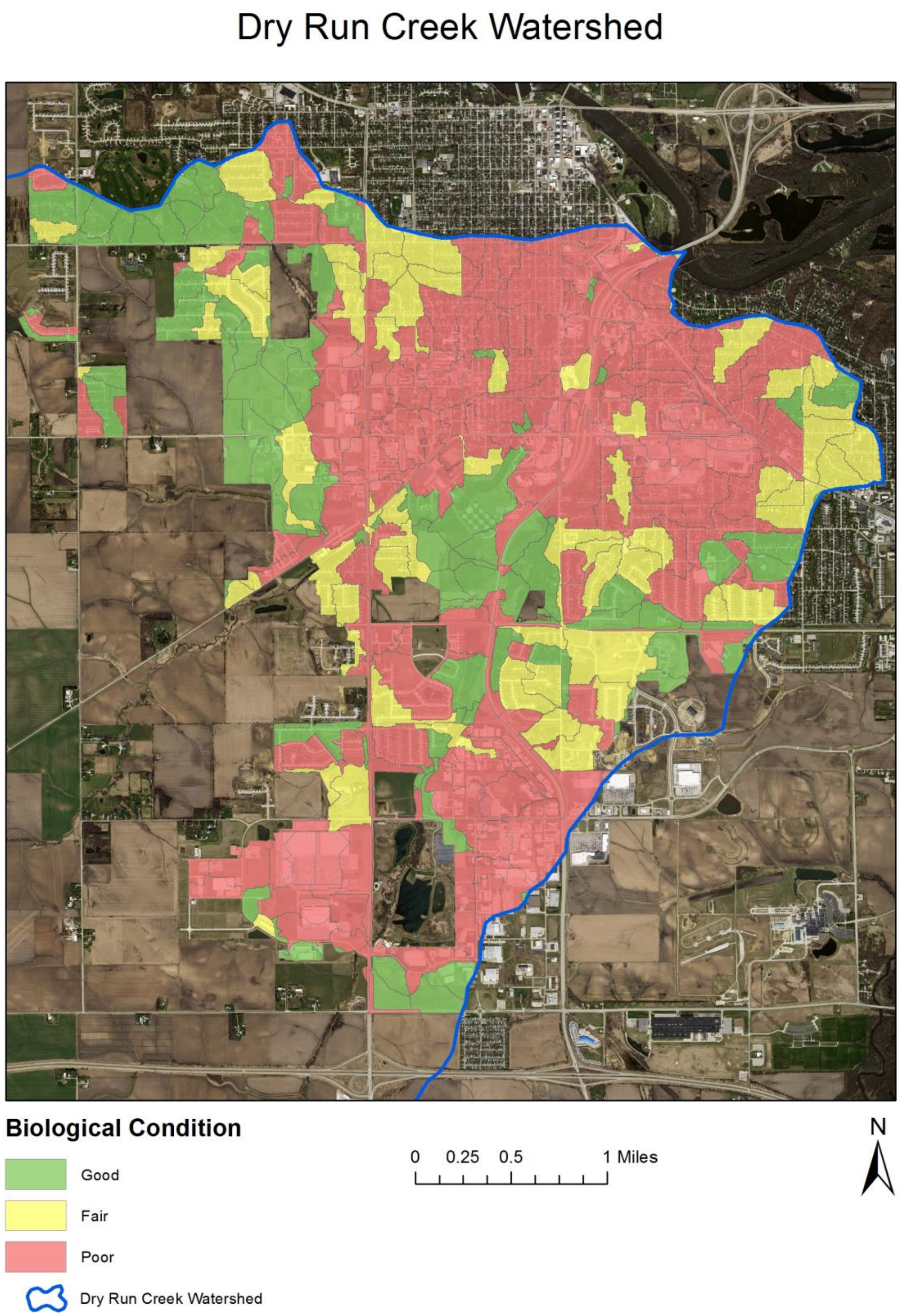

Figure 11: WinSLAMM modeled biological conditions for all sub-watersheds.

Modeling Best Management Practices

The GeoTREE Center collaborated with Josh Balk, the Dry Run Creek Watershed Coordinator, to first define a list of BMPs to model in the watershed, to accurately define drainage area boundaries for each of the BMPs, and to define WinSLAMM parameters for each of the BMPs in one WinSLAMM database per BMP sub-watershed. Josh met with GeoTREE Center Director John DeGroote and GeoTREE students on several occasions to work through this process. The GeoTREE Center developed models for 67 separate BMP drainage areas or sub-watersheds in the DRC Watershed. Figure 12 demonstrates the location of the BMP drainage areas. There were 38 bio-infiltration watersheds, 14 permeable pavement sub-watersheds, and 15 rain gardens. The bio-infiltration devices and rain gardens are modeled as Biofilter Control Practices in WinSLAMM while permeable pavements are modeled as Porous Pavement devices in WinSLAMM. Several of the bio-infiltration sub-watersheds contained multiple BMPS within a single watershed, and were modeled as such (Figure 13). WinSLAMM allows this by the user indicating the number of practices that fall in a given drainage area.

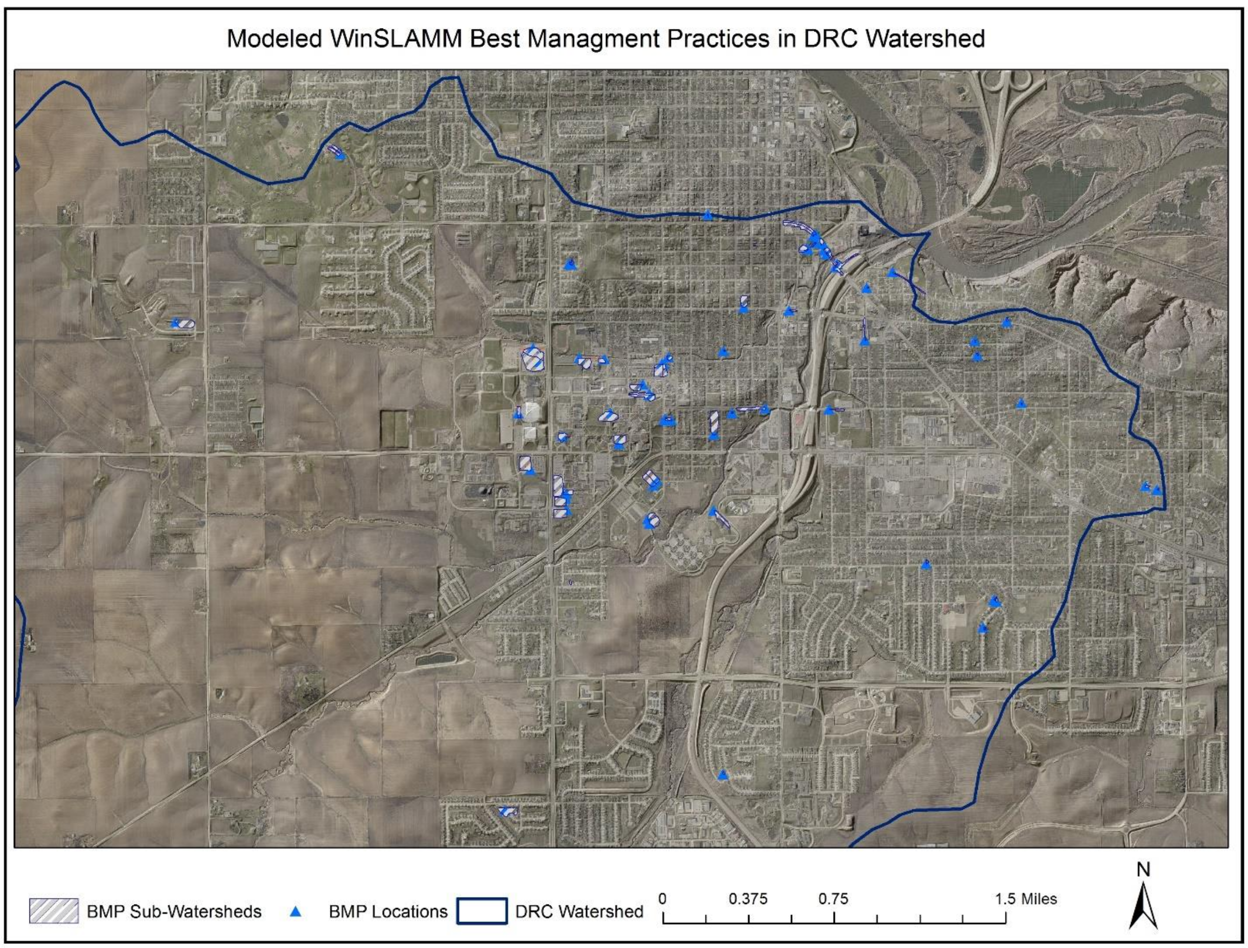

Figure 12: Location of sub-watersheds modeled in WinSLAMM.

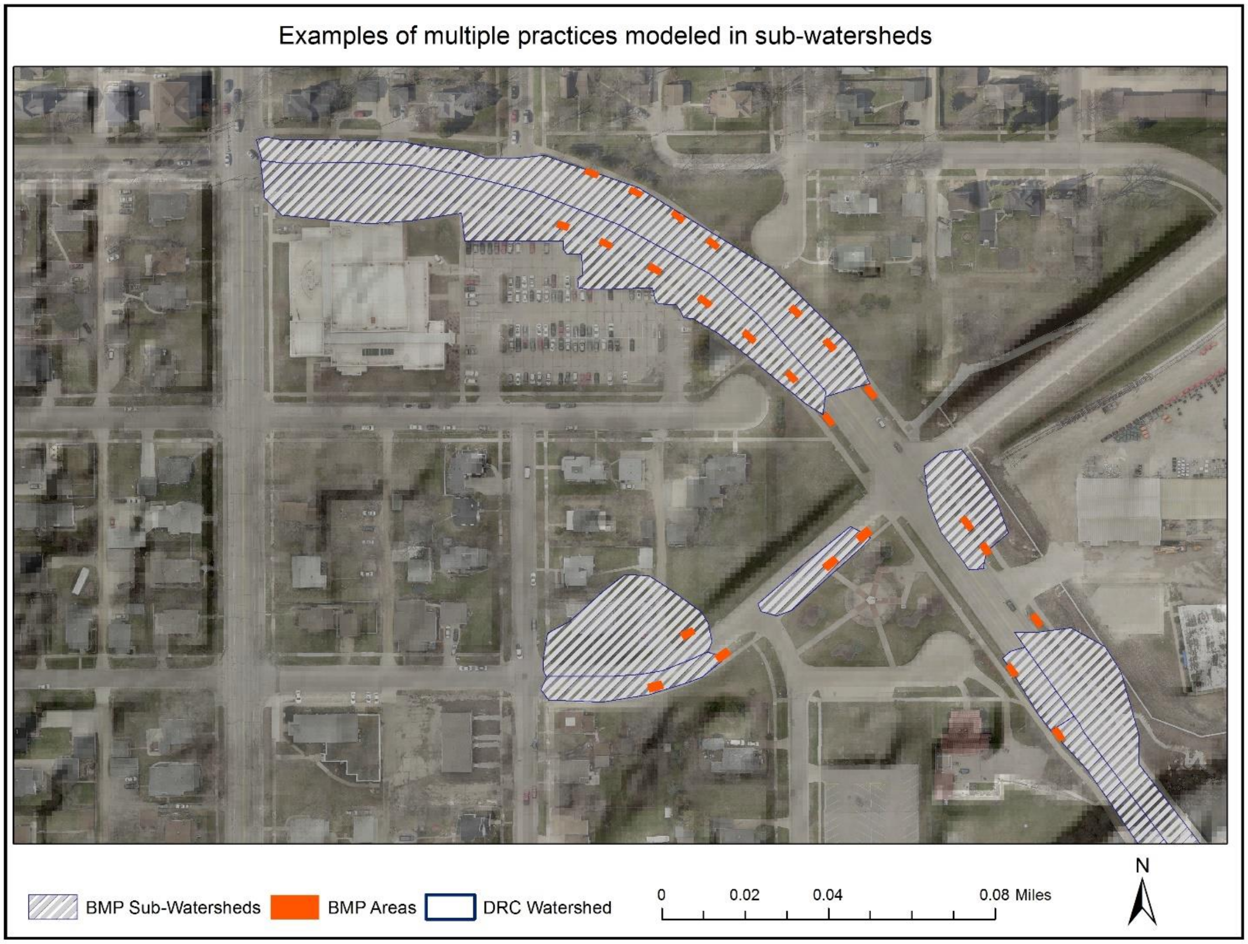

Figure 13: Example of sub-watershed with multiple BMPs being modeled in one WinSLAMM simulation.

The process to carry out modeling for each of the BMP sub-watersheds followed this process:

- Defined detailed source areas (using the areas as described in the Detailed source areas database section above).
- Develop sub-watershed boundaries. This was an iterative process in which LiDAR data was used with ArcSLAMM catchment delineation tools to initially derive sub-watershed boundaries. Subsequently, Josh Balk and the GeoTREE Center met to refine the boundaries. This refinement relied on local knowledge, some actual site visits, inclusion of local data such as stormwater inlets, contours from LiDAR, and a flow accumulation raster derived from LiDAR.
- Intersect detailed source areas with sub-watershed boundaries and produce one WinSLAMM compliant database per sub-watershed.
- Update each of those sub-watershed databases by populating Best Management Practices (BMPs) parameters in each of the individual sub-watershed WinSLAMM databases

- Run WinSLAMM for each of these sub-watersheds databases and compile statistics for this report
- Join results back to sub-watershed boundaries for making maps in this report and producing web mapping application (https://arcg.is/1TqTj8)

The percent reduction in modeled runoff volume and modeled percent reduction in particulate solid loads after running WinSLAMM for each of the WinSLAMM sub-watersheds while including sub-watersheds is shown in Figures 14 and 15. Some of the highest percent reductions are in the residential rain gardens which are difficult to see in the maps due to their small size.

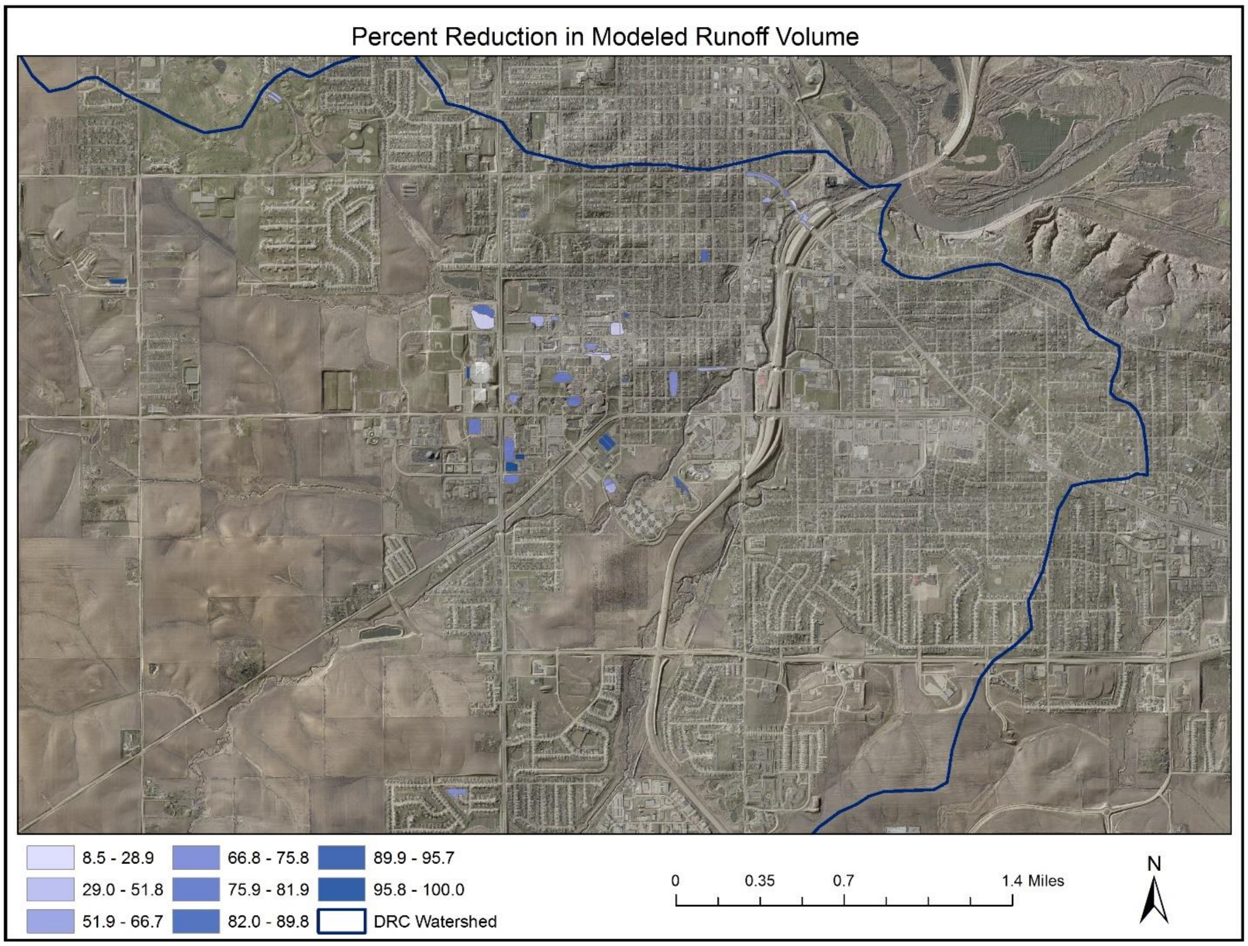

Figure 14: WinSLAMM modeled runoff volume reduction per sub-watershed.

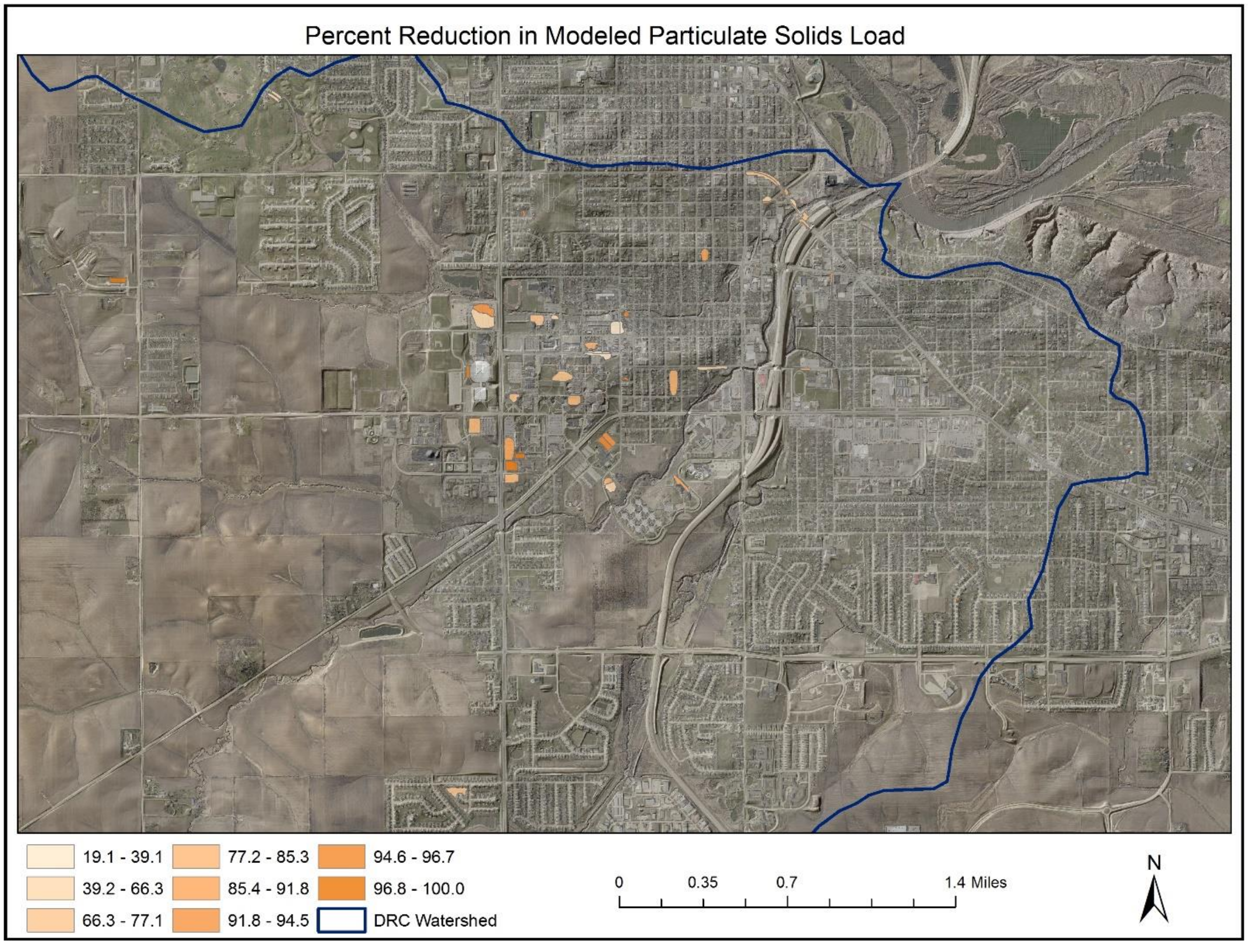

Figure 15: WinSLAMM modeled particulate solid load reduction per sub-watershed.

Table 3 presents summarized results from the pre- and post-BMP WinSLAMM modeling. The table demonstrates total reductions in runoff volume (cubic feet), total solids yield (lbs), total Phosphorus (lbs) and total nitrate reduction (lbs). Appendix 1 holds the runoff volume and pollutant load reductions for each individual sub-watershed. When compared to the modeled urban area in the entire DRC watershed these reductions represent 0.77, 0.88, 0.81, 0.67, and 0.7% total reduction for runoff volume, particulate solid loads, total solid loads, total phosphorus loads, and total nitrogen loads respectively. The total BMP sub-watershed areas (~41 acres) represent approximately 0.71% of the total urban area modeled in the DRC watershed (Table 1). Figure 16 presents the location of the BMP watersheds in the context of the entire urban area of DRC that was modeled. Figure 16 demonstrates that the BMPs have been located in areas of relatively high runoff. However, it also can be noted that there are large areas in commercial (e.g. near College Square) and industrial areas (e.g. industrial park) which lack practices (or at least that were not modeled in this project).

Table 3: Absolute total reductions in modeled runoff volume and pollutant loads and average sub-watershed percent reductions when comparing pre- and post- BMP modeled results.

Parameter	Reduction Total	Reduction Average Percent
Volume (cubic feet)	1188154.7	74
Particulate Solid Yield (lbs)	16127.2	82.7
Total Solid Yield (lbs)	21523.5	80.6
Total Phosphorus Yield (lbs)	38.7	80.7
Total Nitrate Yield (lbs)	25.8	73.8

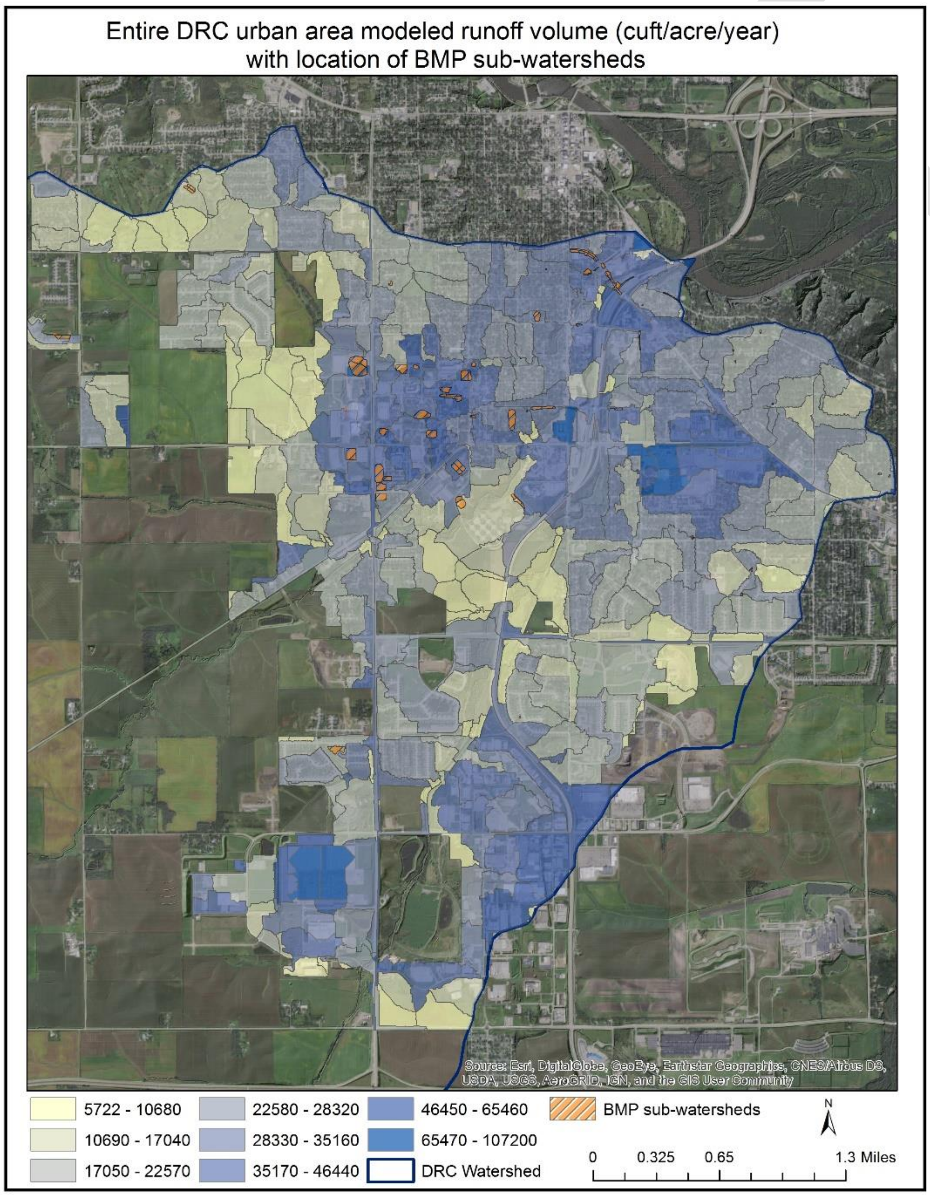

Figure 16: Location of BMP sub-watersheds in the context of modeled runoff volume for the entire urban area of the DRC watershed.

Conclusion

In this project, the GeoTREE Center characterized, in detail, the urban land use in the Dry Run Creek watershed, quantified urban runoff and pollution in the entire urban area of the watershed and carried out modeling on a select group of sub-watersheds with BMPs. The project was funded by the Black Hawk Soil and Water Conservation District and was matched by funding from the Iowa Department of Agriculture and Land Stewardship. The information and data developed and delivered as part of this project could be useful in providing a quantified knowledge base on existing conditions as well as in quantifying the benefits which have already been gained by introduction of BMPs. The data also can be used to help guide future decision making on potential locations of future BMPs.

The project has resulted in a number of products that should be useful for management and planning purposes in the Dry Run Creek watershed. The development of the detailed source area polygons in the geodatabase also allow for the potential for modeling of other sub-watersheds to be developed for other existing BMPs or for potential what-if simulations to be carried out.

The final results are delivered as a series of summarized data in Excel format, GIS database used to prepare inputs and visualize outputs, and WinSLAMM database files. In addition a web mapping application is made available publicly to display the results (https://arcg.is/1TqTj8).

Acknowledgements:

Numerous Geography undergraduate and graduate students (Alex Newkirk, Arif Masrur, Garrett Jepsen, Aaron Padilla) served as student research assistants and participated in this project carrying out tasks including digitizing, database quality control checking, ArcSLAMM/WinSLAMM modeling, web map development, and report writing.

Appendix 1: Modeled results pre- and post-BMP

Volume Reduction

CatchId	ProjectDescription	VolumeReduction_cf	VolumeReduction_Perc
1	14th St. Biocell North (1)	6465.2	44.6
2	14th St. Biocell South (2)	5568.7	88.2
3	14th St. Biocell near Wloo Rd (2)	4715.4	93.0
4	Waterloo Road near Kickstand	7868.6	34.9
5	Waterloo Rd. big south biocell by bike trail	13417.0	49.0
6	Waterloo Rd. big north biocell by bike trail	26213.2	51.8
7	Waterloo Rd. by CFU	8449.4	25.6
8	Waterloo Road Rec Center South (6 biocells)	32236.1	59.2
9	Waterloo Road north (6 biocells)	34456.7	57.2
10	uni commons	27624.1	74.2
11	College Street Biocells (6)	7784.6	8.5
12	23rd st biocelll 1	3752.1	10.0
13	23rd st biocelll 2	3711.2	9.8
14	Cedar Falls Paver Alley	24432.4	64.3
15	towers biocelll	14060.8	56.5
16	tower pavers	43218.3	48.0
17	dome permeable paver	114179.6	81.9
18	dome permeable paver	72264.7	28.9
19	dome paver plaza	32788.8	99.6
21	kamerick bioretention	23720.7	66.7
22	panther village biocelll	65542.3	75.9
24	panther village biocelll 3	16262.6	99.6
25	panther village biocelll Phase 2	13415.5	100.0
26	panther village biocelll Phase 2 - 2	67781.4	74.4
27	meadowiew bioswale	6243.4	61.6
28	uni bcs biocelll	13527.0	50.8
29	uni bcs biocelll	8503.6	60.9
30	uni brc bioretention swale	58744.9	92.9
31	uni brc bioswale	57345.6	94.7
32	UNI Roth Bio Cell	46193.3	86.4
33	UNI South Arts Parking Lot Biocell	103894.7	73.0
34	City Bio Cell	15594.4	37.5
35	Peet Jr. High Biocells (2)	12470.0	62.2

36	Biocells (4) East Street behind Ace Hardware	18381.2	74.1
37	Biocell by Hansens Dairy	6626.3	57.9
38	Lori Williams Rain Garden	200.9	99.0
40	Pheasant Ridge Parking Lot Biocell (2 count)	29249.3	47.5
41	Grand Boulevard Biocells (3)	16251.2	92.9
42	UNI Baker Parking Lot Biocell	49383.6	73.5
43	Wesley Biocell	859.6	100.0
44	Wild Horse 1st Addition	6628.4	100.0
45	Wesley Permeable Paver Driveway	2914.7	89.0
46	Amy Meehan (Kay) Rain Garden	97.4	100.0
47	Roman Rain Garden	266.0	100.0
48	Ed Gruenwald Rain Garden	297.6	100.0
49	Sutton Rain Garden	216.8	99.0
50	Brant Rain Garden	123.6	100.0
51	Bob Peterson Rain Garden	408.3	93.6
52	21st & Olive St. Permeable Alley	6099.9	89.9
53	CF 18th Street Perm Alley	10197.1	78.6
54	CF Seerley Blvd Perm Alley	17010.0	55.5
55	Wesley Foundation Permeable Sidewalk	1294.7	97.9
56	Sherwood Permeable Driveway	1915.9	98.3
58	Dennis Peters Permeable Driveway	2653.4	97.5
59	Bachman Permeable Driveway	1866.2	81.2
60	Zimmerman Permable Driveway	1473.2	100.0
61	Olsen Rain Garden	415.9	94.6
62	Emmert Rain Garden	876.2	97.5
63	Bachman Rain Garden	142.2	100.0
64	Zimmerman Rain Garden	344.0	95.7
65	Johnson Rain Garden	94.7	94.9
66	Keiser Rain Garden	277.7	85.8
67	Cedar Falls PHII	7035.7	72.8
68	Cedar Falls PHII	4338.2	63.6
69	College St Biocells	7209.0	21.1
70	DeGroote Rain Garden	125.7	100.0
71	Bossom Rain Garden	433.8	86.3

Particulate Solid Reduction

CatchId	ProjectDescription	ParticulateSolidReduction_lbs	ParticulateSolidReduction_Perc
1	14th St. Biocell North (1)	149.1	62.3
2	14th St. Biocell South (2)	176.4	93.1
3	14th St. Biocell near Wloo Rd (2)	139.4	96.2
4	Waterloo Road near Kickstand	373.1	66.2
5	Waterloo Rd. big south biocell by bike trail	261.2	73.0
6	Waterloo Rd. big north biocell by bike trail	615.5	75.5
7	Waterloo Rd. by CFU	331.4	52.7
8	Waterloo Road Rec Center South (6 biocells)	571.7	73.5
9	Waterloo Road north (6 biocells)	570.3	72.2
10	uni commons	192.1	76.2
11	College Street Biocells (6)	179.8	19.1
12	23rd st biocelll 1	347.6	26.1
13	23rd st biocelll 2	365.7	25.9
14	Cedar Falls Paver Alley	249.2	85.3
15	towers biocelll	131.1	66.2
16	tower pavers	444.5	76.4
17	dome permeable paver	589.8	90.4
18	dome permeable paver	425.5	36.3
19	dome paver plaza	593.6	100.0
21	kamerick bioretention	123.5	72.9
22	panther village biocelll	1143.6	89.4
24	panther village biocelll 3	418.9	99.9
25	panther village biocelll Phase 2	73.0	100.0
26	panther village biocelll Phase 2 - 2	596.6	80.4
27	meadowiew bioswale	82.9	70.8
28	uni bcs biocelll	129.0	60.7
29	uni bcs biocelll	270.7	83.7
30	uni brc bioretention swale	489.9	94.5

31	uni brc bioswale	477.1	95.8
32	UNI Roth Bio Cell	392.1	89.5
33	UNI South Arts Parking Lot Biocell	917.4	79.4
34	City Bio Cell	383.4	55.9
35	Peet Jr. High Biocells (2)	539.9	84.7
36	Biocells (4) East Street behind Ace Hardware	958.3	91.8
37	Biocell by Hansens Dairy	159.0	76.7
38	Lori Williams Rain Garden	2.3	99.2
40	Pheasant Ridge Parking Lot Biocell (2 count)	291.9	58.4
41	Grand Boulevard Biocells (3)	395.5	95.4
42	UNI Baker Parking Lot Biocell	410.3	80.9
43	Wesley Biocell	4.4	100.0
44	Wild Horse 1st Addition	117.8	100.0
45	Wesley Permeable Paver Driveway	24.4	96.6
46	Amy Meehan (Kay) Rain Garden	0.6	100.0
47	Roman Rain Garden	1.1	100.0
48	Ed Gruenwald Rain Garden	2.6	100.0
49	Sutton Rain Garden	1.5	99.3
50	Brant Rain Garden	0.7	100.0
51	Bob Peterson Rain Garden	2.8	95.3
52	21st & Olive St. Permeable Alley	49.5	96.2
53	CF 18th Street Perm Alley	115.6	91.7
54	CF Seerley Blvd Perm Alley	246.2	79.3
55	Wesley Foundation Permeable Sidewalk	6.3	99.5
56	Sherwood Permeable Driveway	20.0	99.6
58	Dennis Peters Permeable Driveway	23.2	99.4
59	Bachman Permeable Driveway	19.4	93.0
60	Zimmerman Permable Driveway	13.6	100.0
61	Olsen Rain Garden	4.0	95.9
62	Emmert Rain Garden	8.5	98.1
63	Bachman Rain Garden	1.5	100.0

64	Zimmerman Rain Garden	2.7	96.7
65	Johnson Rain Garden	1.4	96.1
66	Keiser Rain Garden	2.0	89.1
67	Cedar Falls PHII	158.5	83.1
68	Cedar Falls PHII	95.1	77.1
69	College St Biocells	235.9	39.1
70	DeGroote Rain Garden	1.0	100.0
71	Bossom Rain Garden	4.9	89.5

Total Solid Reduction

CatchId	ProjectDescription	TotalSolidReduction_lbs	TotalSolidReduction_Perc
1	14th St. Biocell North (1)	181.5	57.9
2	14th St. Biocell South (2)	204.5	92.3
3	14th St. Biocell near Wloo Rd (2)	163.2	95.7
4	Waterloo Road near Kickstand	413.2	60.9
5	Waterloo Rd. big south biocell by bike trail	370.5	63.9
6	Waterloo Rd. big north biocell by bike trail	817.4	67.9
7	Waterloo Rd. by CFU	374.2	46.9
8	Waterloo Road Rec Center South (6 biocells)	731.4	69.7
9	Waterloo Road north (6 biocells)	739.7	68.0
10	uni commons	340.0	74.5
11	College Street Biocells (6)	205.6	16.5
12	23rd st biocelll 1	365.4	24.2
13	23rd st biocelll 2	382.1	24.1
14	Cedar Falls Paver Alley	326.3	79.0
15	towers biocelll	171.5	63.6
16	tower pavers	591.7	66.4
17	dome permeable paver	1207.3	90.1
18	dome permeable paver	1166.1	48.5
19	dome paver plaza	719.7	99.9
21	kamerick bioretention	241.5	69.5
22	panther village biocelll	1420.9	85.7
24	panther village biocelll 3	511.5	99.8
25	panther village biocelll Phase 2	176.7	100.0
26	panther village biocelll Phase 2 - 2	785.4	78.8
27	meadowiew bioswale	123.0	67.5
28	uni bcs biocelll	172.6	56.9
29	uni bcs biocelll	304.4	80.0
30	uni brc bioretention swale	656.4	94.0

31	uni brc bioswale	640.1	95.5
32	UNI Roth Bio Cell	523.4	88.6
33	UNI South Arts Parking Lot Biocell	1205.4	77.7
34	City Bio Cell	458.1	51.6
35	Peet Jr. High Biocells (2)	586.0	82.4
36	Biocells (4) East Street behind Ace Hardware	1053.6	89.8
37	Biocell by Hansens Dairy	209.4	71.2
38	Lori Williams Rain Garden	3.6	99.2
40	Pheasant Ridge Parking Lot Biocell (2 count)	373.1	55.6
41	Grand Boulevard Biocells (3)	474.8	94.9
42	UNI Baker Parking Lot Biocell	591.3	78.3
43	Wesley Biocell	8.8	100.0
44	Wild Horse 1st Addition	159.6	100.0
45	Wesley Permeable Paver Driveway	33.8	93.8
46	Amy Meehan (Kay) Rain Garden	1.1	100.0
47	Roman Rain Garden	2.1	100.0
48	Ed Gruenwald Rain Garden	4.0	100.0
49	Sutton Rain Garden	2.5	99.2
50	Brant Rain Garden	1.2	100.0
51	Bob Peterson Rain Garden	4.5	94.7
52	21st & Olive St. Permeable Alley	74.1	93.5
53	CF 18th Street Perm Alley	168.6	86.8
54	CF Seerley Blvd Perm Alley	335.2	70.3
55	Wesley Foundation Permeable Sidewalk	12.7	98.7
56	Sherwood Permeable Driveway	30.2	99.1
58	Dennis Peters Permeable Driveway	36.1	98.8
59	Bachman Permeable Driveway	28.9	88.6
60	Zimmerman Permable Driveway	20.8	100.0
61	Olsen Rain Garden	6.1	95.5
62	Emmert Rain Garden	13.2	97.8
63	Bachman Rain Garden	2.3	100.0

64	Zimmerman Rain Garden	4.3	96.3
65	Johnson Rain Garden	2.1	95.6
66	Keiser Rain Garden	3.3	87.9
67	Cedar Falls PHII	193.9	80.8
68	Cedar Falls PHII	116.4	74.1
69	College St Biocells	266.0	35.6
70	DeGroote Rain Garden	1.6	100.0
71	Bossom Rain Garden	7.5	88.3

Total Phosphorus Reduction

CatchId	ProjectDescription	TotalPhosphorusReduction_lbs	TotalPhosphorusReduction_Perc
1	14th St. Biocell North (1)	0.422	56.2
2	14th St. Biocell South (2)	0.470	91.9
3	14th St. Biocell near Wloo Rd (2)	0.375	95.3
4	Waterloo Road near Kickstand	0.641	63.3
5	Waterloo Rd. big south biocell by bike trail	0.442	61.5
6	Waterloo Rd. big north biocell by bike trail	0.969	66.5
7	Waterloo Rd. by CFU	0.646	47.2
8	Waterloo Road Rec Center South (6 biocells)	1.634	69.0
9	Waterloo Road north (6 biocells)	1.598	68.6
10	uni commons	0.979	70.6
11	College Street Biocells (6)	0.330	17.1
12	23rd st biocelll 1	0.564	24.7
13	23rd st biocelll 2	0.606	23.1
14	Cedar Falls Paver Alley	0.530	79.9
15	towers biocelll	0.221	64.5
16	tower pavers	0.946	70.3
17	dome permeable paver	2.496	94.8
18	dome permeable paver	3.331	70.5
19	dome paver plaza	1.016	99.9
21	kamerick bioretention	0.538	68.3
22	panther village biocelll	2.198	84.1
24	panther village biocelll 3	0.945	99.8
25	panther village biocelll Phase 2	0.426	100.0
26	panther village biocelll Phase 2 - 2	0.994	79.1
27	meadowiew bioswale	0.555	67.4
28	uni bcs biocelll	0.290	52.3
29	uni bcs biocelll	0.482	76.9
30	uni brc bioretention swale	0.870	93.5

31	uni brc bioswale	0.857	95.0
32	UNI Roth Bio Cell	0.698	87.9
33	UNI South Arts Parking Lot Biocell	1.501	78.5
34	City Bio Cell	1.019	51.2
35	Peet Jr. High Biocells (2)	0.872	83.3
36	Biocells (4) East Street behind Ace Hardware	1.556	90.4
37	Biocell by Hansens Dairy	0.238	71.5
38	Lori Williams Rain Garden	0.017	99.2
40	Pheasant Ridge Parking Lot Biocell (2 count)	0.473	56.6
41	Grand Boulevard Biocells (3)	1.041	95.0
42	UNI Baker Parking Lot Biocell	0.968	76.8
43	Wesley Biocell	0.022	100.0
44	Wild Horse 1st Addition	0.577	100.0
45	Wesley Permeable Paver Driveway	0.057	92.7
46	Amy Meehan (Kay) Rain Garden	0.004	100.0
47	Roman Rain Garden	0.005	100.0
48	Ed Gruenwald Rain Garden	0.012	100.0
49	Sutton Rain Garden	0.009	99.1
50	Brant Rain Garden	0.004	100.0
51	Bob Peterson Rain Garden	0.017	94.5
52	21st & Olive St. Permeable Alley	0.182	92.0
53	CF 18th Street Perm Alley	0.474	85.1
54	CF Seerley Blvd Perm Alley	1.000	67.6
55	Wesley Foundation Permeable Sidewalk	0.026	98.8
56	Sherwood Permeable Driveway	0.083	98.9
58	Dennis Peters Permeable Driveway	0.081	98.8
59	Bachman Permeable Driveway	0.081	86.7
60	Zimmerman Permable Driveway	0.050	100.0
61	Olsen Rain Garden	0.014	94.9
62	Emmert Rain Garden	0.044	97.5
63	Bachman Rain Garden	0.010	100.0

64	Zimmerman Rain Garden	0.018	96.3
65	Johnson Rain Garden	0.010	95.6
66	Keiser Rain Garden	0.010	86.3
67	Cedar Falls PHII	0.443	79.8
68	Cedar Falls PHII	0.256	74.3
69	College St Biocells	0.401	36.4
70	DeGroote Rain Garden	0.007	100.0
71	Bossom Rain Garden	0.032	87.9

Total Nitrate Reduction

CatchId	ProjectDescription	TotalNitrateReduction_lbs	TotalNitrateReduction_Perc
1	14th St. Biocell North (1)	0.149	44.5
2	14th St. Biocell South (2)	0.124	88.2
3	14th St. Biocell near Wloo Rd (2)	0.106	92.9
4	Waterloo Road near Kickstand	0.210	34.9
5	Waterloo Rd. big south biocell by bike trail	0.365	49.1
6	Waterloo Rd. big north biocell by bike trail	0.705	52.0
7	Waterloo Rd. by CFU	0.205	25.8
8	Waterloo Road Rec Center South (6 biocells)	0.738	59.2
9	Waterloo Road north (6 biocells)	0.807	57.1
10	uni commons	0.561	73.1
11	College Street Biocells (6)	0.198	8.5
12	23rd st biocelll 1	0.091	10.0
13	23rd st biocelll 2	0.085	9.7
14	Cedar Falls Paver Alley	0.536	64.2
15	towers biocelll	0.297	56.5
16	tower pavers	1.042	47.9
17	dome permeable paver	2.162	80.2
18	dome permeable paver	1.065	22.0
19	dome paver plaza	0.820	99.6
21	kamerick bioretention	0.510	66.6
22	panther village biocelll	1.497	77.2
24	panther village biocelll 3	0.455	99.6
25	panther village biocelll Phase 2	0.158	100.0
26	panther village biocelll Phase 2 - 2	1.439	74.4
27	meadowiew bioswale	0.158	61.6
28	uni bcs biocelll	0.293	49.9
29	uni bcs biocelll	0.204	60.4
30	uni brc bioretention swale	1.250	92.8

31	uni brc bioswale	1.220	94.6
32	UNI Roth Bio Cell	0.982	86.4
33	UNI South Arts Parking Lot Biocell	2.205	73.0
34	City Bio Cell	0.356	37.4
35	Peet Jr. High Biocells (2)	0.287	62.3
36	Biocells (4) East Street behind Ace Hardware	0.502	74.2
37	Biocell by Hansens Dairy	0.168	58.1
38	Lori Williams Rain Garden	0.005	99.0
40	Pheasant Ridge Parking Lot Biocell (2 count)	0.621	47.5
41	Grand Boulevard Biocells (3)	0.385	92.9
42	UNI Baker Parking Lot Biocell	1.146	73.6
43	Wesley Biocell	0.019	100.0
44	Wild Horse 1st Addition	0.161	100.0
45	Wesley Permeable Paver Driveway	0.066	88.1
46	Amy Meehan (Kay) Rain Garden	0.003	100.0
47	Roman Rain Garden	0.007	100.0
48	Ed Gruenwald Rain Garden	0.007	100.0
49	Sutton Rain Garden	0.006	98.9
50	Brant Rain Garden	0.003	100.0
51	Bob Peterson Rain Garden	0.011	93.5
52	21st & Olive St. Permeable Alley	0.152	89.9
53	CF 18th Street Perm Alley	0.219	77.6
54	CF Seerley Blvd Perm Alley	0.367	54.3
55	Wesley Foundation Permeable Sidewalk	0.025	97.9
56	Sherwood Permeable Driveway	0.039	98.2
58	Dennis Peters Permeable Driveway	0.053	97.4
59	Bachman Permeable Driveway	0.040	79.6
60	Zimmerman Permable Driveway	0.030	100.0
61	Olsen Rain Garden	0.008	94.3
62	Emmert Rain Garden	0.020	97.3
63	Bachman Rain Garden	0.004	100.0

64	Zimmerman Rain Garden	0.009	95.7
65	Johnson Rain Garden	0.002	94.9
66	Keiser Rain Garden	0.006	84.7
67	Cedar Falls PHII	0.161	72.7
68	Cedar Falls PHII	0.103	63.5
69	College St Biocells	0.166	21.1
70	DeGroote Rain Garden	0.003	100.0
71	Bossom Rain Garden	0.011	86.1