MANAGEMENT OF RUNOFF FROM SURFACE TRANSPORTATION FACILITIES

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ABSTRACT

This project, which is funded by the National Cooperative Highway Research Program, includes both a synthesis of current information and a plan to guide future research. The issues to be studied include regulations and permitting, runoff water quality characteristics, best management practices, receiving water impacts, and habitat impacts.

The tasks include a detailed review of existing information plus digitization of key information and software development to identify gaps in the current state of knowledge. A nationwide survey of experts will assist in identifying existing information.

After the information has been scanned to identify gaps, the team will identify and prioritize future research to fill the gaps. This research plan will then influence future NCHRP funding on highway runoff research projects.

INTRODUCTION

One technical problem in evaluating research needs is the wide dissemination of "all" information despite the existence of various syntheses concerning specialized areas related to runoff. The objective is to get all the significant information in a single location, have a process to continuously update it with the most current research findings, and make it easily accessible to all potential users. This technical problem lends itself to an electronic data management solution.

Regarding literature on the transportation runoff technical problem: we have known for decades about and consider Professor Robert Sylvester's 1972, Washington State Highway Department Research Report No. 7.1, *Character and Significance of Highway Runoff Waters*, to be a forerunner of present concerns. A look at this work to support this project reinforces the thought that this is a truly excellent early report on the nature of road runoff waters.

- The runoff quantity and quality is changed over the natural from the same area due to the impervious surface and drainage systems, emissions from passing vehicles, the erosion or solution of substances from the road materials and from de-icing substances. Vehicle emissions include oil and grease, dirt, wear or parts and tires, litter, and the additives to fuel, and heavy metals, particularly lead.
- A significant portion of the potential substances emitted along a highway are from the vehicle exhausts. Present data indicate that a major portion of this is swept off the road surface area to later deposit along the roadside or to be carried away by air currents. Those fractions deposited on a right-of-way soil surface are probably largely retained in the soil although there is no specific evidence to corroborate this hypothesis other than the large amounts of lead that have been found in the soil adjacent to highways.
- Substances found in highway runoff are similar in type and quantity to those found in storm water runoff from urban areas for the usual parameters measured: oil nutrients, solids, COD, BOD and coliform bacteria. Preliminary data on heavy metals show a higher concentration in highway runoff.
- The quantity and quality of substances washed from a roadway is primarily a function of the number of vehicles passing, their speed, the number of dry days preceding a given rainstorm and the quantity of rainfall. (Technical Note: although logical, Sylvester's notion that water quality is related to ADT and speed has been difficult to substantiate. Barriers to substantiation are the high costs of securing representative samples in a sound experimental design and the lack of a national cross section of data. This is reflected in the fundamental difference between the 1981 FHWA highway stormwater runoff methodology and the 1990 methodology that replaced, it, namely the manner in which the influence of traffic density is addressed. The 1990 methodology significantly differs from the previous one in that the impervious surface area of the roadway is an important factor in the predictive equations primarily because it influences the runoff

volume from a storm event. Site-specific ADT is a key variable in the predictive equations of the 1981 methodology. However, the FHWA research for the 1990 method indicated that pollutant loadings are not dependent on ADT. A statistically significant difference between the pollutant discharge of urban highways (ADT greater than 30,000 vehicles per day) and rural highways (ADT less than 30,000 vehicles per day) was found, and it was concluded that ADT should be used only as an indicator to distinguish between urban and rural highways. However, current research at the University of Cincinnati and at GKY&A is attempting to reveal logical cause and effect between ADT and water quality.) The first flush from a rainstorm contains the largest concentration of pollutants which then diminish logarithmically as the rainstorm continues.

- In general, a reduction in the pollutants from highway runoff could be accomplished through: a) minimal use of de-icing chemicals; b) reduction in the additives to gasoline, particularly lead; c) more frequent surface sweeping and the development of better cleaning methods; d) better control over truck traffic to minimize spills; and e) runoff water treatment.
- In certain limited problem areas, sedimentation basins can be constructed to remove floatables (including oil) and settleable solids. A significant fraction of the heavy metals, oil and nutrients would be removed as they apparently are adsorbed to dust and dirt fractions.

Present day highway water quality issues and technologies are assembled and presented in the synthesis report prepared by GKY and Associates, Inc., with Mr. Fred Bank as FHWA COTR, *Evaluation and Management of Highway Runoff Water Quality*, FHWA 1996. This 480-page report has a focus on highway runoff water quality mitigation using Best Management Practices. This work included questionnaires to SHA practitioners and site visits to states.

A number of research problem statements on management of runoff have recently appeared, and collectively they have perplexed and confounded rational choice of which problem merits attention first, and of what should be done next – in short, how do you prioritize the diverse interests of states and TRB committee recommendations? The interests and recommendations overlap with regional differences coming to play to generate slightly different versions of the same need. What sets this research project apart from previous information syntheses on the subject is the objective of identifying and prioritizing research needs with an anticipation of future needs.

The objectives of this present effort, 25-20, as paraphrased from the problem statement are to:

1. Generate a useful, synthesized product for immediate usage.
2. Provide a strategic research plan to fill gaps in knowledge.
3. Set up a medium for information exchange.

TECHNICAL APPROACH

Task 1. *Prepare a comprehensive listing of topic areas appropriate for a synthesis of knowledge and practice and for a strategic research plan.*

The subject of runoff from surface transportation facilities encompasses a wide range of issues. The Transportation Research Board has identified research needs with regard to runoff quality and quantity in the past. The NCHRP panel identified topic areas that are relevant to the data synthesis and we edited and added to this list. We addressed the complex issues related to the impacts and management of highway runoff during construction, operation, and maintenance phases with studies that have involved surface water and groundwater impact assessments, watershed and ecosystem based analyses, and the development of management plans to implement project-appropriate best management practices and mitigation strategies.

The major headings on the comprehensive list are as follows:

- Water quality assessment;
- Habitat assessment;
- Biological/ecological assessment
- BMPs;
- Information systems and technology exchange;
- Systems planning;
- Constraints and regulations;
- Stormwater hydrology and hydraulics;
- Constituents and loadings; and,
- Groundwater.

Each of these major headings had several subheadings to focus attention.

As part of this task, we identified and secured the "top ten" public domain reports to form the backbone of our knowledge base. The following is a listing of these documents:

- Federal Highway Administration, "Ultra-Urban Best Management Practices." Office of Environment and Planning, Washington, DC (October 1999).
- Federal Highway Administration, "Evaluation and Management of Highway Runoff Water Quality." Publication No. FHWA-PD-96-032 (June 1996).
- Horner, R.R., Skupien, J.J., Livingston, E.H., and Shaver, H.E., "Fundamentals of Urban Runoff Management: Technical and Institutional Issues." Chapters 3, *Aquatic Impacts of Urban Land Use*, and 6, *Biological Community Assessments* (August 1994).
- Northern Virginia Planning District Commission, "Nonstructural Urban BMP Handbook" (December 1996).
- Terrene Institute, "Riparian Road Guide, Managing Roads to Enhance Riparian Areas," Washington, DC (1994).
- U.S. Environmental Protection Agency, "Rapid Bioassessment Protocols for Use in Streams and Rivers," Draft (October 21, 1998).
- U.S. Environmental Protection Agency, "Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters," Chapter 4, *Management Measures for*

Urban Areal, Section VII, Roads, Highways and Bridges, Report Number 840-B-92-002 (January 1993).

- U.S. Environmental Protection Agency, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Part 1." EPA-600/6-82-004b (September 1982).
- U.S. Environmental Protection Agency, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Part 1." EPA-600/6-82-004a (September 1982).
- U.S. Environmental Protection Agency, "Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants, Part 2." EPA-600/6-82-004b (September 1982).
- Watershed Management Institute, Inc., "Institutional Aspects of Urban Runoff Management: A Guide for Program Development and Implementation," Washington, DC (May 1997).
- Annotated Bibliography (192 citation; 1994 through 1999).

Task 2. *Critically review published and unpublished literature, databases, and information systems to identify the present states of practice and knowledge related to the topic areas identified in Task 1. Consider research carried out by NCHRP, FHWA; EPA; AASHTO (namely, the Environmental Technical Assistance Program--ETAP); the U.S. Navy; other federal, state, and local agencies; and universities. Synthesize the relevant findings in a form that is useful for planning, designing, constructing, and maintaining transportation facilities. Prepare an annotated bibliography and identify shortcomings, weaknesses, and gaps in understanding.*

We digitized the top 10 documents and developed a knowledge base CD with the documents which includes extensive search capabilities. A practitioner can search for a topic area, and the software will return a listing of all pages within all of the documents which include the topic ranked by number of number of instances the topic was found within the page.

Identification of knowledge gaps followed two methodologies: 1) an analysis of the knowledge base and annotated bibliography, and 2) a survey of practitioners.

Knowledge Base Analysis

The team used the CD to identify gaps in existing knowledge by analyzing the context within which keywords occur in the knowledge base and the content of the annotated bibliography.

Practitioner Survey

Transportation practitioners were surveyed to confirm the preliminary information gaps and to identify new ones. Officials from transportation organizations and environmental review agencies involved with transportation facility runoff issues from all regions of the country were contacted, including:

- State Departments of Transportation
- State Highway Authorities
- Metropolitan Planning Agencies
- Federal Highway Administration
- Transportation Research Board Committee Members
- TRB Environmental Research Needs Report Participants
- U.S. Environmental Protection Agency
- U.S. Army Corps of Engineers
- U.S. Fish and Wildlife Service
- U.S. Department of Interior
- U.S. Coast Guard
- U.S. Navy
- National Oceanic and Atmospheric Administration

The survey was posted to a website for quick and easy submission. The survey indicated that ecological issues, receiving water impacts, data collection, and information transfer are perceived to have gaps in the current state of the practice.

The CD will also be utilized to generate information about gaps and shortcomings in the major categories: System and Project Planning, Constituents, Stormwater Hydraulics, Assessment Methods (Water Quality, Habitat, Physical), Groundwater, BMP (Design, Maintenance, Nonstructural, Performance, Selection, Other), Information Exchange, Social Issues, and Regulations. Team members accessed the knowledge base on CD and evaluated gaps and needs.

These collective efforts generated a task report identifying shortcomings, weaknesses, and gaps in understanding in the knowledge base.

Task 3.*Identify present sources and levels of funding for current research relevant to the management of runoff, and assess each source's potential in continuing this activity. (This information will be used by the NCHRP and others to determine opportunities for partnering in future research efforts.)*

Our team contacted key people and agencies to secure information. The web was a n excellent source of information on funding sources.

Task 4.*Develop a draft strategic research plan. The plan shall include a prioritized program of serial and concurrent research to meet the critical and important needs related to runoff management. Individual projects shall be described with a title, brief scope and objective, and estimated costs and time.*

Typical NCHRP problem statements have a Phase I (6 months, $50,000) and a Phase II (24 months ±, up to $400,000) component. We will use this format. Draft problem statements were developed and prioritized. A precedence diagram was provided to show which problems require completion prior to initiation of other problems and which problems can be concurrent.

A barrier in the water quality area is the high cost of chemistry associated with representative cross sectional studies. You can sample one, two, or three sites, but it is very difficult to sample a representative number of sites (say 10 to 20) and remain within a $450,000 project budget. This is a huge barrier to good science.

Consequently cross-sectional studies need to be broken apart to facilitate funding or the goal of representative samples is abandoned in favor of very selected sampling with extrapolation using mathematical models. However, models are not well integrated into habitat and ecologic impact studies which are still largely descriptive. This difficulty must be addressed in this prioritized program and suggested practical pathways to good science specified – even if the cost is necessarily high. As a precedent, the high costs of bridge scour studies are being handled by multi-year programming.

Task 5. *Within 6 months of contract initiation, submit draft report no. 1 that includes the results of Tasks 1 through 4. The Task 2 synthesis and Task 4 research plan will each be included as stand-alone appendices. Research will be suspended for approximately 1 month to allow for panel review of the report before Task 6.*

The deliverable will be a summary report describing what the team did and the supporting justifications, a prioritized research plan (skeletonized as specified in Task 4), and the CD containing the knowledge base accessible using Windows Help/Internet Browser technologies.

Task 6. *Participate in a 2-day contractor-panel meeting to discuss and refine draft report no. 1. (Likely sites for the meeting will be the National Research Council facilities in Washington, DC or Irvine, CA. The NCHRP will provide the facility and cover the costs for the travel and subsistence of the responsible project panel.)*

We will present the problem statements and justifications in order of priority thought most likely to elucidate consensus from the panel. Discussions and votes can be used, if necessary, to adjust the order. Total consensus may not happen (almost certainly will not) and minority opinions will be documented.

Task 7. *Based on the contractor-panel interaction, produce draft report no. 2.*

The diverse panel undoubtedly will make their technical knowledge and preferences known during the Task 6 meeting and by return of comments on the draft report. The problem statements will be redrafted with sufficient detail to be sound, scientific NCHRP problem statements to be considered and hopefully endorsed by the AASHTO Standing Committee on Research and by the TRB staff, State Program Coordinators, and by in-house research decisions of FHWA and other federal agencies. The result of this task will be a draft for widespread dissemination to secure more feedback in Task 8.

Task 8. *In cooperation with NCHRP staff, disseminate the synthesis and strategic research plan portions of draft report no. 2 to state DOTs and other interested organizations to obtain input and determine interest in partnering and financing portions of the research plan. Consider the*

input and revise the draft report accordingly.

State DOTs will receive the Task 7 draft and the knowledge based CD for study and feedback. A discussion area will be set up on the GKY&A web site to facilitate comment. The information on the CD could also be hosted on the GKY&A web site to secure a wider audience.

Key people approached in Task 3 will be called for discussion and feedback.

Task 9.*Analyze the feasibility of creating an electronic repository and exchange system for information on management of runoff from surface transportation facilities. Contact potential organizations with the capability and interest to sustain such an effort and evaluate cost and financing strategies. Recommend options for further consideration in the implementation of the system.*

A database accessible on the World Wide Web would permit regional and national studies to be conducted and would provide investigators with easy access to information outside their state or municipal boundaries. Also, information on stormwater management effectiveness could be shared by agencies, and monitoring data at similar sites could be shared to reduce the cost burden of complying with the regulations. Development of a structure and a method to manage the data would facilitate dissemination of the correct information and acceptance of new data from varied sources. The site could provide a means to share data and to have quality control and to partially overcome the budgeting problems associated with water quality sampling data acquisition on a representative national scale.

CONCLUSIONS

The objective of this project is to generate a prioritized plan for future research. This plan will have five integrated features:

1. NCHRP formatted problem statements.
2. Estimated budgets per statement in amounts consistent with typical funding.
3. A prioritization of the statements.
4. A sequencing schedule that includes suggestions as to which projects can proceed in parallel and which in series.
5. A list of potential implementation partners.

Additional products that support the research plan will have immediate value to practitioners:

1. A knowledge base that can be accessed by key words and phrases to point transportation planners and engineers to information that is useful for specific issues concerning the management of runoff from surface transportation facilities.
2. A web page that will permit communication of the knowledge base and the research plan to practitioners and provide for continuing information exchange among practitioners.