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Field Collection of Site Development Characteristics – Standard Operation Procedure

Introduction

Correct knowledge of local development characteristics helps improve the accuracy of stormwater quality and quantity modeling. Development characteristics of interest include impervious cover types and quantities, landscaping, roofing materials, areas of different surfaces, drainage system information, etc. Different surfaces in urban areas contribute flows and pollutants differently from other types of surfaces. As an example, pitched roofs are much more efficient in producing runoff than flat roofs. Treated wood, galvanized metals, and other coverings, all affect the concentrations of heavy metals from roofs. Similar differences exist for other types of urban surfaces. Obviously, the magnitude of "impervious" surfaces in each land use in an area has a large effect on runoff production. The ways these surfaces are connected to the drainage system also affects the amount of runoff produced. In addition, the types and extent of disturbed urban soils all affect runoff quality and quantity. It is therefore necessary to survey an area to determine these development characteristics in order to produce the most accurate runoff quality and quantity predictions, and to identify opportunities for retro-fitting stormwater management practices in existing areas. The data from these surveys can also be used to help identify public education programs and to identify changes in future development that can decrease runoff problems.

The first step in this process is to collect available land use information for the areas of study. Local planning agencies have very distinct land use descriptions and these categories should be the basis for the stormwater quality modeling. In some cases, these land use descriptions may be further subdivided, depending on age of development, etc. Aerial photographs of the study area are also needed in order to identify how the land use categories are located throughout the area, and to enable major differences in the main land use categories to be identified (amounts of mature vegetation, etc.). In major cities, from 10 to 20 land use categories and subcategories are usually sufficient to represent the range of conditions encountered. About 10 to 15 example homogeneous neighborhoods are selected in each of these categories for the site surveys. Each homogeneous area is relatively small, such as a single block area, a single school or church, a mall, a cemetery, a park, or up to about 5 or 10 acres of other areas. The selected neighborhoods are then surveyed by visiting the areas and filling out a form containing basic site information, supplemented by photographs. Surfaces in each of the selected neighborhoods are also carefully measured using aerial photographs to determine the areas associated with the different surfaces. Relatively high resolution aerial photographs are of most use for this phase. Automatic image processing can be used for part of these analyses, but manual measurements are also usually needed. The following discussion describes these survey steps, after a description of typical land use categories.

Land Use Categories used during the Field Inventory Effort

A stormwater/watershed study should use the locally available land use data and definitions usually defined by the local planning agency. This section briefly describes the land use descriptions according to the documentation supplied with WinSLAMM (Pitt and Voorhees 2002), based on land use surveys mostly conducted in Wisconsin. Again, these definitions would need to be adjusted according to local planning agency definitions and available data, and may need to be further subdivided. As an example, it is common to subdivide the low and medium density residential areas according to when they were constructed, as major shifts in development characteristics have occurred over the years, and these areas usually make up the majority of the land uses in a community. During this inventory effort, all land covers are considered in each land use. These usually include streets, building roofs, parking lots, walkways, landscaped areas, undeveloped parcels, etc. Some planning agencies separate the streets from the land uses and consider these surfaces as part of a larger transportation land use. If that is the case, the areas need to be adjusted to include these surfaces as an integral part of each of the land uses. Appendix A includes example surface area summaries for several land uses as measured during a recent investigation in the Jefferson

County, AL, area (Bochis 2007 and Bochis, *et al*. 2008). These summaries indicate the different surfaces that were measured in each of the land uses during that study.

Residential Land Uses

High Density Residential: Urban single family housing having a density greater than 6 units/acre. This land use includes the homes (roofs), driveways, yards, sidewalks, and streets, in addition to some minor surfaces.

Medium Density Residential*:* Urban single family housing at a density of 2 to 6 units/acre. The same as above, the homes, driveways, yards, sidewalks and streets adjacent to the house are included as the main surfaces.

Low Density Residential: Similar to the previous residential areas, except having a density of 0.7 to 2 units/acre.

Duplexes: Connected housing of two family units being 1 to 3 stories in height. Units may be adjoined up-and-down, side-by-side or front-and-rear. This land use includes the streets, buildings, yards, parking lots, and driveways as the main surfaces.

Multiple Families: Like duplexes, but housing containing three or more family units that are 1 to 3 stories in height.

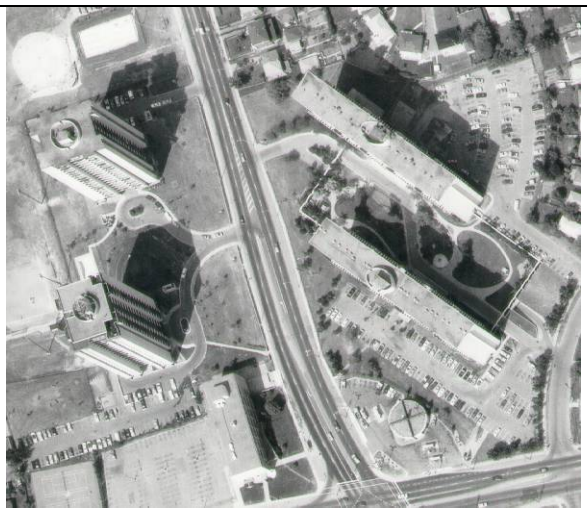
Apartments: Multiple family units of 4 or more stories in height.

Trailer Parks: A mobile home or trailer park that includes all vehicle homes, yards, driveways, streets, walkways, and office area.

Medium Density Residential Area (no alleys)

Older Medium Density Residential Area (no alleys, but with more mature trees)

High Density Residential Area (no alleys)

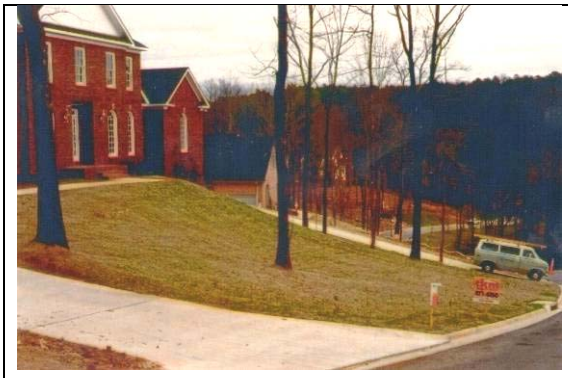


High Rise Apartments

Example aerial photographs of different residential area categories (Pitt and McLean 1986).

Multi-family residential areas. Impervious areas (pitched roofs and parking areas) are all directly connected. Small amounts of landscaped areas are also present.


Older medium density residential area.




Newer medium density residential area.

Commercial Land Uses

Strip Commercial: Includes buildings for which the primary function is the sale of goods or services. Some institutional land use such as post offices, fire and police stations, and court houses are also included in this category. The strip commercial land use includes the buildings, parking lots, and streets. This category does not include buildings used for the manufacturing of goods or warehouses, nurseries, tree farms, or lumber yards.

Shopping Centers: These are commercial areas where the related parking lot is at least 2.5 times the building roof area. The buildings in this category are usually surrounded by parking areas. This land use includes the buildings, parking areas, and the streets, plus any landscaping. This area also includes large regional shopping malls.

Office Parks: This is a land use containing non-retail businesses. The buildings are usually multi-story buildings surrounded by larger areas of lawn and other landscaping. This land use includes the buildings, the lawn, parking areas, and streets. The types of businesses found in this category may include: insurance offices, government buildings, company headquarters, etc.

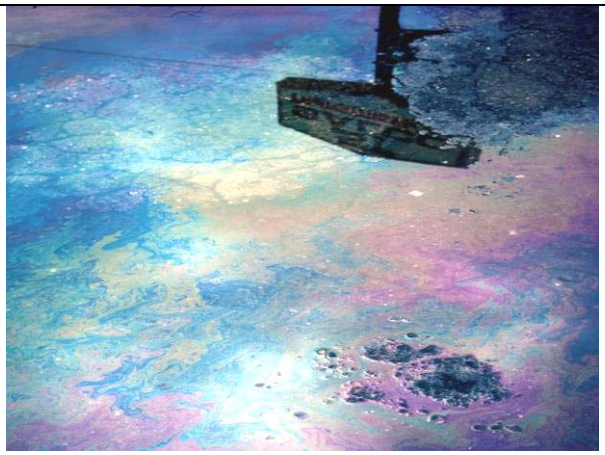
Downtown Central Business District: Highly impervious downtown areas of commercial and institutional land use. This land use also includes the buildings, parking areas, streets, but with minimal landscaping.

Example aerial photograph of strip commercial area surrounded by older high density residential area (Pitt and McLean 1986).

Paved parking area with frequent automobile movement

Contamination of paved parking areas due to commercial activities

Contamination of paved parking area due to inappropriate waste disposal



Parking area at automobile service area

Typical problem areas in commercial areas that should be documented during the field survey.

Typical strip commercial areas

Commercial shopping mall

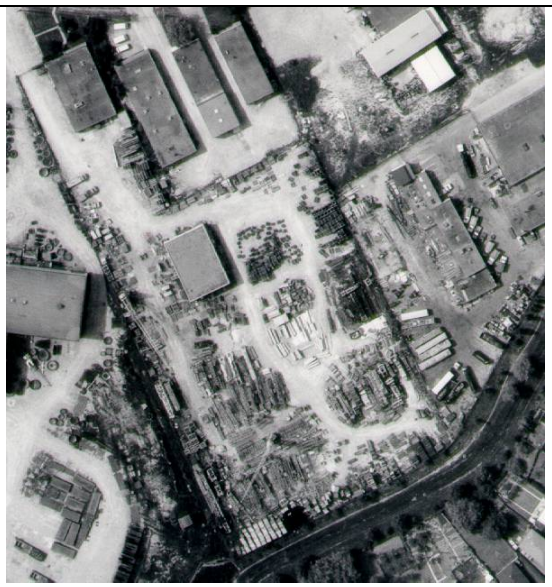
Industrial Land Uses

Manufacturing (Heavy) Industrial: Those buildings and premises which are devoted to the manufacture of products, with many of the operations conducted outside, such as power plants, steel mills, and cement plants.

Medium Industrial: This category includes businesses such as lumber yards, auto salvage yards, junk yards, grain elevators, agricultural coops, oil tank farms, coal and salt storage areas, slaughter houses, and areas for bulk storage of fertilizers. Municipal public works yards are also included in this category.

Non-Manufacturing (Light) Industrial: Those buildings which are used for the storage and/or distribution of goods awaiting further processing or sale to retailers. This category mostly includes warehouses and wholesalers where all operations are conducted indoors, but with truck loading and transfer operations conducted outside.

Non-manufacturing, light industrial area - warehousing



Medium industry - scrap yard/storage area

Example aerial photographs of industrial areas (Pitt and McLean 1986).

Contaminated paved storage area at vehicle junk yard

Contaminated unpaved storage area

Very large-scale metal recycling operation on unpaved surface

Heavy equipment storage area on concrete surface

Activities in industrial areas that contribute to stormwater pollutants that should be documented during field surveys.

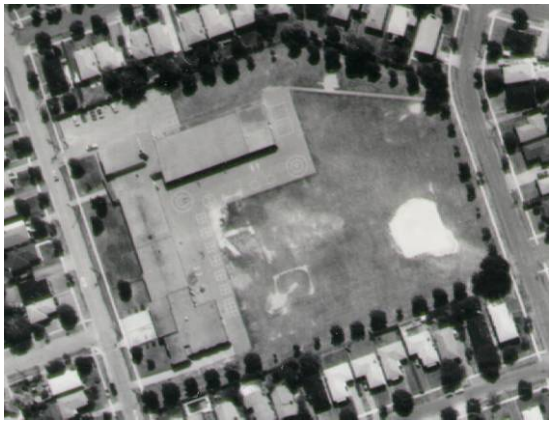
Light and medium industrial land use activities.

Institutional Land Uses

Hospitals: Medical facilities that provide patient overnight care. Includes nursing homes, state, county, or private facilities. This land use includes the buildings, grounds, parking lots, and driveways as the main surfaces.

Education (Schools): Includes any public or private primary, secondary, or college educational institutional grounds. The land use consists of the buildings, playgrounds, athletic fields, roads, parking lots, and lawn areas.

Miscellaneous Institutional: Churches and large areas of institutional property not part of strip commercial and downtown areas.



Example aerial photograph of educational land use area (Pitt and McLean 1986).

School

Church

Open Space Land Uses

Cemeteries: Includes cemetery grounds, roads, and buildings located on the grounds.

Parks: Outdoor recreational areas including municipal playgrounds, botanical gardens and arboretums, golf courses, and natural areas.

Undeveloped: Lands that are private or publicly owned with no structures and have an almost complete vegetative cover. This includes vacant lots, transformer stations, radio and TV transmission areas, water towers, and railroad rights-of-way.


Example aerial photograph of open space land use area, a cemetery (Pitt and McLean 1986).

Freeway Land Uses

Freeways: These are limited access highways and the interchange areas, including any vegetated rights-of-ways.

Example aerial photograph of freeway land use area (Pitt and McLean 1986).

Suburban freeway with large shoulders and grass swales at median

Urban freeway with minimal grass area, almost completely paved right-of-way


Depressed downtown freeway with eroding embankment

Homogeneous Neighborhood Surveys

An “Area Description” field sheet is used to record important characteristics of the homogeneous land use areas during the field surveys (Figure 1). In addition, aerial photographs, such as from TerraServer USA http://terraservice.net/ (Figure 2) or preferably higher resolution satellite images (Figure 3) are used to measure the actual coverage of each type of surface in each neighborhood studied. The following discussion describes the field sheet and the information requested.

Location: Site number:
Date: Time:
Photo numbers:
Land-use and industrial activity:
Residential: low medium high density single family
multiple family
trailer parks
high rise apartments
Income level: low medium high
Age of development: <1960 1960-1980 1980-2000 >2000
Institutional: school church hospital other (type):
Commercial: strip shopping center/mall downtown hotel offices
Industrial: light medium heavy (manufacturing) describe:
Open space: undeveloped park golf cemetery
Other: freeway utility ROW railroad ROW other:
Maintenance of building: excellent moderate poor
Heights of buildings: 1 2 3 4+ stories
Roof drains: % underground % gutter % impervious % pervious
Roof types: flat composition shingle wood shingle metal other:
Sediment source nearby? No Yes (describe):
Treated wood near drainage system or directly connected pavement? No telephone poles fence other:
Landscaping near road or directly connected impervious surfaces:
Quantity: none some much
Type: deciduous evergreen lawn
Maintenance: excessive adequate poor
Leafs on street: none some much
Topography:
Street slope: flat (<2%) medium (2-5%) steep (>5%)
Land slope (next to street): flat (<2%) medium (2-5%) steep (>5%)
Traffic speed: <25mph 25-40mph >40mph
Traffic density: light moderate heavy
Parking density: none light (20 to 50%) moderate (50 to 80%) heavy (>80%)
Width of street: number of parking lanes:
number of driving lanes:
Condition of street: good fair poor
Texture of street: smooth intermediate rough very rough
Pavement material: asphalt concrete unpaved
Driveways: paved unpaved
Condition: good fair poor
Texture: smooth intermediate rough
Gutter material: grass swale lined ditch concrete asphalt
Condition: good fair poor
Street/gutter interface: smooth fair uneven
Litter loadings near street: clean fair dirty
Parking/storage areas (describe):
Condition of pavement: good fair poor
Texture of pavement: smooth intermediate rough unpaved
Directly connected to drainage: yes no
Other paved areas (such as alleys and playgrounds), describe:
Condition: good fair poor
Texture: smooth intermediate rough
Directly connected to drainage: yes no
Other notes/comments:

Figure 1. Area description field sheet.

Figure 2. Example of 1 m monochromatic aerial photograph (USGS photo).

Figure 3. Example of sub meter color satellite image (Google).

Detailed Instructions for Field Inventory Sheet

• *Location*:
The block address number range and the street name are noted. A sub-area name can also be used to describe the drainage area, or portion of town. A field sheet is filled out for each homogeneous land use area being investigated in the study area. Specific blocks to be surveyed are selected based on maps and aerial photographs before the survey is conducted. Each site needs at least two photographs taken: one is a general scene and the other is a close-up showing about 25 by 40 centimeters of pavement. Additional photographs are usually taken to record unusual conditions. A photograph is also taken of the completed field sheet at the end of each neighborhood survey to separate and label the images. These photographs are very important to confirm the descriptions recorded on the data sheets and to verify the consistency of information for the different areas within each category. The photographs are also very important when additional site information is needed, but not specifically recorded on the data sheets.

• *Land-use*:
The land-use type that best describe the block is circled. The previous land use descriptions are one scheme that has been used with WinSLAMM. However, these definitions may need to be modified based on local practice and information. Also, some of the homogeneous areas may need to be re-categorized after the data is obtained. As an example, the housing density initial estimates may be incorrect for some areas and the surveyed areas may need to be moved to another category after the accurate measurements are available. If more than one land-use is present in an area being studies (would happen if conducting a survey in a monitored area), then a separate form should be used for each homogeneous land use subarea. The approximate income level for the residential areas is also circled. The specific types of industrial activities (warehouses, metal plating, bottling, electronics, gas station, etc.) for industrial and commercial areas are also noted on the form. Also, the approximate age of development is circled.

• *Roof drainage*:
The discharge location of the roof drains is also noted on the form. The approximate distribution of the discharge locations is noted if more than one location is evident. This is determined by driving around the complete area and tallying the roof drain locations. It is assumed that all backyard drains are disconnected, unless alleys are present. In that case, drive the alleys and note the back drain connections. Obviously, do not trespass to view all the drains. The "underground" location may be to storm sewers, sanitary sewers, or dry wells. Some areas have the roof drains apparently directed underground but are actually discharged to the roadside gutter or drainage ditch. If they lead to the gutter (discharge locations are usually seen along the gutter), then the "to gutter" category is circled. Additionally, if the flow path length is less than about five feet over pervious ground for a typical house, it is functionally directly connected to impervious areas, requiring circling the "to impervious" category. The roof types and building heights are also indicated (again, the approximate distributions are noted if more than one type is present in the "homogeneous" subarea). It is necessary to take an inventory of all visible roof drains in the study block by keeping tallies of each type of drain connection. The distribution of the percentage per connection type was put on the sheet. If other categories of characteristics vary in the study block (paved or unpaved driveway categories is another common variation), then these are also tallied.

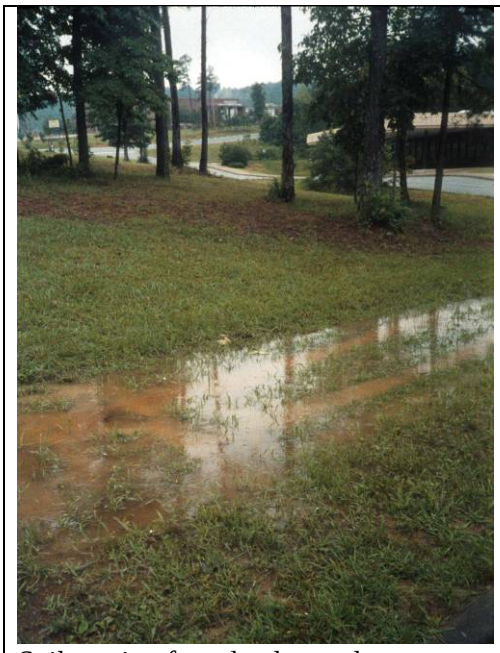
A directly connected roof drain

A disconnected roof drain (drains to pervious area)

Pitched metal roof

Flat commercial roofs

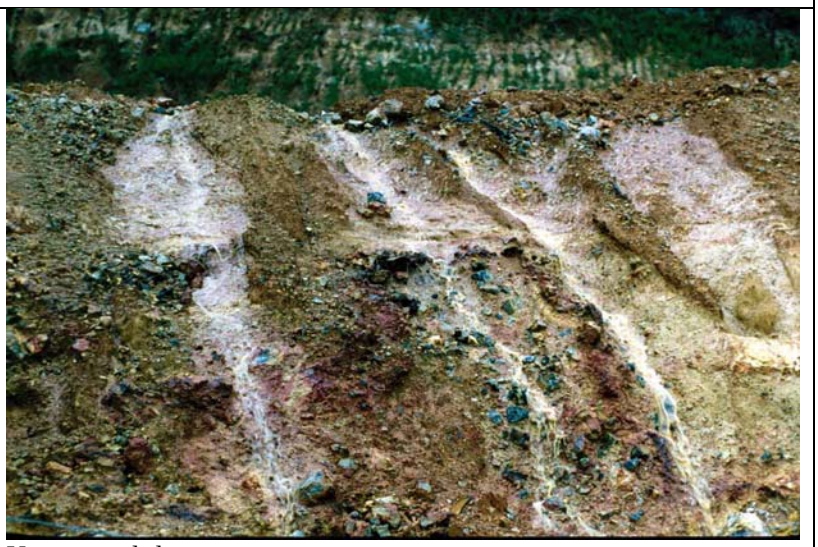
• *Sediment sources*:
Sediment sources near the drainage (street, drainage way, or gutter), such as construction sites, unpaved driveways, unpaved parking areas or storage lots, or eroding vacant land, are described and photographed.



Soil erosion from landscaped areas having fine-grained soils during periods of high rain intensities

Scoured drain from paved area.

Utility work near street.



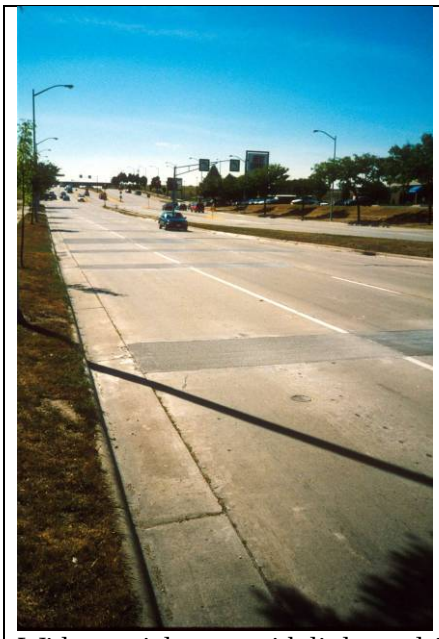
Unprotected slope.

- *Treat wood near drainage system or directly connected impervious area:*

Circle or describe any treated wood that is located near any directly connected impervious area. Most wood treatment chemicals (heavy metals or organic compounds) are effectively captured if drained to landscaped areas. If drain to pavement, much of the toxicants can directly enter the drainage system. Also describe the type of wood preservative, if possible (Copper-chromium-arsenic, CCA, creosote, etc.).

Treated wood near drainage system or directly connected impervious areas can contribute toxicants to the storm drainage system.

• *Landscaping near road or directly connected impervious surfaces:*
Describe the type of landscaping near the road and other directly connected impervious surfaces. Large amounts of trees near these surfaces can add nutrients to the stormwater. Deciduous vegetation can add large amounts of leaf litter in the fall that requires special cleanup operations to prevent clogging of the drainage system. Excessive maintenance (total absence of weeds, for example) implies an excess amount of chemical use (fertilizers, herbicides, and pesticides) that also contribute to stormwater degradation.



Wide arterial street with little roadside vegetation.

Narrow residential street with substantial adjacent vegetation (Bannerman photo).

• *Parking density:*
Vehicles parked along a street cleaning route reduce the length of curb that may be cleaned by municipal street cleaning operations. Since most of the street surface pollutants are found close to the curb on smooth streets with little parking, parked vehicles can drastically reduce the cleaning effectiveness of normal cleaning programs on these streets. Extensively parked cars block the migration of particulates towards the curb, resulting in higher "middle of the street" loading values than for streets with little or no parking. The percentage of curb length occupied by parked vehicles is close to the percentage of parking spaces occupied, but is usually smaller due to parking restrictions such as driveways and fire hydrants. As the number of parked cars increases, the percentage of' curb left uncleaned by street cleaning operations increases proportionally, especially as the street cleaning equipment must also maneuver around the parked cars.

If a smooth street has extensive on-street parking 24 hours a day (such as in a high density residential neighborhood), most of the street surface particulates would not be within the 8 ft. strip next to the curb that is usually cleaned by street cleaning equipment. If the percentage of curb length occupied by parked cars exceeds about 80 percent for extensive 24 hour parking conditions, it would be best if the parked cars remained and the street cleaner swept around the cars (in the 8 to 16 ft. strip from the curb). Of course, all of the cars should be removed periodically to allow the street cleaner to operate next to the curb to remove litter caught under the cars. In an area with extensive daytime parking only (such as in downtown commercial areas), the parked cars should remain parked during cleaning (daytime cleaning) if the percentage of curb length occupied exceeds about 95 percent.

• *Street and Pavement*:
The numbers of traffic and parking lanes are also noted on the field sheet. Pavement condition and texture are different characteristics and are noted separately. Condition implies the state of repair, specifically relating to cracks and holes in the pavement. Texture implies roughness. A rough street may be in excellent condition: many new street overlays result in very rough streets. Some much worn streets may also be quite smooth, but with many cracks. Rough or streets in poor condition have much greater street dirt loadings and are much more difficult to clean with street cleaning equipment. They also produce less washoff of the street dirt during rains. Smooth streets are cleaned by both street cleaning equipment and rains more effectively.

A close-up photograph of the street surface is used to make final determinations of street texture by comparing with reference photographs. An overview photograph of the street is also taken to make the final determination of the street condition. The gutter/street interface condition is an indication of how well the street pavement and the gutter

material join. Many new streets overly jobs are uneven, resulting in a several centimeter ridge along the gutter/street interface. If the street interface has poor condition or is uneven, an additional photograph is taken to show the interface close-up. The litter perception is also indicated on the field sheet and another photograph is taken of heavily littered areas.


Smooth textured street.


Intermediate textured street.


Rough textured street


Very rough textured street.

Aerial Photographic Measurements of Source Areas

The measurements of the source areas from aerial photographs are also needed. After the field data description sheets are filled out during each neighborhood survey, the corresponding aerial photographs from TerraServer USA and/or satellite images are examined, and the individual elements (roofs, parking areas, street areas, sidewalks, landscaping, etc) are measured using. This can be done manually or by using automated tools, such as GIS Tools (ArcGIS 9.0). The aerial photograph area measurements are tabulated and summarized in Excel spreadsheets

(examples in Appendix A). These data are then used to build the WinSLAMM files to describe each land use area. This information can be manually measured from aerial photographs and recorded on data sheets, using one sheet for each site surveyed. An example of this manual measurement data sheet is shown below.

Little Shades Creek Stormwater Study - Site Characteristics

Site #: 66 Land use: Single-Family Zoning: R-1 Govt: VCSt.

Description: High density buildings

Location: Chestnut Road

Total area: 11.6 ha.

Total number of units in area: 31 Density: 2.67 /ha

Streets: Total street length: 992.2 m Street length density: 85.53 m/ha

Average street width: 6.05 m Street area: 6002.8 m^2

Street area density: 517.48 m^2/ha

Grass area between sidewalk and street: width: _____ m length: _____ m

area: _____ m^2 density: X m^2/ha

Sidewalk: width: _____ m length: _____ m area: _____ m^2 density: X m^2/ha

Front landscaping: average per unit 2350 m^2 x 31 # units = 72838 m^2

density: 6279 m^2/ha

Driveways: avg. per unit 78.65 m^2 x 31 # units = 2438.15 m^2 density: 210.19 m^2/ha

100 % paved; 210.19 m^2/ha

0 % unpaved; 0 m^2/ha

Parking areas: _____ m^2 density: X m^2/ha

_____ % paved; X m^2/ha

_____ % unpaved; X m^2/ha

Storage areas: _____ m^2 density: X m^2/ha

_____ % paved; X m^2/ha

_____ % unpaved; X m^2/ha

Playgrounds: _____ m^2 density: X m^2/ha

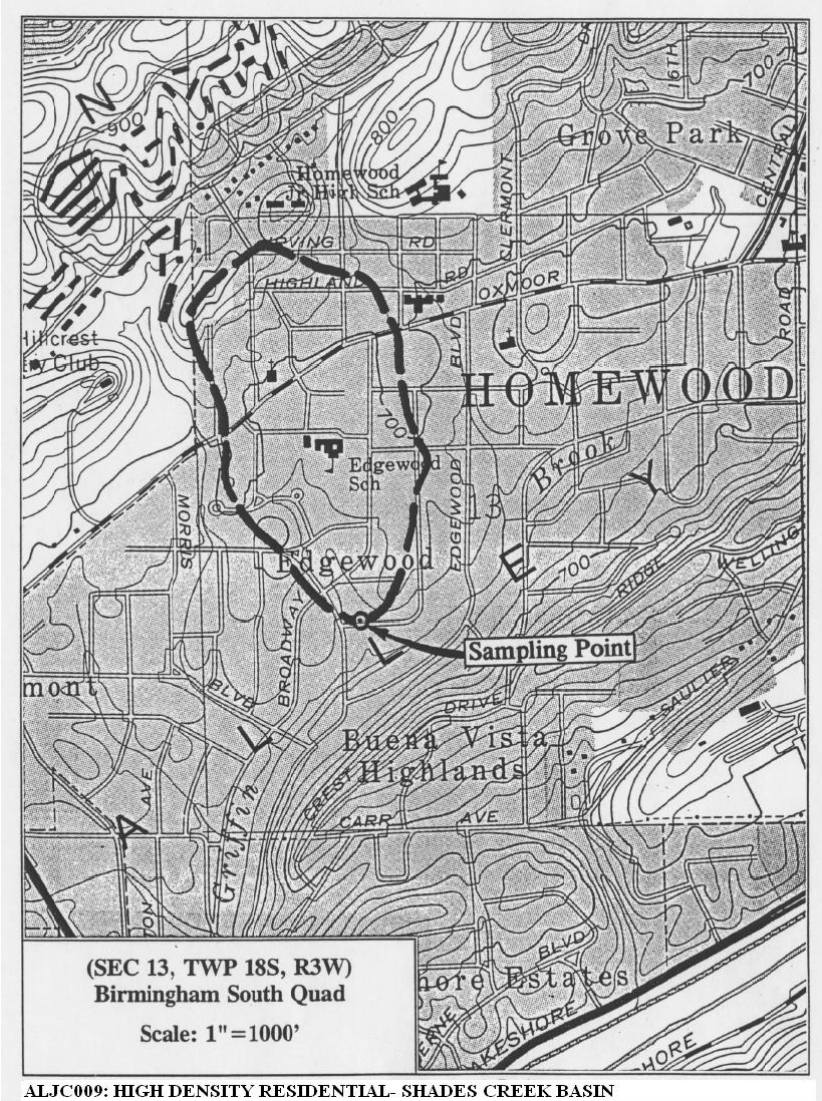
_____ % paved; X m^2/ha

_____ % unpaved; X m^2/ha

Example of first page of the area measurement sheets.

Bochis (2007) and Bochis, *et al*. (2008) recently examined several different approaches using automated methods to acquire the source area data as part of a stormwater study in Jefferson County, AL. The first step was to obtain satellite imagery taken during 2001 and 2003, plus watersheds paper maps from the Storm Water Management Authority of Jefferson County (SWMA). All images were originally purchased from Space Imaging and acquired by IKONOS Satellite imagery which is a high-resolution satellite operated by Space Imaging LLC. IKONOS produces 1-meter black-and-white (panchromatic) and 4-meter multi-spectral (red, blue, green, near infrared) imagery that can be combined in a variety of ways to accommodate a wide range of high-resolution imagery applications. The satellite was launched on September 24, 1999 and has been delivering commercial data since early 2000.

The second step was the electronic delineation of the study watersheds using map digitizing and GIS tools. The multi-spectral image of Jefferson County and the paper maps of the watersheds were used to manually digitize and then cut each of the watersheds using ArcGIS 9 (ArcMap). Each watershed was saved separately as a shape file (.SHP). The following are examples of a high density residential shape file, showing the location on the USGSA quad map and the cut out shape aerial image. Since these were monitored watersheds, they usually included a mixture of land uses, although each was predominately a single land use. Therefore, several homogeneous land use neighborhoods were inventoried in each watershed to represent each of the land uses present. The areas of these land uses were also determined and the characteristics of the complete watershed were therefore known.



ALJC009: HIGH DENSITY RESIDENTIAL- SHADES CREEK BASIN

Mixed High Density Residential Area - Site Satellite Image (Bochis 2007).

The multi-spectral Jefferson.sid aerial images were obtained from the National Aerial Photography Program (NAPP) which were further processed by SWMA. Film negatives were purchased by SWMA from the USGS and were scanned and saved into digital format, orthorectified and sid'ed into USGS quad arrangements (one singular layer). They were not scanned by a metric scanner (which would have resulted in sharper and more precise output image).

The National Aerial Photography Program was initiated in 1980 and coordinated by the USGS. The purpose is to acquire aerial photography of each of the 48 lower states every five years. They are acquired at 20,000 feet elevation and centered on 1:24,000 scale USGS maps, with eight frames making up one USGS quadrangle map. Each frame represents 32.3 sq.mi. at 2-ft pixels. Final output are digital ortho quarter quads (DOQQ) and revised approximately every five years. For more information about NAPP, see: http://eros.usgs.gov/products/aerial/napp.php. The next step used the two 1-meter panchromatic satellite images ("Leafoff.img" flown December 2000 and "Leaffon.img", flown summer 2001; raster format "ERDAS IMAGE", number of raster bands: 1) of Jefferson County. These images were purchased by SWMA from Space Imaging and were assembled into mosaics using a PLSS-Township arrangements. It is complete for the entire county area, but with cloud obstructions in some areas. The overlapping/cutting process made use of GIS Tools: ArcInfo, ArcToolbox and ArcMap 8.9. Each image was saved separately (.IMG extension) having the equivalent name of the watershed.

The satellite image measurement process was initially used to describe the different land uses within the watersheds. For residential land uses, the most visible neighborhoods (having minimal tree cover) were selected and their individual elements were electronically measured. However, for industrial, commercial, and institutional areas, it was necessary to take account of all the elements incorporated into the land use due to greater variabilities of the different surface cover areas. The areas of the individual elements were calculated using ArcGIS and stored in the shape file attribute table.

Data measurement storage and processing

The older Little Shades Creek area measurements were obtained manually from aerial photographs and then transferred to Excel worksheets (Appendix A for a summary). The individual elements of the six Jefferson County watersheds were measured in square feet units and recorded directly in an electronic format (.dBASE IV). For easier handling of these data, the files were later converted into Excel worksheet files. Data normalizing was also performed to account for rounding errors.

In order to construct WinSLAMM files, several types of information about the sites are needed: drainage system (grass swales, curb and gutter in good/fair/poor condition, undeveloped roadside) and the fraction of each type of drainage system serving the study area; the soil type (sandy, silty, clayey); some of the field information (roof type, street texture, etc.), and the area measurements normalized data. All of the information was obtained during the field surveys, or during the aerial photograph measurements. A separate SOP describes soil surveys need to characterize the disturbed urban soils in a developed area.

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Appendix A: Area Measurements of Different Land Uses in the Little Shades Creek Watershed, Jefferson County, AL.

Little Shades Creek Watershed, near Birmingham, AL: Average Source Areas by Land Use (Percent of total area)

Land Use	Street Area	Driveways Paved Connected	Driveways Paved Disconnected	Driveways Unpaved	Parking Paved Connected	Parking Paved Disconnected	Playground Paved Disconnected
High Dens. Residential	7.8	1.6	1.9	0.0	0.0	0.0	0.0
Med. Dens. Residential (<1960)	5.6	1.1	2.0	0.0	0.0	0.0	0.0
Med. Dens. Residential (1961-80)	6.7	1.3	1.9	0.0	0.0	0.0	0.0
Med. Dens. Residential (>1980)	7.5	0.0	1.1	1.1	0.0	0.0	0.0
Low Dens. Residential	5.3	0.23	0.80	0.0	0.0	0.0	0.0
Apartments	9.8	0.52	1.0	0.0	6.6	3.9	0.84
Multiple Families	7.3	0.60	0.60	0.0	8.7	0.0	0.16

SOURCE: Bochis (2007).

Little Shades Creek Watershed, near Birmingham, AL: Average Source Areas by Land Use (Percent of total area)

Land Use	Front Landscape	Back Landscape	Undeveloped	Roof Drained to Impervious	Roof Drained to Pervious	Walkway	Total
High Dens. Residential	40	32	3.9	4.6	8.1	0.0	100
Med. Dens. Residential (<1960)	58	23	0.0	4.0	5.5	0.0	100
Med. Dens. Residential (1961-80)	53	28	0.17	2.2	6.6	0.0	100
Med. Dens. Residential (>1980)	51	24	4.8	6.6	3.2	0.0	100
Low Dens. Residential	33	48	8.4	0.87	2.9	0.0	100
Apartments	32	23	3.3	3.6	16	0.0	100
Multiple Families	28	30	6.9	11	6.7	0.1	100

SOURCE: Bochis (2007).

Little Shades Creek Watershed, near Birmingham, AL: Average Source Areas by Land Use (Percent of total area)

Land Use	Street Area	Driveways Paved Connected	Driveways Paved Disconnected	Drive ways Unpaved	Parking Paved Connected	Parking Paved Disconnected	Parking Unpaved	Play ground Paved Disconnected	Playground Unpaved
Offices	16	1.1	0.62	0.0	25	1.9	0.0	0.0	0.0
Shopping Centers	16	0.74	0.0	0.0	29	0.0	0.61	0.0	0.0
Schools	4.2	0.10	0.10	0.0	5.7	0.0	0.0	0.0	15
Churches	18	0.38	0.38	0.0	25	0.0	4.8	0.0	0.0
Industrial	8.0	0.32	0.10	0.0	8.9	2.5	1.8	0.0	0.0
Parks	16	0.11	0.11	0.0	16	0.0	0.0	8.3	25
Cemeteries	6.9	0.0	0.07	3.3	0.0	9.2	1.8	0.0	0.0
Golf Courses	1.2	0.08	0.08	0.0	0.65	0.0	0.0	0.68	0.0
Vacant	4.8	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0

SOURCE: Bochis (2007).

Little Shades Creek Watershed, near Birmingham, AL: Average Source Areas by Land Use (Percent of total area)

Land Use	Storage Paved Connected	Storage Unpaved	Front Landscape	Back Landscape	Large Turf	Undeveloped	Roof Drained to Impervious	Roof Drained to Pervious	Total
Offices	0.0	0.0	24	15	0.0	0.0	17	0.33	100
Shopping Centers	0.0	0.0	30	1.8	0.0	0.0	18	3.6	100
Schools	0.0	0.0	23	26	14	1.0	6.1	4.8	100
Churches	0.0	0.0	21	12	0.0	7.0	10	1.7	100
Industrial	16	8.1	27	17	0.0	0.0	5.5	5.4	100
Parks	0.0	0.0	1.0	4.3	15	14	0.0	0.0	100
Cemeteries	0.0	0.0	8.3	0.0	70	0.0	0.0	0.98	100
Golf Courses	0.0	0.0	19	0.0	76	0.0	0.0	2.8	100
Vacant	0.0	0.0	0.0	0.0	27	67	0.	0.0	100

SOURCE: Bochis (2007).