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4101 Gourrier Ave., Baton Rouge, LA 70808

Volume Balance and Toxicity Analysis for the Cross Lake Bridge

Introduction

The Cross Lake Bridge is approximately 10,000 feet long and spans Cross Lake. It is part of Interstate 220 that bypasses Shreveport, Louisiana from Interstate 20, the longest interstate highway in the country and heavily traveled by both car and truck traffic. Cross Lake, however, serves as the potable water supply for the city of Shreveport. During construction of the bridge, concern was expressed over the possibility of an accident on the bridge that might result in contamination of the city's water supply. As a result, the Louisiana Department of Transportation and Development (LADOTD) agreed to modify the bridge to include a "closed" drainage system and to construct a concrete-lined holding pond on the east bank of the lake to collect and hold runoff from precipitation prior to testing and discharge.

Previous research results found that only about 50 percent of the rainfall onto the bridge was reaching the pond due to leakage of the collection system on the bridge. As a result, LADOTD carried out repairs to the collection system, creating the need to determine the degree to which the repairs were successful.

Earlier research also identified substantial levels of conventional pollutants as well as heavy metals in runoff from the bridge. Much of this material was sediment bound and settled to the bottom of the pond. Toxicity testing has become a popular means of assessing effluent quality in a variety of discharges, and a need was identified for an easy-to-use, rapid means of determining the toxicity of the pond discharge to downstream life forms.

Objective

There were two overall objectives for this project: (1) to assess leakage from the bridge once repairs to the collection system were completed and (2) to investigate "Microtox," a toxicity screening tool manufactured by Azur environmental, as a means of assessing the toxicity of the liquid phase of the discharge as well as the toxicity of the material that settles in the pond.

Scope

The first objective was achieved by computing the ratio of runoff volume to rainfall volume for 22 precipitation events and comparing these values to published values for highly impervious areas. The second was achieved by first conducting a literature review to examine the degree to which Microtox has been used and accepted as a toxicity screening tool and then applying Microtox to determine the acute toxicity of the liquid and solid phases of the pond contents.

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Principal Investigator:
D.M. Griffin, Jr., Ph.D., P.E.

LTRC Contact:
Chester Wilmot, Ph.D., P.E.
Phone: (225) 578-4694

Louisiana Transportation Research Center

Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

4101 Gourrier Avenue
Baton Rouge, LA 70808-4443
www.ltrc.lsu.edu

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Methodology

A different research approach was required for the two objectives. In order to examine leakage from the bridge, recording rain gages were installed at each end of the bridge. This allowed the volume of precipitation falling on the bridge to be computed. Flow entered the pond through a 36-in. diameter culvert. Depth of flow as well as flow velocity were recorded by an American Sigma, programmable flow meter, thus producing an inflow hydrograph. Numerically integrating the area under the hydrograph allowed the volume of water entering the pond to be measured. The ratio of the volume of runoff to the volume of rainfall is termed the "runoff coefficient," and published values exist for a wide variety of land uses.

The toxicity of pond components (liquid and sediment) was assessed using Microtox. The system assessed acute toxicity by measuring the light output from a strain of luminescent bacteria. The endpoint for the acute toxicity test occurred for liquid samples when the percentage of effluents in distilled water reduced the light output from the sample to 50 percent of that of a control sample, distilled water only and is termed the EC50. In sediment samples, the EC50 occurs when the sediment concentration in distilled water is sufficient to reduce light output by 50 percent.

Conclusions

Volume Balance

Rainfall and runoff from 22 storm events were measured between November 2004 and April 2005. The ratio of runoff volume to rainfall on the bridge was computed for each. The average value for the ratio was 0.85, which compares favorably with published values of runoff coefficients for impervious areas for events with return periods of from 5 to 10 years. Based on these results, it appears that repairs to the Cross Lake Bridge were successful at reducing leakage from the bridge.

Toxicity of Pond Contents

Sixteen samples from the water column in the Cross Lake holding pond were collected between March 2004 and February 2005. Only three of the samples indicated any toxic effects as measured by the EC50, the remainder indicated "no effect." These results indicate minimal toxicity is associated with the water column in the Cross Lake pond.

Thirteen samples of sediment were collected between September 2004 and July 2005. EC50 values ranged from 4,243 mg/liter to 259,000 mg/liter. All samples indicated some level of toxic response. This suggests that toxicity in pond discharges to the environment are localized in the sediment fraction rather than the water column.

Recommendations

LADOTD should develop release scenarios from the Cross Lake pond designed to minimize scouring of sediment from the pond bottom. Furthermore, the pond should be cleaned on a one- or two-month schedule to minimize sediment buildup and reduce the possibility of scour.