The Rhode Island
Stormwater Management and Treatment Demonstration Facility
(RI SDF)

A Joint-Proposal

Submitted by

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Introduction

Numerous reports/studies have concluded that urban roadways contribute large amounts of suspended solids/sediment, heavy metals, petroleum hydrocarbons, deicing chemicals, bacteria and other constituents to receiving waterways. The EPA National Urban Runoff Program (NURP) indicated that lead, zinc and copper were the pollutants most likely to be found in urban stormwater runoff. The occurrence of toxic heavy metals from Rhode Island highways, verified in a report completed by Thiem, Bade & Alkhatibe in 1998, showed that cadmium, chromium, copper, lead, nickel and zinc exceeded EPA's acute and/or chronic water quality criteria. Besides toxic metals, stormwater also contains petroleum hydrocarbons, nutrients, and microbial matter as well as many other chemical compounds (Goebel et al., 2007). These toxic stormwater constituents are easily washed into water bodies, causing a decrease in overall stream diversity. In addition, toxic compounds often bind to soil particles and, upon entering drainage and runoff treatment structures, have to be removed and safely disposed of.

As a result of efforts to comply with local and national stormwater quality discharge standards as well as current regulations for environment protection, the Rhode Island Department of Transportation (RIDOT) has installed many structural Best Management Practices (BMP's) in an attempt to lessen pollutant loads to receiving waterways. For instance, between 1997 and 2007 more than 70 hydrodynamic separator units were installed by RI DOT. The selection of the various, commercially available BMP systems relies mostly on unverified manufacturer's data or is based on performance reports from other parts of the country where local environmental conditions are much different than those in Rhode Island. In general, there is insufficient data for science-based selection of the most appropriate BMP for addressing specific applications in Rhode Island. The focus of this joint-proposal is on providing RI DOT and the URI transportation community with a new facility where BMP structures can be evaluated against the manufacturer's claims and under environmental conditions prevailing in our state. This facility will be known as the "*Rhode Island Stormwater Management and Treatment Demonstration Facility*" (RI SDF).

This proposal is organized around three tasks. Task I revolves around the set-up of the RI SDF facility. Task II focuses on the contaminant removal efficiencies of several commercial hydrodynamic separator/water quality (WQ) units, while the Task III seeks to evaluate the performance of both pervious concrete amended with organo-soils as well as a tree-box filter. Task II and III will be the first projects to take advantage of the newly built RI SDF site.

In the following we describe each task's goals and objectives, the work plans and the work schedule, including the deliverables. Each task description is followed by a budget and budget justification. The project supports two URI graduate students. Task I and II are proposed directly to RI DOT, while Task III is proposed to the URI Transportation Center. The overall amount of funding requested from RI DOT is $176,127 and $74,377 from URI TC. While Tasks II and II have a one year project horizon, we view Task I as a long-term commitment. That is, in the future, we seek support from RI DOT/URI TC to operate the RI SDF facility for the three years following the set-up of the facility. Afterwards we expect to support RI SDF with fees and revenues generated from testing BMPs and other structures for commercial customers.

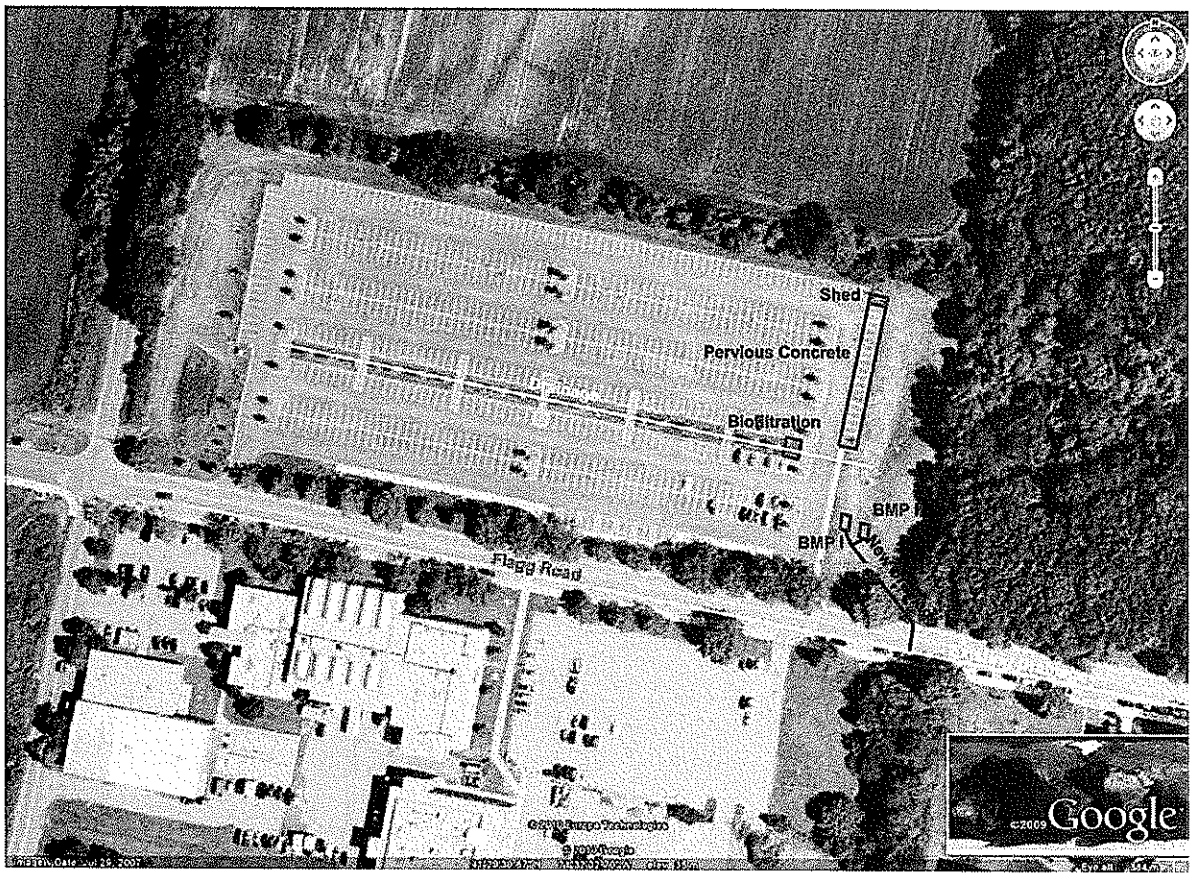

Figure 1: Schematic of the proposed stormwater management and treatment demonstration facility (RI SDF) on the URI campus in Kingston, RI. There are two drainage systems to which BMPs can be connected to either treat the runoff generated on the surface of the parking lot (yellow) or from Flagg Road (red). Shown are the tentative locations for the hydraulic separator (BMP I, Task I) and the pervious pavement (Task II). Also shown are the tentative locations of other treatment structures, such as a biofiltration unit and another BMP.

TASK I: Instalation of Stormwater Management and Treatment Demonstration Facility

(Lead: Boving; all others assist)

Goals and Objectives: Under *Task I*, we will set-up a demonstration facility for testing innovative stormwater treatment systems and best management pratices on the URI Kingston Campus. This facility will be known as the "*Rhode Island Stormwater Management and Treatment Demonstration Facility*" (RI SDF) and will provide the test grounds for evaluating commercial or innovative in-situ best management practices (BMP). Such a facility is needed in Rhode Island because it will enable testing and demonstration of BMPs and novel strategies for the effective treatment of the stormwater runoff under conditions prevalent in Rhode Island. The RI SDF ties into an existing catch basin structure (Figure 1), which permits direct comparison of this conventional treatment approach to other more innovative ones to be tested at this new installation. Task II (hydraulic separator/WQ unit) and Task III (permeable concrete) are the first projects to be implemented. In additon, one company has already requested to install an innovative BMP systems for treating stormwater runoff at RI SDF.

Work Plan: The RI SDF will focus on the treatment of suspended solids, toxic metals and petroleum hydrocarbons, nutrients and other relevant water quality parameters. Special emphasis will be paid to investigating the "first flush" performance, i.e. the runoff resulting from the first inch of rain, long-term performance monitoring, and seasonality in BMP performance include extreme weather conditions. The data generated by RI SDF can, for example, be used to address *Phase II* requirements. In addition, RI SDF will eventually promote research focused on exploring the potential reuse of treated stormwater for domestic, agricultural and commercial uses and generic water resources protection. URI researchers will independently evaluate BMP systems based on parameters such as:
Implementation, operation, and maintenance: simple, sustainable solutions that do not requiring massive maintenance are preferred.
Scalability and transferability: systems ideally can be used at different scales from residential to commercial.
Resiliency: systems must be able to survive and perform well under severe conditions (e.g. hurricanes, flooding, snow and ice, changing weather patterns).
Materials: most of the construction materials should be produced using "green engineering" principles to minimize environmental impact and enhance sustainability.
Cost: implementation, operational, and disposal cost associated with the technologies have to be known.
RI SDF will be located on the URI, Kingston Campus – adjacent to a parking lot on Flag Road. We have already obtained a letter from URI that supports this project and the proposed test site location. This site was selected because minimal construction is required to prepare the site for our purposes.

Site Characteristics: By tying into the existing drainage system (Figure 1), the runoff water from an existing parking lot will be used to conduct all tests. In addition, we propose to connect the Flag Road storm runoff drainage system to the site. This will provide us with even greater flexibility in conducting our tests, plus it may provide a secondary runoff stream with slightly different chemical characteristics. The runoff water will feed one or more treatment units (see Task II and III), allowing a direct performance comparison of treated versus untreated runoff quality. Dedicated sample ports at the influent and effluent sides together with ports inside the treatment unit(s) will provide the data needed for performance evaluation. Whenever possible, on-site probes and loggers will be used to guarantee semi-continuous data collection. Monitoring construction and operating cost together with maintenance requirements will provide BMP specific cost data. The closeness to our URI laboratories ensures quick analysis turnaround times and provides our students with important field experience.

Work Schedule and Deliverables: This a one-year project. Project activities will begin immediately upon funding of the project. We are currently applying for RI SDF set-up cost (Task I). We will submit a separate budget for the following year of operation at a later time.

TASK I: Set-Up of proposed URI/RIDoT Testing Facility

Leader : Boving, URI - CVE/GEO

Proposed Start: Summer 2010
Project Duration: 1 year

		No. of Units	Cost per Unit	Total Cost
1. Personnel				
Dr. Boving (0.75 month summer)		0.75	$10,602	$7,951
	Total:			**$7,951**
2. Benefits				
None		0	$0	$0
	Total:			**$0**
3. Operational				
None		0	$0	$0
	Total:			**$0**
4. (Fabricated) Equipment				
Field testing equipment (loggers, samplers, computer etc)		1	$15,000	$15,000
Consumables (pipes, wire, etc)		1	$4,500	$4,500
	Total:			**$19,500**
5. Travel				
none		0	0	$0
	Total:			$0
5. Other				
Outreach and Advertisement of new test site		1	$1,500	$1,500
Site design and installation (subcontract)		1	$30,000	$30,000
	Total:			**$31,500**
Total Cost				**$58,951**
Indirect Cost (25% rate				**$8,613**
***25% on first $25,000 of subcontract**				
	Total Project Cost			**$67,564**

Justification for Start-Up Budget

The start-up budget covers the cost of setting up the RI SDF demonstration site on the URI campus and preparing it for Task II and III. We have identified an area adjacent to the parking lot on Flag Road across from the URI Purchasing Office building as the tentative site. The amount of $19,500 is requested to design, install, and equip the demonstration site with monitoring and testing equipment, incl. landscaping, fencing, and shelter. We plan to subcontract some or all site design and installation activities ($30,000). The installation of the BMP test units is covered under Tasks II and III, respectively. PI Boving requests 0.75 month of summer salary to supervise the set-up of the demonstration facility. The amount of $1,500 covers outreach and advertisement activities to inform potential RI SDF site users of its existence and capabilities. An indirect cost rate of 25% applies to all expenses except fabricated equipment over $5,000. 25% overhead is charged by URI on the first $25,000 of subcontract.

TASK II: Field Performance Testing of Hydrodynamic Separator Unit

(Lead: Thiem; all others assist, incl. DeRotto).

Goals and Objectives: The objective of Task II is to investigate the overall performance of a commercial hydrodynamic separator (Vortechs® or similar) and potentially an ADS Water Quality Unit (as manufactured by Advanced Drainage Systems, Inc.). This study will be performed on the new *Rhode Island Stormwater Management and Treatment Demonstration Facility* (RI SDF). Hydrodynamic separators are designed to treat stormwater runoff by capturing floatable debris, oil & grease and reducing Total Suspended Solids (TSS) concentrations. ADS WQ Units work on the principles of water treatment i.e. settling chambers are incorporated into the design, removing a percentage of particles in the process. Under the Phase II program, each State develops a stormwater management plan for regulating pollution to receiving waterways. Our goal is that the information obtained from this study will assist RIDOT in assessing the Hydrodynamic Separator performance /effectiveness on the background of current and future stormwater discharge policies developed by the Rhode Island Department of Environmental Management (RIDEM) and Coastal Resources Management Council (CRMC). Also, this project will compare our results with manufacturer's documented data for similar storm events (to the extent practicable). Based on the field performance data and review of the pertinent literature, we will make recommendations to RIDOT whether hydrodynamic separator/WQ unitis suitable for environmental applications typical for Rhode Island. The Technology Assessment Protocol – Ecology (January, 2008) ("TAPE"), The Technology Acceptance Reciprocity Partnership (updated July, 2003) ("TARP"), Urban Stormwater BMP Performance Monitoring (ASCE, April, 2002) and APPENDIX J of the RI Stormwater Design and Installation Standards Manual will be used as guidance for the proposed BMP field testing.

Work Plan: Recommendations from other "stormwater treatment unit" studies include (a) the need for measuring sediment accumulations within the units to determine if previously captured pollutants were retained (or not), (b) considering standards other than "80% TSS removal", which cannot be precisely confirmed and (c) the need to characterize the whole range of contaminants in runoff, accounting for rainfall intensity, antecedent conditions, particle sizes, traffic volumes, impervious areas and flow (Barbaro, 2001). These studies also suggest that source control measures such as catch basin cleaning; street sweeping; the use of more efficient maintenance equipment; reducing the amount of sand used in winter operations and public programs (e.g. litter pick-up) should not be overlooked. This project will make a concerted effort to address most of these recommendations. This project will also provide training for employees of RIDOT and URI students in stormwater management. The results from this project will be disseminated by publication of these results in an appropriate journal as well as presentations at conferences and seminars.

A commercial hydrodynamic separator as well as an innovative water quality unit will be installed on or immediately adjacent to the RI SDF site. EPA's "Environmental Technology Verification Program" (ETV) and the "Stormwater Best Management Practice Demonstration, Tier II Protocol for Interstate Reciprocity" that has been endorsed by California, Massachusetts, New Jersey, Pennsylvania and Virginia, are two protocols that we will apply to the performance verification of the hydrodynamic separator. We will use these protocols as guides only, i.e., evaluation of the hydrodynamic separator will be based on a minimum of six (6) rainfall events having at least 0.25 inch of total rainfall and a minimum inter-event period of at least 6 hours. Preference will be given to intense storms that generate more than 0.25 in of rain. After meeting the requirements of a rainfall event (through rain gauge monitoring), influent and effluent flow-weighted (and, perhaps, time-proportion for comparison) samples will be collected from the unit and will be analyzed for the targeted pollutants (e.g. total cadmium, total copper, total iron, total lead, total zinc and total suspended solids TSS). EPA approved analytical and QA/QC methods will be closely followed. Sediment sampling (grab samples) will be conducted to provide typical particle-size profiles. Incidental information including, but not limited to, weather, inspection and maintenance of the units as well as monitoring equipment malfunction shall also be documented.

Work Schedule and Deliverables: Task II will completed within one year (see timeline below). The performance testing begins after the hydrodynamic separator unit has been installed and found fully

functional. Due to the nature of wet weather sampling, i.e., required antecedent dry period, rainfall duration and intensity, sampling dates cannot be predicted far in advance. Testing for three months is covered under this project. Subsequent testing will be conducted under a second year grant. Overall, the sampling of rainfall events in the summer months as well as the winter months are planned to highlight differences in water quality.

TASK II: Field Performance Testing of Hydrodynamic Separator Unit

Leader : Thiem, URI - CVE

Project Start: Summer 2010
Project Duration: 1 year

		No. of Units	Cost per Unit	Total Cost
1. Personnel				
Graduate Research Assistant				
Academic Year (Sept through May)		1	$14,924	$14,924
Summer (50%)		0.5	$11,608	$5,804
Supervisors				
Dr.Thiem (0.75 month summer)		0.75	$9,890	$7,417
	Total:			**$28,145**
2. Benefits (exempt from indirect cost)				
Graduate Research Assistant				
Summer FICA (June through Aug)*		1	$888	$888
Health Insurance and fees		1	$1,269	$1,269
	Total:			**$2,157**
3. Operational				
Consumable field and lab supplies (incl. lab analysis)		1	$46,570	$46,570
	Total:			**$46,570**
4. Equipment				
None		0	$0	$0
	Total:			**$0**
5. Travel				
Out State (Conferences)		1	$2,500	$2,500
	Total:			**$2,500**
6. Tuition (exempt from indirect cost)				
Graduate Research Assistant (In-State)		1	$9,887	$9,887
	Total:			**$9,887**
Total Project Cost (per year)				**$89,259**
Indirect Cost (25% rate; per year)				**$19,304**
	Total			**$108,563**

Task II Budget Justification

The overall amount requested from RIDoT is $108,563. The budget covers a stipend ($14,924 AY and $5,804 50% summer) and in-state tuition ($11,608) plus health benefits and fees ($2,157) for one graduate student. PI Thiem requests 0.75 month of summer salary to supervise the project ($7,417)

Under Operational, the amount of $46,570 is requested to plan for and install a commercial hydrodynamic separator on the RI SDF site, purchase consumable field and lab supplies, and for testing water and other media. $2,500 is requested for out of state travel and conference participation. An indirect cost rate of 25% applies to all expenses except tuition and benefits.

TASK III: Pervious Concrete for Enhanced Pollutant Removal

(Lead: Craver, all others assist,)

Goals and Objectives: The focus of Task III is on the development and study of enhanced pervious concrete system at different scales (laboratory and pilot scale). This study will be performed on the new *Rhode Island Stormwater Management and Treatment Demonstration Facility* (RI SDF). Pervious materials are an alternative to impermeable surfaces – especially as an effective method of stormwater runoff control. Organically modified clays promise to further enhance the pollutant removal efficiency of these pervious materials. Because of its benefits in controlling stormwater runoff and pollution prevention, pervious concrete amended with organo-soils has the potential to help earn a credit point in the U.S. Green Building Council's Leadership in Energy & Environmental Design (LEED) Green Building Rating System (Sustainable Sites Credit 6.1), increasing the chance to obtain LEED project certification. The specific objectives are (1) evaluate at laboratory scale the potential use of organically modified Rhode Island soil to enhance the effectiveness of pervious concrete for the removal of organic and inorganic compounds dissolved in urban stormwater runoff and (2) create an educational facility for local schools visits and support courses at URI. This project will provide new information regarding the enhancement of the pollutant load attenuation in stormwater runoff in parking lots, local roads and sidewalks under conditions typical for Rhode Island, including extreme loading and weather conditions

Work Plan: The objectives will be achieved in three stages (1) laboratory testing, (2) field performance study on the RI SDF site, and (3) report preparation. Our preliminary data proves the potential of organo-soil for the simultaneous removal of heavy metals and volatile organic compounds. Compared to natural clays, organo-soils are organo-philic and increase the sorption capacity for relatively non-polar organic solutes [1, 2]. To our knowledge, no other study has used organo-soil to improve the pollutant removal efficiencies of pervious concrete systems.

During the first stage, we will synthesize two organo-soils from local clay, using two quaternary ammonium compounds: HDTMA bromide [$(CH_3)_3NC_{16}H_{33}Br$] and BTEA chloride [$(C_2H_5)_3NCH_2C_6H_5Cl$]. The organo-soils will then be brought in contact with synthetic stormwater runoff having representative average concentrations similar to that of RI SDF runoff. We will build a plexiglass chamber (Fig. 2) to determine the removal performance of pervious concrete with and without soil amendment. On the top of the chamber a series of sprinklers will produce artificial rain to generate the synthetic stormwater runoff. This small-scale system permits easy modification of the structural components and the environmental conditions, such as runoff temperature. The performance of the systems will be evaluated in term of BOD, Nitrate, Lead , PAH, and mineral oil hydrocarbons. During the second state, field tests will be performed on a pervious concrete system build by Massachusetts Concrete & Aggregate Producers Association (MaCapa) on the RI SDF (URI Kingston Campus).

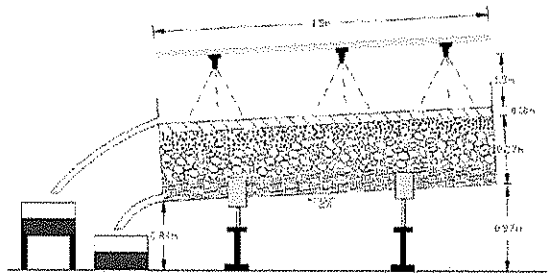

Figure 2. Scheme of the pervious concrete chamber. System components are (bottom to top) subgrade soil, organo-clay, gravel base, and pervious concrete.

Figure 1 depicts the planned location of the pervious concrete test system. The dimension of the system is 21x160 ft (3,360 sqft). The field test system will have several samples points to collect permeate for performance assessment and will be designed based on the previous lab research findings. Design consideration will follow recommendations from manufacturers and research developed at the University of New Hampshire Stormwater center. Figure 3 presents a cross-section detail of a typical pervious pavement faciliti

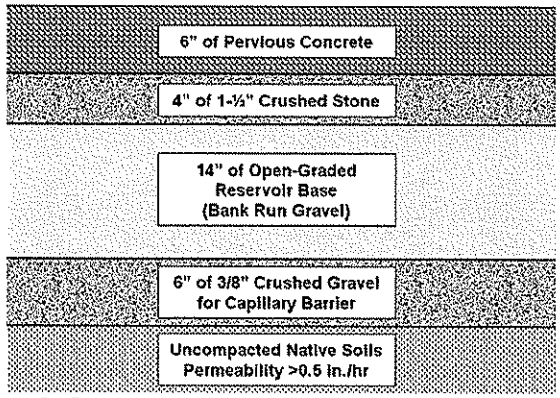

Figure 3. Cross-section area of the pervious concrete facility

Work Schedule and Deliverables: This is a one year project. The pervious concrete system will be build during the summer of 2010. During Fall, we will prepare organo-soils and start tests using the pervious concrete chamber without organo-soil, followed by tests with organo-soil. At the same time, sampling of the pervious concrete system at the RI SDF test site will be carried out. The results from this project will be disseminated by publication in an appropriate journal and presentations at conferences and seminars.

TASK III: Pervious Concrete for Enhanced Pollutant Removal

Leader : Craver, URI - CVE

Project Start: Summer 2010
Project Duration: 1 year

		No. of Units	Cost per Unit	URI TC	Match	3rd Party Match	Total Project
1. Personnel							
Graduate Research Assistant							
Academic Year (Sept through May)		1	$ 14,450	$ 14,450	$ -	$ -	$ 14,450
Summer (50%)		1	$ 10,806	$ 10,806	$ -	$ -	$ 10,806
Supervisors							
Dr.Craver		1	$ 71,750	$ 1,993	$ 12,198	$ -	$ 14,191
Dr. Lee		1	$ 120,882	$ 3,358	$ 14,506	$ -	$ 17,864
Honoraria for final review					$ 500	$ -	$ 500
	Total:			**$ 30,607**	**$ 27,203**	**$ -**	**$ 57,810**
2. Benefits							
Graduate Research Assistant							
Summer FICA (June through Aug)*		1	$ 860	$ 860	$ -	$ -	$ 860
Health Insurance and fees		1	$ 1,269	$ 1,269	$ -	$ -	$ 1,269
Vinka Craver					$ 5,489	$ -	$ 5,489
K.Wayne Lee					$ 5,222	$ -	$ 5,222
	Total:			**$ 2,129**	**$ 10,711**	**$ -**	**$ 12,840**
3. Operational							
Lab Supplies		1	$ 7,000	$ 7,000	$ -	$ -	$ 7,000
Printing of Final Report		1	$ 500	$ -	$ 500	$ -	$ 500
	Total:			**$ 7,000**	**$ 500**	**$ -**	**$ 7,500**
4. Equipment							
Pervious concrete Falg Rd		1	$ 5,000	$ 5,000	$ -	$ 16,000	$ 21,000
	Total:			**$ 5,000**	**$ -**	**$ 16,000**	**$ 21,000**
5. Travel							
None		0	$ -	$ -	$ -	$ -	
	Total:			$ -	$ -	$ -	
6. Tuition (exempt from indirect cost)							
Graduate Research Assistant (In-State)		1	$ 10,170	$ 10,170	$ -	$ -	$ 10,170
	Total:			**$ 10,170**	**$ -**	**$ -**	**$ 10,170**
Total Project Cost (per year)				**$ 54,906**	**$ 38,414**	**$ 16,000**	**$ 109,320**
Indirect Cost (25% rate; per year) (exempt: 4. and 6.)				**$ 19,471**	**$ 18,823**	**$ -**	**$ 38,294**
	Total			**$ 74,377**	**$ 57,237**	**$ 16,000**	**$ 147,614**

Task III Budget Justification

The overall amount requested from URI TC is $74,377. This amount is matched by $57,237 in-kind and $16,000 3rd party contributions.

The budget covers a stipend ($14,450 AY and $10,806 100% summer) and in-state tution ($10,170) plus health benefits and fees ($2,129) for one graduate student. PIs Craver and Lee requets 0.25 month of summer salary ($1,992 and $3,358, respectively). $500 are required for external review honorarium.

Under operational, the amount of $7,500 is requested for lab supplies and printing of the final report. Under equipment, $5,000 are requested for completing the pervious concreate system. An overhead rate of 49% is charged to all except tution and equipment.

Monthly Timeline and Project Responsibilities

Proposed start date: January 2011.

Task	1	2	3	4	5	6	7	8	9	10	11	12	Task Leader
Task I: RI SDF Installation													Boving
Planning and Design													
Contracting													
Construction													
Facility shake-down													
Reporting													
Task II: Hydrodynamic Separator Testing													Thiem
Literature Review													
Planning and Design													
Contracting													
Construction													
Field testing													
Reporting													
Task III: Pervious Concrete Testing													Craver
Laboratory Testing													
Field Testing													
Reporting													

Shown is the timeline (by month) for tasks I through III including the responsible task leader. All project activities are supported by URI graduate students. Although the current project duration is one year, we ask RI DoT to consider funding at least two additional years of testing and evaluating BMPs at the RI SDF. Although the construction period will continue into the winter period, we anticipate to have completed most major construction (porous pavement construction and connecting drainage system to Flagg Road) before weather becomes an issue.

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