The usefulness of impervious cover mapping and analysis based on pre-existing classified land use data sets

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Introduction

Impervious cover (**IC**) is comprised of surfaces that create rainfall runoff and prohibit natural infiltration of rainfall into the soil. Many of these surfaces are associated with urban land cover such as parking lots, roads, sidewalks, driveways, and rooftops. These impervious surfaces can have profoundly negative effects on a local watersheds hydrologic cycle, and overall environmental health. This is because IC disrupts natural hydrologic processes in a number of ways; by increasing runoff and reducing groundwater recharge, reducing water quality through the transportation of pollutants, increasing surface water temperatures that intern create unhealthy environments for aquatic life, and creating stream geometry changes (Prisloe, Giannotti and Sleavin, 2000, Schueler, 1987). Because of the cumulative negative environmental effects associated with IC, the need to map and evaluate IC for individual watersheds has gained more attention as urban and suburban developments continue to flourish.

"Imperviousness is a very useful indicator with which to measure the impacts of land development on aquatic systems" as it "represents a common currency that can be measured and managed by planners, engineers and landscape architects alike. It links activities of the individual development site with its cumulative impact at the watershed scale" (Schueler, 1994, 100 and 110). This 'link' is essential for communities to understand if they aim to appropriately deal with the issues of watershed and stream degradation associated with IC both now and in the future. This is why IC mapping and analysis can be utilized as an important and powerful tool by planners and watershed managers.

IC mapping allows communities to gain an idea of how impacted their watersheds currently are and allows them the opportunity to evaluate potential impacts from future

development, so they can make better-informed decisions towards that future (Prisloe, Lei and Hurd, 2001). The question then becomes, how do we best map this type of urban land cover? Should this mapping be done through direct or indirect methods (Oakland County Planning and Economic Development Services, 2003)? The more direct methods utilize high quality aerial photographs and satellite images to directly determine between IC and non-IC at the pixel level of the imagery (Planning and Economic Development Services of Oakland County, MI., 2003, Flanagan and Civco, 2001, Prisloe, Lei and Hurd, 2001 and Myeong, Nowak, Hopkins and Brock, 2001), while the indirect IC mapping methods utilize impervious surface coefficients in association with pre-existing classified land use data sets to indirectly determine percentages of land use acreage covered by IC (Wyckoff, Manning, Olsson, and Riggs, 2003, Oakland County Planning and Economic Development Services, 2003). Although the differences in the accuracies between these methods is of obvious concern, it may not be the most important difference. Many of these direct IC mapping methods can be quite costly, with relatively high costs for both the imagery and associated computer software necessary to analyze the imagery. The costs of these "high tech" direct methods can simply put them out of reach for many communities and organizations working with limited budgets, who would otherwise like to gain an understanding of the IC situations within their own watersheds. These communities and organizations do however have the ability to utilize pre-existing classified land use data sets, and existing impervious surface coefficients to indirectly map and analyze IC for their local watersheds at a relatively lower and more manageable price. This project aims at determining the usefulness of these less costly indirect IC mapping and analysis methods when compared to the more costly direct mapping and analysis methods.

Project Background

This project aims to determine the differences found in the results of both of the previously mentioned types of IC analyses for the Stony Creek subwatershed in Northeastern Oakland County, Michigan. This project compares the end results, or IC estimates, of a recent

direct IC mapping and analysis project conducted by the Planning and Economic Development Services of Oakland County that utilized a semi-automated classification of very high spatial resolution Color Infrared (**CIR**) imagery, against four indirect IC mapping methods utilizing two different land use data sets and two different sets of impervious surface coefficients for the same geographical area. A comparison of the resulting outcomes of these differing IC mapping and analysis methods will be used to determine the usefulness of pre-existing land use data sets in IC mapping projects for communities and organizations lacking the resources necessary to engage in the more direct, high quality, and costly IC mapping and analysis methods.

While there are no exact measures or assurances of the accuracy and quality of the Planning and Economic Development Services of Oakland County's findings, outside of physically measuring the impervious surfaces of the subwatershed through a surveying method, which is out of the scope of this project, it is assumed that the resources and methods utilized for their direct IC mapping provide the most recent and technologically advanced methods for doing this type of analysis. Due to the spatial resolution and spectral properties of the image data utilized, as well as the use of a rather technical and helpful classification software, it seems promising that the distinction between IC and non-IC is not only possible, but relatively accurate with this type of analysis. With these advantages it would seem that the resulting pixel class summaries for individual communities would be capable of providing results of a higher accuracy than the indirect IC mapping methods performed in this project. The ability to determine percents of IC directly through the classification of CIR imagery, instead of indirectly through the use of land use data sets and impervious surface coefficients lends more credibility to this direct type of mapping and analysis and provides me a basis upon which I can compare my project results. The following sections of this paper will discuss the specifics of the methods utilized in this project and the resulting outcomes.

Methods and Data Used

This project compares the results of four indirect IC mapping methods utilizing two different land use data sets, one at the parcel level and one at a more regional level (digitized from 1:24,000 panchromatic aerial photographs), in association with two different sets of impervious surface coefficients. These impervious surface coefficients represent average IC for different land uses found throughout the subwatershed, and when assigned to their appropriate land use classes in a land use data set, can be a useful tool in determining the percentages of land use acreage covered by IC.

The first set of impervious surface coefficients used were derived by the Rouge Program Office (**RPO**) in Detroit, MI. These values were developed through measurements of IC on aerial photographs for a variety of land uses across Southeast Michigan, which tends to give them a more regional applicability. The second set of coefficients utilized were derived by the Planning and Economic Development Services of Oakland County directly from their recent IC analysis. These coefficients were generated through an averaging of pixel summaries derived for each individual parcel based land use class found throughout the Stony Creek Subwatershed. These coefficients are believed to be useful with Oakland County's parcel based land use data sets, as they were calculated at a more detailed scale (Planning and Economic Development Services of Oakland County, 2003).

Before describing the details of the indirect IC mapping methods used for this project, it is important to give a description of the direct IC analysis that will be utilized as the basis for determine the usefulness of these pre-existing classified land use data sets in IC mapping and analysis projects. The direct IC analysis most recently conducted by the Planning and Economic Development Services of Oakland County is considered to be of a rather high quality, as well as costly, do to the type of data and software utilized. The analysis was conducted using CIR imagery with an 18-inch pixel resolution, and was classified with a semi-automated classification technique through ERDAS software. A strictly automated classification of the image data was not possible due to tonal differences found throughout the image data, which creates a greater chance

of errors in the analysis, but is out weighed by the ability of the infrared band of the imagery to accurately distinguish between vegetation and urban land cover, which in turn allows the semi-automated classification to provide results that can be determined to be relatively accurate. Through this semi-automated classification Oakland County was able to break their data into four classes; nonvegetative cover, vegetative cover, wetlands, and water. The nonvegetative class was then interpreted manually to separate IC consisting of paved areas and rooftops, from bare soil, which consisted of development sites, gravel pits and cultivated lands. All roads were also "burned in" to the data set to account for their IC presence, and gravel roads were also counted in the IC class. With the classifications completed class summaries for all of the pixels were calculated for each community in the subwatershed. These pixel class summaries were then utilized to determine total acres and percents of IC for each community within the subwatershed as well as the subwatershed as a whole (Oakland County Planning and Economic Development Services, 2003). The communities of the subwatershed are Addison Township, The Village of Leonard, The Village of Lake Orion, Oakland Township, Orion Township, Oxford Township, the City of Rochester Hills, and the City of Rochester.

The procedures utilized in my indirect IC analyses loosely follow *Part III: Calculating Impervious Surface Capacity*, from *How Much Development is Too Much? A Guide Book to Using Impervious Surfaces and Gravel Road Capacity Analysis to Manage Growth in Rural and Suburban Communities, August 2003, by Wyckoff, Manning, Olsson, and Riggs*, which runs through the basics of utilizing land use data sets and impervious surface coefficients in conducting an IC mapping and analysis project.

The first land use data set utilized in my IC mapping and analysis was Oakland Counties 2001 parcel based land use data set. This data set contains polygons derived from the Oakland County Tax Parcel data set, where the dominant land use of each parcel was considered to be the land use of the whole parcel, regardless of the parcels size. This fact could potentially lead to some erroneous findings in an IC analysis of this type and will be discussed in greater detail later.

The second land use data set I utilized was the Southeast Michigan Council of Governments (**SEMCOG**) 2000 Regional based land use data set. This data set contained polygons that had been digitized from 1:24,000 panchromatic aerial photographs of the area. While not as precise or spatially detailed as the parcel based data, the regional data doesn't necessarily suffer from the mixed uses within a single parcel problem that can be associated with the parcel based data set.

With my data collected and in order, the first order of business was to ensure that all of my data sets, (shapefiles and coverages) were projected with the same coordinate systems. With this completed I was able to clip out of both data sets, the portions of them that fell within Oakland County's Stony Creek Subwatershed boundary, this was done with ESRI's ArcMap. The outputs of this process were then converted to coverages, through ESRI's ArcCatalog, and built in ARC/INFO to insure the correct update of the newly clipped polygons areas.

With both the parcel and regional based land use data sets clipped to the appropriate geographical region, I was able to begin assigning each land use class its own impervious surface coefficients. *Table 1* in *Appendix A* describes the land use classifications found within the Oakland County parcel based land use data set, and their associated impervious surface coefficients. While assigning the Oakland County derived impervious surface coefficients was very straight forward, due to the fact that the coefficients were developed to work with this parcel based land use data set, assigning the RPO impervious surface coefficients to the parcel based land use data set presented some difficulties.

Top among these difficulties was determining the best way to deal with the eight Single Family land use classifications found within the parcel based data set. The RPO coefficients only contain values for low, medium, and high density residential land uses, so low, medium, and high values had to be determined for these eight Single Family residential classes. These values were determined by allowing for between approximately one and three living units per acre to be considered low density residential, between approximately three to six living units per acre to be

considered medium density residential, and anything greater than six living units per acre to be considered high density residential. These determinations were in accordance with the density rules established for the regional data set also used in this project. The water class was also left in the data set but assigned a value of 0 percent impervious because "While water surfaces are impervious in a hydrologic, sense they do not generally have similar consequences on stream quality, watershed health, or pollutant loading as impervious cover such as roads, parking lots and rooftops" (Wyckoff, Manning, Olsson, and Riggs, 2003, 28).

Table 2 in *Appendix A* describes the land use classifications found within the SEMCOG's regional based land use data set, and their associated impervious surface coefficients. Assigning the RPO impervious surface coefficients was relatively straight forward, due to the fact that the RPO coefficients were developed on a more regional scale and are easily adaptable to this regional data set. However, that doesn't mean that there weren't a few tough spots. The main problem was what to do with land uses 1171-1174 (Developing Single-family Residential), through discussions with individuals at SEMCOG, it was determined that they should be assigned the low density residential impervious surface coefficient as a conservative measure, and also in light of the fact that they made up such a small portion of the overall subwatershed. The 1190 (Developing undefined) was assigned the generic commercial value after discussions with individuals at SEMCOG to represent the proposed future conditions of these sites.

Top among the problems with fitting the Oakland County derived data to the regional land use data set was how to deal with the lack of values for grass lands, woodlots, and wetlands, which all have multiple classes within the regional data set. In order to accurately preserve the details of the data set I amended the Oakland County derived impervious coefficients with the grass lands, woodlots, and wetlands values from the RPO coefficients, creating a type of hybrid coefficient set. This hybrid actually created the closet values of all other data set and impervious surface coefficient combinations to that of Oakland Counties direct IC analysis that utilized the CIR imagery. The values assigned to the 1171-1174 set of classifications were assigned in a manner

that I feel best utilized the multiple values available in the Oakland County coefficient set, while maintaining the low density classifications assigned to these same classes by the RPO coefficients and continuing to follow the density rules established for the regional data set used in this project. Again the water class was left in the data set and assigned a value of 0 percent impervious for the same reasons it was left in the parcel based data set.

With the appropriate impervious surface coefficients assigned to their land use classes, the next step was to clip each individual community's watershed area out of the subwatershed's whole. This geoprocessing was conducted with coverages in ARC/INFO to insure that each polygons area fields were updated through the build command after each subsequent clipping. With all of the individual communities clipped and built, their updated area fields were utilized in equations to calculate the total acres of the subwatershed found within each community's coverage area. This was done with the equation AREA / 43,560 sq. ft.; these total acre results were then added to the FINAL_ACRES field in the attribute table. With acreages calculated, the impervious surface coefficients could now be utilized to indirectly determine how many acres for each polygon were considered impervious. This was done by simply multiplying the FINAL_ACRES field by the RPO impervious surface coefficients fields, (PERCENT_IC) to determine the amount of impervious acres produced with the RPO impervious surface coefficients, and the Oakland County derived impervious surface coefficients fields, (OAKPERCENT_IC) to determine the amount of impervious acres produced with the Oakland County derived impervious surface coefficients. These final values of total acres and total impervious acres allowed me to make my concluding comparisons between data sets, impervious surface coefficients, and IC mapping and analysis methods.

Results, Findings and Discussion

The purpose of this research has been to determine the usefulness of pre-existing classified land use data for IC mapping and analysis projects, and while we would all love to be able to utilize high spatial resolution CIR imagery and powerful classification software to directly

measure IC, it currently isn't feasible. If it was feasible I would recommend it use over the indirect measurement methods utilized in this project, but these indirect measurements are often all that many communities and organizations have access to. Knowing this, it is important to take a few findings and conclusions away from this project that may help to make these indirect measurement methods a little more accurate.

For the sake of simplifying the comparisons of each IC mapping methods end results and to provide a stable framework that gives these results some real world meaning, I have found the Impervious Cover Model (**ICM**) to be an excellent tool. "The ICM is a deceptively simple model that raises extremely complex and profound policy implications for watershed managers" (Schueler, 2003, 2). The ICM determines the quality of streams and rivers throughout a watershed by the percentage of the watershed that is covered by IC. In doing so three general classifications have been determined by Schueler, 1994, and are as follows:

- **Sensitive (0-10% IC)** - near natural stream channel conditions with minimal nonpoint source pollution impacts.
- **Impacted (11-25% IC)** - greater physical and chemical stream changes along with a decrease in stream biodiversity (Prisole, Lei and Hurd, 2001).
- **Non-supporting (25-100% IC)** - a degraded aquatic environment where "predevelopment channel stability and biodiversity cannot be fully maintained, even when stormwater practices or retrofits are fully applied" (Schueler, 1994).

It is with these classifications that I have found the best method to detail the findings of this project.

For this project, Oakland County's recent direct IC mapping and analysis, utilizing CIR imagery and a semi-automated classification system acts as the basis upon which the indirectly determined IC mapping and analysis methods undertook are to be compared against. Oakland County's recent IC analysis produced results, for Oakland County's portion of the Stony Creek

subwatershed, that place the subwatershed in the *sensitive* class of the ICM with an IC of 6.62%, see *Table 3* below.

Table 3.

Oakland Co.'s IC Estimates for the Subwatershed Communities

Community Name	Total Acres	Impervious Acres	Percent Impervious
Addison Township	16,570.1	835.5	5.0
Village of Leonard	455.5	36.3	8.0
Village of Lake Orion	8.0	2.9	36.3
Oakland Township	13,677.6	700.4	5.1
Orion Township	742.9	143.5	19.3
Oxford Township	4,461.7	433.5	9.7
City of Rochester Hills	1,425.1	218.8	15.4
City of Rochester	621.5	142.5	22.9
Totals for Water Shed	**37,962.40**	**2,513.40**	**6.62**

As can be seen in the above table Orion Township, The City of Rochester Hills, and the City of Rochester's portions of the subwatershed have all fallen into the *impacted* category while the Village of Lake Orion has fallen into the non-supporting class, which can be blamed on the relatively small portion of the subwatershed actually located within the Village. Of more importance are the *sensitive* classifications assigned to the results obtained for Addison, Oakland, and Oxford Townships, which contain the majority of both impervious acres and total acres for the subwatershed, as well as the rest of the communities within the subwatershed. These are relatively important and promising findings, which should be taken into account as this portion of Oakland County continues to suburbanize through increased development in these formerly rural and agricultural settings.

As far as the indirectly produced IC mapping results obtained through the use of the pre-existing classified land use data sets go, the subwatershed as a whole was placed into the *impacted* (11-25%) category with every combination of land use data sets and impervious surface

coefficients utilized, but at varying percents depending on which land use data set and impervious surface coefficients were combined. The first land use data set and impervious surface coefficient combination used was Oakland County's parcel based land use data set with the RPO impervious surface coefficients. This classification method placed the subwatershed as a whole firmly within the *impacted* classification of the ICM at 17.35% of IC and represented the furthest departure of results from Oakland County's findings. See *Table 4* below for the results of this analysis.

Table 4.

Year 2000 IC Estimates from Parcel Based Data utilizing RPO IC numbers

Community Name	Total Acres	Impervious Acres	Percent Impervious
Addison Township	16,573.67	2,675.64	16.14
Village of Leonard	457.65	74.15	16.20
Village of Lake Orion	7.12	1.92	27.00
Oakland Township	13,667.63	1,989.34	14.56
Orion Township	744.75	159.86	21.46
Oxford Township	4,464.95	1,136.68	25.46
City of Rochester Hills	1,442.97	362.81	25.14
City of Rochester	604.46	187.48	31.02
Totals for Watershed	**37,963.18**	**6,587.87**	**17.35**

As can be seen from the above table, the combination of the parcel based data set and the RPO impervious surface coefficients placed four communities into the *non-supporting* classification of the ICM, The Village of Lake Orion, Oxford Township, the City of Rochester Hills, and the City of Rochester, again the Lake Orion value can be misleading if the total acres of the community within the subwatershed are not taken into account. And although the values of IC for all communities within the subwatershed are quite elevated when compared to the IC values produced by Oakland County's original IC analysis, the major trends and rankings among

communities tend to remain intact between this analysis and the base analysis. An example of this can be seen with Addison and Oakland Townships which both had similar values in the mid-*supporting* classification with Oakland County's direct IC analysis now have similar values in the mid-*impacted* classification of the ICM.

The main reason for the increase seen in IC values for this data set and impervious surface coefficient combination stems from the use of the parcel based data set. While creating a rather spatially detailed representation of the communities in the subwatershed this data set is flawed for this type of IC work. By assigning the dominant land use present in each parcel to the entire parcel, many errors can occur though the type of indirect IC analysis utilized in this project. This type of land use classification can work well for higher density residential properties but may cause some erroneous findings when low density residential, industrial or commercial land uses are being mapped and analyzed. Because these low density residential, industrial or commercial parcels may only contain IC on a portion of their parcels, while the rest of the parcel remains pervious, erroneous results can occur when the acreage of the entire parcel is considered in the calculations associated with the impervious surface coefficients. This combination of parcel based data and RPO coefficients produced results that were the furthest from the direct results obtained by Oakland County in their IC analysis and are not deemed useful.

The second land use data set and impervious surface coefficient combination utilized for this project was Oakland County's parcel based land use data set with Oakland Counties own derived coefficients and the third was SEMCOG's regional data set with the RPO coefficients. These classification methods both placed the subwatershed as a whole in the lower portion of the ICM *impacted* classification with 13.76% and 12.53% of IC respectively. No real shocking changes in the individual community values were seen between these two indirect IC mapping methods with the exception of the results obtained for Oxford Township, with the regional data set, which had a much lowered percent of IC than in the previous two mapping methods utilizing parcel based data sets, and the switching of the dominance in IC for the City of Rochester Hills

over The City of Rochester with the use of the regional data set. Both of these changes can be attributed to the change in land use data sets used. Although these two indirect methods produced results closer to those that Oakland County produced, they are not deemed to be as useful as the final indirect IC mapping and analysis method tested. See *Tables 5 and 6* in *Appendix B* for the results of these analyses.

The final land use data set and impervious surface coefficient combination used was again SEMCOG's regional based land use data set with the Hybrid Oakland County derived impervious surface coefficients, discussed previously. This indirect mapping method produced an *impacted* ICM value of 11.86% IC for the subwatershed as a whole. This analysis produced results that were the closest, of the four data set and coefficient combinations used, to those of Oakland County's directly determined IC values and has been deemed to be the most useful of the four analyses tested. See *Table 7* below for the results of this analysis.

Table 7.
Year 2000 IC Estimates from Regional Based Data utilizing a Hybrid of Oakland Co.'s IC numbers

Community Name	Total Acres	Impervious Acres	Percent Impervious
Addison Township	16,574.56	1,859.31	11.22
Village of Leonard	457.66	44.04	9.62
Village of Lake Orion	7.11	1.83	25.73
Oakland Township	13,675.42	1,385.77	10.13
Orion Township	744.75	167.77	22.53
Oxford Township	4,465.00	597.55	13.38
City of Rochester Hills	1,442.81	328.03	22.74
City of Rochester	604.57	120.56	19.94
Totals For Watershed	**37,971.88**	**4,504.87**	**11.86**

The results of this analysis can be summarized in the same manner as the results from the third analysis, while taking into consideration the slightly greater accuracy of the data set and hybrid coefficient combination. The fact that this data set doesn't suffer from the extreme over assignment of IC acres to entire polygons as the parcel based data set can, combined with the fact that the hybrid impervious surface coefficients utilized combined the accuracy developed through the averaging of pixel summaries obtained by Oakland County's original IC analysis for this geographical area specifically, while accurately preserve the details of the regional data set, it is easy to understand how this combination resulted in IC values that most closely resembled those of Oakland County's direct IC mapping method that is being used as a basis for this project.

Conclusion

With the continuation of suburban growth across Southeast Michigan, and the country as a whole, accurate methods of impervious mapping can be potentially useful for land use planners worried about the negative impacts that increasing impervious surfaces are having on our water resources and environment as a whole. Based on the results of this project, a few basic statements regarding the usefulness of indirect IC mapping and analysis based on the use of pre-existing land use data set and impervious surface coefficients can be made. These are as follows:

- The utilization of high spatial and enhanced spectral imagery to directly determine IC over a watershed is the preferred method when conducting an IC mapping or analysis project.
- However, when budgetary limits restrict the type of IC mapping and analysis projects that can be conducted to those that utilize pre-existing land use data sets and impervious surface coefficients to indirectly determine IC over a watershed the following guidelines should be followed:
    - Parcel based land use data sets which have inherent flaws in there usefulness for this type of IC mapping and analysis should be avoided.
    - Land use data sets constructed through the direct digitization of individual land use class polygons from aerial photography is preferred for this type of IC mapping and

analysis, as these types of data sets don't suffer from the extreme over assignment of IC acres to entire polygons, as is possible with parcel based data sets.

- For the most accurate IC mapping and analysis results utilizing pre-existing data sets and impervious surface coefficients, individual sets of impervious surface coefficients should be determined on a per project basis. This can help to ensure that the impervious surface coefficients accurately preserve the details found in the original data sets being used, while at the same time considering both the local landscape characteristics and urban structure of the local area.

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Appendix A

Table 1.

Parcel Based Data Set (Oakland Co. 2000 Parcel based Landuse)

LULC Code	Definition		RPO-%IC		Oak-%IC
A	Agricultural		2.0		1.76
C	Commercial		56.2		73.21
I	Industrial		75.9		54.27
M	Multiple Family		51.4		47.94
O	Mobile Home Park		60.0		47.67
P	Public / Institutional		28.0		45.74
R	Recreation and Conservation		10.9		10.07
S20	Single Family, 10 acres or greater		18.8		3.89
S21	Single Family, 5 to 9.9 acres		18.8		5.66
S22	Single Family, 2.5 to 4.9 acres		18.8		8.32
S23	Single Family, 1 to 2.5 acres		18.8		13.31
S24	Single Family, 14,000 to 43,559 sq. ft.		18.8		25.83
S25	Single Family, 8,000 to 13,999 sq. ft.		37.8		36.23
S26	Single Family, less than 8,000 sq. ft.		51.4		41.73
S27	Single Family, More than one unit per parcel		51.4		66.04
T	Transportation, Utility, and Communication		52.9		22.37
W	Water		0.0		0.00
X	Railroad Right-of-way		52.9		10.34
Y	Road Right-of-way		52.9		62.00
V	Vacant		10.9		13.56
E	Extractive		10.0		14.75

Notes:
RPO-%IC = Rouge Project Office Impervious Surface Coefficients
OAK-%IC = Oakland County Derived Impervious Surface Coefficients

Table 2.

Regional Data Set (SEMCOGs 2000 Landuse)

LULC Code	Definition		RPO-%IC		Oak-%IC
1120	Multiple-family Residential / Low Rise		51.40		47.94
1130	Single Family Residential / Duplex		37.80		36.23
1150	Manufactured Home Park		60.00		47.67
1171	~75% Developing Single-family Residential		18.80		25.83
1172	~50% Developing Single-family Residential		18.80		13.31
1173	~25% Developing Single-family Residential		18.80		13.31
1174	~0% Developing Single-family Residential		18.80		8.32
1190	Developing-Undefined		56.20		73.21
1210	Primary / Central Business District		76.30		73.21
1220	Shopping Centers / Malls / Retail Centers		80.00		73.21
1240	Secondary / Mixed Business Area		88.00		73.21
1260	Institutional Establishments		28.00		45.74
1300	General Industrial		75.90		54.27
1380	Industrial Parks		65.90		54.27
1424	Rail Road Tracks		52.90		10.34
1441	Roadway		52.90		62.00
1450	Communications		52.90		22.37
1460	Utilities		65.90		22.37
1461	Electrical Transmission Lines		65.90		22.37
1710	Open Pit / Above Ground Extractive		10.00		14.75
1930	Outdoor Recreation		10.90		10.07
1940	Cemetery		12.80		10.07
2100	Cropland		2.00		1.76
2200	Orchards, Bush Fruits, Vineyards, ect.		2.00		1.76
2400	Permanent Pasture		2.00		1.76
2900	Other Agricultural Lands		2.00		1.76
2910	Farmsteads		37.80		36.23
3100	Herbaceous Open Land		2.00		2.00
3200	Shrub Land		2.00		2.00
4120	Central Hardwood / Oak		1.90		1.90
4130	Aspen / White Birch Association		1.90		1.90
4210	Pine		1.90		1.90
4220	Other Upland Conifer		1.90		1.90
4290	Christmas Tree Plantation		1.90		1.90
5200	Lakes		0.00		0.00
6120	Shrub/Scrub Wetland		2.00		2.00
6130	Lowland Hardwood (wetlands)		2.00		2.00
6140	Lowland Conifer (wetlands)		2.00		2.00
6150	Mixed Wooded Wetland		2.00		2.00
6210	Aquatic Bed (wetland)		2.00		2.00
6220	Emergent Wetland		2.00		2.00

Notes: RPO-%IC = Rouge Project Office Impervious Surface Coefficients
OAK-%IC = Oakland County Derived Impervious Surface Coefficients

Appendix B

Table 5.

Year 2000 IC Estimates from Parcel Based Data utilizing Oakland Co.'s IC numbers

Community Name	Total Acres	Impervious Acres	Percent Impervious
Addison Township	16,573.67	1,897.51	11.45
Village of Leonard	457.65	52.90	11.56
Village of Lake Orion	7.12	2.26	31.81
Oakland Township	13,667.63	1,586.22	11.61
Orion Township	744.75	169.86	22.81
Oxford Township	4,464.95	934.47	20.93
City of Rochester Hills	1,442.97	371.79	25.77
City of Rochester	604.46	209.39	34.64
Totals for Watershed	**37963.18**	**5224.41**	**13.76**

Table 6.

Year 2000 IC Estimates from Regional Based Data utilizing RPO IC numbers

Community Name	Total Acres	Impervious Acres	Percent Impervious
Addison Township	16,574.56	1,995.68	12.04
Village of Leonard	457.66	49.70	10.86
Village of Lake Orion	7.11	1.90	26.67
Oakland Township	13,675.42	1,449.73	10.60
Orion Township	744.75	178.71	24.00
Oxford Township	4,465.00	597.30	13.38
City of Rochester Hills	1,442.81	346.90	24.04
City of Rochester	604.57	136.88	22.64
Totals for Watershed	**37,971.88**	**4,756.80**	**12.53**

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