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MESM 2007 Group Project Proposal:
“Evaluation of Rainfall-Runoff Relationships to Inform Development of an Incentive Program for Stormwater Reduction in South Coast Watersheds”

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I. ABSTRACT

Impervious surfaces alter the storm hydrograph, increasing peak flows, decreasing lag times, and increasing the overall magnitude of discharge in a watershed. As the South Coast region of California becomes more densely urbanized, the percentage of impervious surfaces in the region is likely to increase. Our study employs a HEC-HMS-based hydrologic model developed by Beighley et al. (2003) to examine how the percentage of impervious surfaces in two Santa Barbara catchments, the Mission Creek Watershed and the Atascadero Watershed, affects runoff characteristics. We will research strategies to return the storm hydrograph to more natural conditions, such as alternatives to impervious surfaces and other related BMPs. We will compare the costs and benefits of each of these strategies relative to practices more commonly used. Additionally, we will consider overall consumer demand for alternatives to impervious surfaces and other related BMPs. Subsequently, we will explore methods to implement strategies to return the storm hydrograph to more natural conditions, such as regulation and incentive programs. Although we will focus our study on the Mission Creek and Atascadero watersheds, watershed managers will be able to apply the framework we develop to address similar issues in other watersheds in the South Coast region.

II. EXECUTIVE SUMMARY

Changing the amount and timing of runoff in a watershed may impact the quality of receiving waters and the frequency and intensity of flooding. Increasing the percentage of impervious surface cover in a watershed often alters the storm hydrograph. Changes in the hydrograph may include greater discharge volumes, shorter lag times, and higher peak flows in the watershed.

Impervious surfaces prohibit the infiltration of rainwater into the ground and provide accelerated pathways for rainwater to reach streams. Because no infiltration occurs through impervious surfaces, more rainwater reaches the streams, leading to greater discharge volumes. Furthermore, rainwater reaches the streams more quickly, shortening the time between the peak rainfall intensity and peak discharge, or lag time. Since the volumes of discharge are greater, and lag times are shorter, peak flows in watersheds with high impervious surface cover are greater than those in watersheds with more permeable surface cover.

Urbanization tends to increase the percentage of impervious surface cover in a watershed. Streets, parking lots, and other transportation-related structures comprise the bulk of these surfaces. Thus, many impervious surfaces receive and collect pollution from vehicles, such as grease and oils. Runoff generated by early-season rains can mobilize and transport these pollutants to streams. This may impact the health of receiving streams as well as the coastal waters into which these streams flow.

To reduce the effect urbanization has on the storm hydrograph, several strategies are available. These strategies include low-impact development, using permeable surfaces in place of impervious surfaces, and other stormwater runoff Best Management Practices (BMPs). These
BMPs, which may be structural or non-structural, can help to return runoff patterns to their natural, non-urbanized state. Permeable surfaces, for instance, unlike impervious surfaces, enable rain to infiltrate into the soil (if the soil is not saturated).

We propose to evaluate how reducing the percentage of impervious surface cover in two watersheds in the South Coast region of California will affect the storm hydrograph. To do this, we will use a HEC-HMS-based model developed by Beighley et al. to model runoff in the South Coast (2003). We will customize Beighley’s model for the Atascadero and Mission Creek watersheds, using land use data, including impervious surface coverage, storm drain network maps, rainfall data, and other available, relevant information. We will model several scenarios, to better understand the relationship between reduction in impervious surfaces and the location of the change within the watersheds.

Next, we will research a variety of permeable surfaces and other structural and non-structural BMPs that reduce runoff. We will explore the respective advantages and disadvantages of these options, including how much they cost, how they affect runoff, what sort of maintenance they require, and whether they are aesthetically-pleasing. We will also speak with local contractors and developers to roughly assess how much consumers are willing to pay for impervious surface substitutes.

Finally, we will consider some of the different ways to implement runoff reduction BMPs. We will research notable and innovative implementation programs that have been employed in other areas, considering both incentive programs and regulatory mechanisms. Talking to city and county officials will help us to determine what is and what is not feasible in terms of implementation in this area. This will help us to direct our research and to assemble insightful information about implementation that watershed managers here can use.

A watershed modeling analysis and mitigation toolkit will be developed, based on the results of this modeling effort. The toolkit will integrate different aspects such as the setting up of a watershed analysis framework, the application of modeling software, landscape data consolidation and analysis, and a comparison of costs and benefits of converting to pervious surface material. The toolkit will also provide a suite of mitigation strategies that may be applied to different watersheds in the South Coast region, to reduce impervious surfaces and stormwater runoff.

**III. OBJECTIVES**

The purpose of this project is to scientifically analyze how impervious surfaces affect the storm hydrograph in two local watersheds. We will modify and use Beighley et al.’s (2003) South Coast watershed runoff model to determine by what percent impervious surfaces must be reduced in order to return the hydrograph to more natural conditions. In addition, we will provide options to local water managers that encourage the conversion of impervious surfaces in areas of residential or commercial development.
IV. BACKGROUND INFORMATION

Unlike natural areas covered with soil and vegetation, which absorb water and filter pollutants, impervious surfaces (i.e. roads, parking lots, sidewalks, driveways and roofs) prevent rain from soaking into the ground. Instead of absorbing water, impervious surfaces force the water to run off and be transported quickly down storm drains and into local waterways. This alteration in runoff conditions can have a significant impact on the storm hydrograph by causing greater discharge volumes, shorter lag times, and higher peak flows in the watershed.

This hydrologic disruption in watersheds with high impervious surface cover gives rise to increased severity of flooding due to stormwater flows that are greater in volume and in peak intensity (Carter, 1961; Anderson, 1968; Leopold, 1968; Tourbier and Westmacott, 1981). The negative consequences of flooding include increased erosion, road and property damage, and further exacerbation of water quality issues. Furthermore, accelerated runoff over impervious surfaces can lead to groundwater shortages and loss of aquatic habitat, when there is no water left in the watershed at the end of the rainy season (Ferguson, 2002). The reduction in the quantity of stormwater runoff has the potential to recover the area’s natural (non-urbanized) hydrograph and to buffer extreme run-off situations which are important factors in flood control.

Seventy percent of impervious surfaces are used for transportation purposes (Arnold, 1996). Consequently, these surfaces accumulate hydrocarbons and other auto-related pollutants throughout the dry season. During the first flush, or the first major rainfall event of the season, stormwater runoff will carry these pollutants directly to streams and eventually to the ocean, having the potential to threaten stream ecosystems, marine life and trigger health warnings (“beach advisories”) at popular recreation areas. Beach advisories not only warn of a public health threat, but they also harm our local economy, which is heavily dependent on coastal and beach-related tourism (SWRCB, 2000).

Stormwater management will become even more of a challenge as the region becomes more densely urbanized and the percentage of land covered by paved, or "impervious" surfaces increases. Developed watersheds in southern Santa Barbara County have urban areas with impervious surface coverage ranging from 20-40 percent (QEC, 2004/2005). As urbanized areas increase along the South Coast, so will the intensity of runoff problems associated with impervious surfaces.

Conventional systems for dealing with stormwater runoff often involve massive infrastructure projects. These projects have substantial economic, environmental, public safety, political, and practical limitations. One alternative to large infrastructure is low impact development (LID), an economically sustainable land-management technique. LID can be used to return urban runoff conditions to resemble the natural hydrograph of the watershed. LID is designed to address and reduce the burdens of the conventional practices of stormwater management (Coffman, 2002).

There are also a number of best management practices (BMPs) that can be used to improve stormwater infiltration. Permeable pavement and impermeable surfaces that are “disconnected” with plantings are examples of BMPs that are gaining increased attention. Permeable pavement is a unique cement-based product with a porous structure that allows water to pass directly
through the pavement and into the soil naturally. The widespread use of porous pavement, along with strategically placed plantings, has the potential to significantly increase the lag time and decrease the quantity of runoff throughout a watershed.

Rainfall-runoff models can be used to evaluate the volume and intensity of runoff that results from varying land uses and amounts of rainfall and discharge. Watersheds along the Santa Barbara coastline have a Mediterranean climate, with storms consisting of brief, high-intensity downpours. The model described in Beighley et al. (2003) was selected for this project because it was specifically designed for South Coast catchments and can accurately assess the runoff associated with the “flash” storms that are prevalent in this particular climate.

V. SIGNIFICANCE OF PROJECT

Returning the urbanized storm hydrograph to a more natural state provides many benefits. Replacing impervious surfaces with permeable cover and implementing other runoff-related BMPs will decrease the peak flow and provide a more attenuated recessional limb to the storm hydrograph. The research results from this project will:

- Provide a scientific basis for evaluating the reduction of impervious surfaces and its effects on stream runoff
- Weigh the benefits and drawbacks of alternative permeable surfaces and best management practices
- Propose a suite of options for the Santa Barbara area aimed at converting existing hardscape into more permeable surfaces and implementing effective BMPs

VI. APPROACH

- Determine which watersheds to model
  - establish criteria for watershed selection (i.e. availability of land cover data, stormwater drain maps, rainfall and discharge gage data; future development plans; governmental/public interest; political feasibility; and ability to apply results to other watersheds)
  - discuss options with county and city water managers
  - use criteria to choose two to three watersheds

- Learn and employ Beighley et al.’s South Coast watershed runoff model
  - justify use of this particular model
  - determine and understand important model inputs
  - obtain necessary input data for Beighley et al.’s model from county and city agencies
  - recognize and deal with the model’s uncertainty
  - attempt to demonstrate that reducing impervious surface coverage will decrease runoff
- consider areas (parcels, areas, sub-basins) for which impervious surface reduction could be critical

  - Research strategies to reduce discharge
    - pervious pavements (i.e. GrassyPave, GravelPave, EcoBlock, porous Portland Concrete)
    - other structural BMPs (i.e. bioswales, filter strips, green roof technology)
    - non-structural BMPs

  - Meet with prominent “eco-friendly” developers and contractors
    - roughly gage consumer willingness-to-pay for pervious surfaces
    - discuss practical problems and benefits associated with pervious surfaces, such as aesthetics and maintenance requirements

  - Research the implementation of strategies to reduce discharge
    - compare different strategies to reduce discharge in terms of costs and benefits
    - explore other municipalities’ implementation programs, including incentive programs
    - discuss feasibility with county and city water managers

VII. DELIVERABLES

- Customized rainfall-runoff model for selected watersheds in Santa Barbara county
- Comparison of discharge quantity under different land use/impervious percentage scenarios
- Final report summarizing model outputs, comparing alternative permeable surfaces, and providing options on how to decrease discharge via BMPs, incentives, and/or regulations

VIII. MILESTONES

- By end of Spring 06
  - be in contact with all relevant stakeholders
  - complete proposal review
  - finish literature review
    - organized in appropriate G:folders with citation
  - attain all relevant model input layers
  - have Beighley model up and running

- By end of Summer 06
  - model customized for appropriate watersheds
    - complete runs with differing %imperviousness
    - ability to manipulate model at will
    - begin identification of priority areas (sensitivity analysis)
- group maintains communication through periodic emails and phone calls
- **By end of Fall 06**
  - finished results from model
  - incentive options researched
  - begin writing of select sections of GP report (ie: bkg, methods)
- **By end of Winter 07**
  - finish writing GP project
  - prepare for defense
  - final GP project report completed
- **By early Spring 07**
  - design and print poster
  - prepare for final presentation
    - executive summary
    - power point presentation

### IX. REFERENCES


