Appendix A

Research Project Work Plan

for

ASSESSING HIGHWAY SYSTEM IMPACTS ON TOTAL MAXIMUM DAILY LOAD (TMDL WATERSHEDS USING THE STOCHASTIC EMPIRICAL LOADING AND DILUTION MODEL (SELDM)

SPR 798

Submitted by

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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)
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1.2 Principal Investigators

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1.3 Technical Advisory Committee (TAC) Members

Kira Glover-Cutter, Chair (ODOT)
William Fletcher (ODOT)
Alvin Shoblom (ODOT)
Jeff Moore (ODOT)
Tom Loynes (ODOT)
Susan Jones (FHWA)

1.4 Friends of the Committee

NA

1.5 Research Coordinator

Kira Glover-Cutter, Ph.D.
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2.0 Problem Statement

Stormwater runoff from every land use including industrial areas, commercial areas, residential areas, roads and highways, developed open space, agriculture, rangelands, and even forested areas increase concentrations and loads of water-quality constituents such as sediment, nutrients, and metals in receiving waters (Maestre and Pitt, 2005; Washington State Department of Ecology, 2011; Clary and Leisenring, 2015). State and municipal governments have limited resources and the costs for implementing stormwater mitigation measures are expensive. For example, Taylor and others (2014) estimated that the long-term life-cycle costs for removing a pound of sediment, phosphorus, or copper by using conventional stormwater (BMPs), were, on average, about $9.32, $5,111, or 38,488, respectively. Therefore, decision makers need the tools, techniques, and information to maximize potential environmental benefits with available resources.

Regulations covering water quality in Oregon's streams and rivers are implemented and enforced by the Oregon Department of Environmental Quality (ODEQ). Section 303(d) of the Clean Water Act requires States to identify waters not meeting water quality standards, and to apply a Total Maximum Daily Load (TMDL) plan for water-quality limited resources. Since 1991, ODEQ has defined TMDLs for numerous rivers and lakes in Oregon (Oregon Department of Environmental Quality, 2007). National Pollutant Discharge Elimination System (NPDES) permits are required for many activities that discharge stormwater directly to a water body, including runoff from ODOT owned roadways.

ODOT's responsibilities to mitigate potential effects of its roadways according to ODEQ programs and guidelines are of critical importance to their mission. However, ODEQ and ODOT agree that opportunities for mitigating potential effects of highway runoff are limited because ODOT controls a narrow right of way that crosses multiple watersheds and water bodies (ODEQ and ODOT, 2011). Although some guidelines for implementing the TMDLs have been published by ODEQ, both agencies recognize that better methods and technologies are needed to quantify the contribution of contaminants from upstream basins and roads to downstream water bodies. Without new tools, it will be difficult for ODOT and ODEQ to economically implement best management practices (BMPs) that mitigate, and control contaminant sources and their downstream movement. ODOT support for watershed-scale mitigation-banking approaches may provide opportunities to implement mitigation measures that reduce adverse effects of runoff on receiving waters at locations that will maximize treatment, while minimizing the cost of operating and maintaining stormwater BMPs. However, methods are needed to assess the potential contribution of different sources and to evaluate the potential effectiveness of such mitigation measures.
In cooperation with the FHWA, the USGS Massachusetts Water Science Center (MWSC) developed methods for managing highway stormwater pollutant loads and concentrations. Using a Monte Carlo approach, the Stochastic Empirical Loading and Dilution Model (SELDM) estimates combinations of contaminant loads and concentrations from upstream basins and stormwater runoff affecting the water quality of receiving streams (Granato,

2006; Granato, 2008; Granato, 2010; Granato and Cazenas, 2009; Granato and others, 2009). Although SELDM is nominally a highway runoff model, it is a lumped parameter model that can be used to model the quality and quantity of runoff from many land uses. By facilitating scenario simulation and sensitivity analysis, SELDM can determine the potential risk of downstream water-quality exceedances resulting from stormwater runoff.
In a study funded by ODOT and the USGS, SELDM was used to estimate stormflows and hypothetical constituent loadings and concentrations in six western Oregon highway study sites (Risley and Granato, 2014). The upstream watersheds of the sites ranged from 0.16 to 6.56 square miles. Although two of the study sites were in nested watersheds, the other four sites were located in separate watersheds. In this new proposed study, ODOT and the USGS are interested in applying SELDM at multiple locations within a watershed. In watersheds where ODOT has more than a single stream crossing, the contribution of ODOT's stormwater to the watershed's pollutant load is complicated and not always well understood. ODOT's efforts to meet its TMDL obligations in watersheds with multiple crossings could be inefficient and less cost effective than necessary. By applying SELDM in a watershed-scale analysis it will be possible to develop guidance protocol that will help ODOT plan and direct its mitigation strategies at locations where their efforts will have the greatest over all benefit to the watershed.

3.0 Objectives of the Study

The proposed study has three primary objectives:

1. Develop and demonstrate techniques for geographic analysis that use the roadway and land use/land cover information in Streamstats to apply SELDM at selected points in the watershed. These techniques will include manual and batch-processing techniques that can be used to help model contributions of flows, concentrations and loads of stormwater from highway sites and other upstream land uses. These techniques will be used to do mass-balance analyses in selected watersheds with SELDM based on the land use/cover percentages upstream of any selected highway site.

2. Demonstrate methods for using SELDM with statistics on the quantity and quality of runoff from highways and other land uses and BMP treatment statistics to model the cumulative effects of runoff from different areas at different points in a stream basin. These techniques can be used by ODOT to help identify the application of mitigation measures to maximize benefits, while minimizing potential effects of runoff on receiving streams within a watershed, minimizing costs for implementing stormwater BMPs.

3. Create guidance for watershed-scale analyses using SELDM that are based on results and experience learned in the second objective and document this information in at least one report.

3.1 Benefits

The mission of the ODOT is to provide a safe, efficient transportation system that supports economic opportunity and livable communities for Oregonians (Oregon Department of Transportation, 2009). The livable-communities mission is widely recognized as a mandate to support environmental sustainability in planning, construction and operation of the transportation system, which includes management of stormwater from state-owned roadways. Therefore, this study will directly benefit ODOT and other State, local, and Federal entities that are responsible for mitigating the potential effects of stormwater runoff on receiving waters. It will also benefit ODEQ, which is responsible for enforcing Federal clean water standards. ODEQ could potentially use SELDM to identify the best ways to mitigate potential effects of runoff on receiving waters. The study will also benefit USGS, FHWA, and academic researchers involved with improving methods of quantifying the impacts of stormwater runoff on receiving streams.

4.0 Implementation

Modeling results and guidance for future watershed-scale SELDM applications will be presented in a USGS Scientific Investigations Report (SIR) and in possible conference or journal papers. A 30-minute PowerPoint© presentation demonstrating the analysis procedures and a 30-minute PowerPoint© presentation describing an example analysis will be developed for use by the USGS and ODOT.

5.0 Research Tasks

Task 1. Geographic analysis of State roadways and upstream land uses/land covers. In 2015, the USGS in cooperation with ODOT developed state-wide Geographic Information System (GIS) coverages for roadways and selected land covers within the state and added these coverages to the USGS Streamstats application for Oregon. This effort provides land use, land cover, and basin properties anywhere in the state. The USGS will use GIS techniques and the batch-processing capabilities in Streamstats to do geographic analyses to examine the potential effects of State roadways on receiving water quality. Two types of analyses will be done on selected basins in Oregon. In the first set of analyses, drainage areas of different sizes (for example 5, 10, 20, 50 and 100 square miles) on the main stem and tributaries in a large river basin (or basins) will be processed to identify the percentage of land cover for state roads, local roads, natural land covers, cultivated land covers, developed land covers and total impervious areas. In the second set of analyses, the roadway coverages will be used to identify state-owned road crossings within large river basin(s); these locations will be used to delineate upstream basins and obtain land use/land cover statistics and basin properties. These analyses will result in a set of statistics identifying the prevalence of different land use/cover areas in basins of various sizes. The methods for manual and batch processing used in this task will be described with the results of analysis in the final report.
Time Frame: July-November 2016
Responsible Party: PI
Cost: $27,000

Deliverable: Technical Advisory Committee (TAC) kickoff meeting to discuss strategy of selection coordination for Tasks 1 and 2. Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Provide input on site selection and project strategy; review quarterly reports.

Task 2. Select example subbasins for stormwater analyses. In this task the USGS will work closely with ODOT in selecting watersheds within Oregon (fig. 1) that are suitable for study objectives. These watersheds may be actual geographic locations and/or may be hypothetical basins that represent commonly found land use/cover conditions identified in Task 1. Watersheds will be selected to demonstrate the initial dilution-factor analysis process, and a subset of two watersheds will be selected for water-quality analyses with SELDM (Granato, 2014; Risley and Granato, 2014). The selection criteria and simulated basin properties will be described in the final report. If site visits are agreed upon, prior to accessing ODOT right-of-way (ROW), all personnel who will work on ODOT ROW shall complete safety training appropriate to the work to be performed within the ROW. The Project Investigator shall notify Project Coordinator in writing (email accepted) prior to the first day of work within the ROW that all project personnel who will access ODOT ROW have been trained. Until all ROW work is completed, the Project Investigator shall notify Project Coordinator in writing (email accepted) that an active safety training appropriate to the work to be performed within the ROW has been completed by all personnel who will work on ODOT ROW.
Time Frame: August-October 2016
Responsible Party: PI
Cost: $11,700
Deliverable: TAC kickoff meeting to discuss strategy of selection coordination for Tasks 1 and 2. Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Provide input on site selection and project strategy; review quarterly reports.

Task 3. Compute or compile storm precipitation and hydrologic statistics.
Pre-storm streamflow, storm-event precipitation, runoff coefficients, and storm-event hydrograph statistics, which are used as input to SELDM, will be compiled for two study watersheds. These storm statistics can be computed from hourly meteorological and streamflow data measured in the study watersheds if those data are available and reliable. Otherwise, these statistics will be extracted from existing GIS data sets that have already been created for the conterminous U.S. (Granato, 2008; Granato, 2010) and specifically for Oregon (Risley and Granato, 2014).
Time Frame: August-November 2016
Responsible Party: PI
Cost: $6,800
Deliverable: Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Review Task progress in quarterly report.

Task 4. Compile runoff-quality data and statistics for simulating highway-runoff discharges. In this task, the USGS will compile runoff-quality data and statistics for selected

highway-runoff constituents based on the availability and quality of such data. Sources such as the USGS-FHWA highway runoff database (Granato and Cazenas, 2009; Smith and Granato, 2010), the National Stormwater Quality Database (Maestre and Pitt, 2005), and the International BMP database (http://www.bmpdatabase.org/) will be examined for relevant data. A literature search and outreach efforts will also be done in an effort to help identify datasets representative of conditions in the Pacific Northwest and, if appropriate, its major sub-regions. The data and statistics used in the final analyses will be described in the final report.
Time Frame: August-November 2016
Responsible Party: PI
Cost: $6,800
Deliverable: Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Review Task progress in quarterly report.

Task 5. Compile runoff-quality data and statistics for simulating runoff discharges from non-highway land uses. In this task the USGS will compile runoff-quality data and statistics based on the availability and quality of such data. Sources such as the USGS National Water Information System (http://waterdata.usgs.gov/nwis), the National Stormwater Quality Database (Maestre and Pitt, 2005), and the International BMP database (http://www.bmpdatabase.org/) will be examined for relevant data. A literature search and outreach efforts will also be done in an effort to help identify datasets representative of conditions in the Pacific Northwest. The data and statistics used in the final analyses will be described in the final report.
Time Frame: August-November 2016
Responsible Party: PI
Cost: $13,600
Deliverable: Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Review Task progress in quarterly report.

Task 6. Perform preliminary watershed-scale SELDM model runs. Although SELDM is not a watershed model, the mass balance approach that SELDM uses can be applied to assess the effects of runoff from a site of interest and an upstream basin at any point along the stream. SELDM will be configured to do a series of preliminary dilution-factor analyses to assess the contribution of the highway under different upstream scenarios. These results will be used to select water-quality scenarios that reflect the effect of various land uses on stormflow water quality upstream and downstream of highway-discharge points. Separate SELDM runs will be made for the sub-basins of interest in the watershed. For nested sub-basins, the upstream sub-basin runs will be made first. Output from upstream runs will be used as input to the downstream runs.
Time Frame: December 2016
Responsible Party: PI
Cost: $17,800
Deliverable: Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Review Task progress in quarterly report.

Task 7. Simulate the potential effectiveness of stormwater mitigation methods for reducing the risks for water-quality exceedances. Simulations will be done with and without application of flow reduction, hydrograph extension, and concentration reductions by stormwater BMPs for the highway sites and aggregated upstream land-use areas. Representative statistics documented by Granato (2014) will be used to simulate the effects of several commonly used stormwater BMPs.
Time Frame: January-March 2017
Responsible Party: PI
Cost: $14,000
Deliverable: Update Task progress in standard ODOT Research quarterly report.
ODOT Action or Decision: Review Task progress in quarterly report.

Task 8. Create guidance for conducting watershed-scale SELDM applications. Both ODOT and the USGS will meet and assess modeling results and experiences learned in tasks 1, 2, and 7. The assessment will be used to formulate practical guidance for watershed-scale SELDM applications on watersheds with multiple highway stream crossing sites.
Time Frame: February-April 2017
Responsible Party: PI
Cost: $17,600
Deliverable: Meetings with USGS, ODOT TAC, and other ODOT interested parties.
ODOT Action or Decision: Review and approve guidance.

Task 9. Write a report describing watershed-scale SELDM results and guidance. Data sets, model results, and guidance for SELDM analysis will be included in a USGS Scientific Investigations Report (SIR) publication to be completed at the end of the study.
Time Frame: March-July 2017
Responsible Party: PI
Cost: $28,000
Deliverable: Final report and final report TAC recommended revisions if necessary.
ODOT Action or Decision: Review report. Provide formal acceptance of report.

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6.0 Time Schedule

									Oregon Fiscal Year 2016-17														
	Federal Fiscal Year 2016											Federal Fiscal Year 2017											
Description	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**
Task 1. Geographic analysis of State roadways and upstream land uses/land covers.										■	■	■	■	■										
Task 2. Select example subbasins for stormwater analyses.											■	■	■											
Task 3. Compute or compile storm precipitation and hydrologic statistics.											■	■	■	■										
Task 4. Compile runoff-quality data and statistics for simulating highway-runoff discharges											■	■	■	■										
Task 5. Compile runoff-quality data and statistics for simulating runoff discharges from non-highway land uses.											■	■	■	■										
Task 6. Perform preliminary watershed-scale SELDM model runs.															■									
Task 7. Simulate the potential effectiveness of stormwater mitigation methods for reducing the risks for water-quality exceedances.																■	■	■						
Task 8. Create guidance for conducting watershed-scale SELDM applications.																	■	■	■					
Task 9. Write a report describing watershed-scale SELDM results and guidance.																		■	■	■	■	■		

7.0 Budget Estimate

Breakdown by Federal fiscal year (Oct. 1 to Sept. 30) and agency:

	FY 2016	FY 2017	Total by agency
USGS (35%):	$20,565	$36,561	$57,126
ODOT (65%):	$38,193	$67,898	$106,091
Total by FY:	$58,758	$104,459	**$163,217**

Breakdown by category:

Description	Budget
Task 1. Geographic analysis of State roadways and upstream land uses/land covers.	$27,035
Task 2. Select example subbasins for stormwater analyses.	$11,773
Task 3. Compute or compile storm precipitation and hydrologic statistics.	$6,827
Task 4. Compile runoff-quality data and statistics for simulating highway-runoff discharges	$6,827
Task 5. Compile runoff-quality data and statistics for simulating runoff discharges from non-highway land uses.	$13,654
Task 6. Perform preliminary watershed-scale SELDM model runs.	$17,843
Task 7. Simulate the potential effectiveness of stormwater mitigation methods for reducing the risks for water-quality exceedances.	$13,999
Task 8. Create guidance for conducting watershed-scale SELDM applications.	$17,577
Task 9. Write a report describing watershed-scale SELDM results and guidance.	$27,966
Total labor	**$143,501**
Travel--Site visits	$4,359
Software purchase	$436
Training	$4,023
Report publication	$10,898
Total project costs	**$163,217**