Background
• February 2001: BS in Geography from Romania
  • Minor in Meteorology-Hydrology
• May 2007: MSE (Environmental) at UA
• December 2008: Ph.D. in Civil Engineering at UA
  • Concentration: Water Resources / Environmental
• Graduate Research Assistant since Jan. 2002
• Engineering Math Advancement Program - Graduate Program Coordinator since Jan. 2005

Objectives
1. Determined the nature of impervious surfaces
   - How they vary for different land uses
   - How the different surface configurations affect stormwater quality and quantity
2. Describe the method of field data collection and data processing necessary to examine land use characteristics
   - Jefferson Co. Storm Water Management Authority (SWMA) five outfalls (40 neighborhoods)
   - Little Shades Creek Watershed (125 neighborhoods)

Main Findings of Literature Review
• Purpose of this research was to provide more detail on impervious surfaces for different land uses in the Southeast United States
• There is a general recognition that directly connected impervious areas (DCIA) are the most important feature affecting most runoff characteristics
• Very little data available and published to support the many assumptions that people have about impervious surfaces
• Impervious surfaces have not been described in enough detail to be efficiently used in association with biological condition observations
**Approach**

- Investigated many land uses in the Birmingham, AL, area:
  - 1 large watershed, the Little Shades Creek Watershed (125 neighborhoods / 6 land uses) (original data collected in mid 1990s by USDA Earth Team volunteers)
  - 5 drainage areas (40 neighborhoods having 2-6 land uses each) which are part of the Jefferson County, AL, Stormwater Permit Monitoring Program (intensive field investigations and surveys were conducted as part of this thesis research)

- Used WinSLAMM to:
  - Calculated runoff characteristics
  - Estimated the biological conditions of the receiving waters due to quantity of runoff for different land use and development characteristics

**Field Data Collection**

- Delineation of the watersheds and neighborhoods

- Single land use neighborhood surveys: 6 to 12 per study area land use to determine the variability of the development characteristics

- Site Inventory had 2 parts:
  - Field data collection
  - Aerial photographic measurements of different land covers

- Each site had at least two photographs taken:
  - one as a general view
  - one as a close-up of the street texture

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**Field Inventory Sheet Prepared for Each Neighborhood**

When in the field we look for:

1. Roof types (flat or pitched)
2. Roof connections (connected, disconnected)
3. Pavement conditions and texture (smooth, interm., rough)
4. Storm drainage type (grass swales, curb and gutters, and roof drains)
Land Use Categories Examined

- **Residential**
  - High, medium, low density
  - Apartments, Multi-family units
- **Commercial**
  - Strip commercial, shopping centers
  - Office parks, downtown business district
- **Industrial**
  - Manufacturing (power plants, steel mills, cement plants)
  - Non-manufacturing (warehouses)
  - Medium Industrial (lumber yards, junk and auto salvage yards, storage areas)
- **Institutional**
  - Schools, churches, hospitals, nursing homes
- **Open Space**
  - Parks, cemeteries, golf courses
  - Vacant spaces, undeveloped areas
- **Freeways** – drained by swales

**Little Shades Creek Watershed**

**Average Land Cover Distribution**

- High Density Residential (6 houses/acre)
  - TIA = 25%
  - DCIA = 15%
  - TR-55 = 52 - 65%
Little Shades Creek Watershed Variation in Land Cover Distribution

Little Shades Creek and Jefferson Co. Drainage Areas: TIA by Land Use

Little Shades Creek and Jefferson Co. Drainage Areas: DCIA by Land Use
**Average Percent Directly Connected Impervious Area**

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Local Conditions</th>
<th>TR – 55 (using interpolation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDR (&gt; 6 units/ac)</td>
<td>21</td>
<td>52</td>
</tr>
<tr>
<td>MDR (2-6 units/ac)</td>
<td>11</td>
<td>39</td>
</tr>
<tr>
<td>LDR (&lt; 2 units/ac)</td>
<td>5</td>
<td>23</td>
</tr>
<tr>
<td>APARTMENTS</td>
<td>23</td>
<td>65</td>
</tr>
<tr>
<td>COM</td>
<td>71</td>
<td>85</td>
</tr>
<tr>
<td>IND</td>
<td>50</td>
<td>72</td>
</tr>
</tbody>
</table>

- TR- 55 assumes all impervious areas to be directly connected to the drainage system.
- Overestimation of impervious cover for local conditions.

**Curb Length vs Land Use**

1 mile = 1.6 km  
1 ac = 0.4 ha

**Relationship between Directly Connected Impervious Areas, Volumetric Runoff Coefficient, and Expected Biological Conditions**
<table>
<thead>
<tr>
<th>Watershed ID</th>
<th>Major Land Use</th>
<th>Area (ac)</th>
<th>Pervious Areas (%)</th>
<th>Directly Connected Impervious Areas (%)</th>
<th>Disconnected Impervious Areas (%)</th>
<th>Vol. Runoff Coeff. (Rv)</th>
<th>Expected Biological Conditions of Receiving Waters</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALJC 001</td>
<td>IND</td>
<td>341</td>
<td>25</td>
<td>72</td>
<td>2.8</td>
<td>0.67</td>
<td>Poor</td>
</tr>
<tr>
<td>ALJC 002</td>
<td>IND</td>
<td>721</td>
<td>40</td>
<td>53</td>
<td>7.3</td>
<td>0.51</td>
<td>Poor</td>
</tr>
<tr>
<td>ALJC 009</td>
<td>Resid. High Dens.</td>
<td>102</td>
<td>54</td>
<td>34</td>
<td>12</td>
<td>0.37</td>
<td>Poor</td>
</tr>
<tr>
<td>ALJC 010</td>
<td>Resid. Med. Dens.</td>
<td>133</td>
<td>64</td>
<td>28</td>
<td>7.9</td>
<td>0.30</td>
<td>Poor</td>
</tr>
<tr>
<td>ALJC 012</td>
<td>COM</td>
<td>228</td>
<td>36</td>
<td>61</td>
<td>3.4</td>
<td>0.61</td>
<td>Poor</td>
</tr>
<tr>
<td>Little Shades Creek</td>
<td>RES</td>
<td>5120</td>
<td>67</td>
<td>21</td>
<td>12</td>
<td>0.29</td>
<td>Poor</td>
</tr>
</tbody>
</table>

**Expected Biological Conditions of Receiving Waters**

- **ALJC 012**: Expected biological conditions improved from “poor” to “fair” due to stormwater controls.

### Flow-Duration Curves for Different Stormwater Conservation Design Practices

- **Top Set**: No Controls
- **Middle Set**: Pond, Swales and Bioretention
- **Bottom Set**: Pond, Pond and Swales, Pond and Bioretention

Flow Duration Curves are Ranked in Order of Peak Flows

- **Discharge (cfs)**
- **% Greater than Discharge Rate**

### Example of Stormwater Control Implementation

- **Annualized Total Costs ($/year/ac)**
- **Runoff Coefficient (Rv)**
- **% Reduction of Total Runoff Volume Discharges**
- **Unit Removal Costs for Runoff Volume ($/Rv)**
- **Expected biological conditions in receiving waters (based on Rv)**

<table>
<thead>
<tr>
<th>No controls</th>
<th>Pond Only</th>
<th>Swales Only</th>
<th>Bioretention Only</th>
<th>Pond, Swales and Bioretention</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>118</td>
<td>404</td>
<td>1974</td>
<td>2456</td>
</tr>
<tr>
<td>0.61</td>
<td>0.60</td>
<td>0.54</td>
<td>0.26</td>
<td>0.20</td>
</tr>
<tr>
<td>n/a</td>
<td>1.4%</td>
<td>10%</td>
<td>58%</td>
<td>67%</td>
</tr>
<tr>
<td>n/a</td>
<td>0.07</td>
<td>0.03</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td>poor</td>
<td><strong>fair</strong></td>
</tr>
</tbody>
</table>

- **Site ALJC 012**
- **Area 228 acres = 92.3 ha**
- **Bioretention devices give the greatest reduction in runoff volume discharged**
- **The biological conditions improved from “poor” to “fair” due to stormwater controls**
Conclusions

• Literature assumptions on impervious cover are not very accurate when applied to SE US conditions

• Almost all impervious surfaces are directly connected in the Jefferson County study areas examined

• Impervious cover variability within land uses need to be considered when modeling runoff conditions

• WinSLAMM showed that stream quality in the receiving waters is in poor condition, a fact confirmed by in-stream investigations by the SWMA biologists,

• Substantial applications of complimentary stormwater controls are needed to improve these conditions.

Acknowledgments

• Storm Water Management Authority at Birmingham, AL who provided the data

• SWMA employees who helped in this research

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• Dr. Pitt and UA-CE graduate students who helped in the field data collection