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## **An Assessment of Fecal Coliform Bacteria in the Sinclair/Dyes Inlet Watershed, Puget Sound, WA, USA**

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An assessment of fecal coliform sources and pathways in Sinclair -Dye Inlet was conducted as part of the Project ENVironmental InVESTment (ENVVEST) being conducted by the Puget Sound Naval Shipyard and Intermediate Maintenance Facility in cooperation with the U.S. Environmental Protection Agency, Washington State Department of Ecology, the Suquamish Tribe, Kitsap County, the City of Bremerton, the City of Port Orchard, and other local stakeholders. The goal of this study was to identify microbial pollution problems within the Sinclair-Dyes Inlet watershed and to provide a comprehensive assessment of fecal coliform (FC) contamination from all identifiable sources in the watershed. This study quantifies levels of contamination and estimated loadings from known sources within the watersheds and describes pollutant transport mechanisms found in the study area. In addition, the effectiveness of pollution prevention and mitigation measures currently in place within the Sinclair-Dyes Inlet watershed is discussed. This comprehensive study relies on historical data collected by several cooperating agencies, in addition to data collected during the study period from spring 2001 through summer 2005.

The major objectives of Sinclair-Dyes Inlet microbial pollution assessment technical study were as follows:

- Identify and quantify the contribution of significant sources of microbial pollution to the system by measuring concentrations and loading from these sources
- Investigate the effects of seasonal factors, storm events, and land-use conditions on microbial pollution loading to the system
- Model the distribution of microbial pollution within the Sinclair-Dyes Inlet watershed as it is affected by loads from point and non-point sources (NPS), tidal circulation and transport, and the natural process of die-off of bacteria and other microbial organisms
- Use the developed model to predict the effect of pollution on water quality at various locations in the Sinclair-Dyes Inlet watershed
- Compare the levels of microbial contamination to current water-quality standards for the protection of beneficial uses (e.g. shellfish harvest and contact recreation). Provide information to determine the pollution reductions that are needed so that local communities, agencies, and other affected parties can develop and implement appropriate source-control, mitigation, and cleanup strategies.

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The findings of the Sinclair-Dyes Inlet microbial pollution assessment study indicate the presence of numerous sources of bacterial pollution in the Sinclair-Dyes Inlet watershed and multiple modes of transport of FC bacteria from sources to receiving waters and shellfish growing areas. In general, FC levels are higher in more developed watersheds with greater population densities, in areas with a greater percentage of impervious area, and in areas served by older sewer infrastructure or onsite wastewater treatment (septic) systems (OWTS). Water quality violations are more likely in urbanizing streams served by stormwater infrastructure and in those draining more developed watershed areas. Higher FC levels and violations of water-quality standards (WQS) are also more likely following a major storm event that produces stormwater runoff that enters the marine receiving waters via streams and stormwater outfalls; engineered stormwater systems can be an efficient means of transporting microbial pollution from source areas to receiving waters. However, elevated nearshore FC levels appear to be localized and persist for only a short period of time after storm events or during extended periods of rainfall with significant stormwater runoff and stormflow inputs. In nearshore and estuarine areas where shoreline development is intense or where urbanized streams and stormwater outfalls are common, elevated FC levels can persist as a chronic pollution problem. In general, the FC levels found during storm season sampling are an order of magnitude greater than those for non-storm periods, especially for nearshore sites with adjacent highly urbanized drainage sub-basins. Relationships between bacterial pollution and land-use were also investigated. The loss of natural forest cover and the increase in impervious surfaces associated with suburban and urban levels of development were correlated with FC contamination levels and the resultant violations of WQS.

In addition to conventional bacterial pollution mitigation measures (e.g. pollution source identification and correction), recommendations for improving the water quality in the Sinclair-Dyes Inlet watershed include enhancing natural systems, such as wetlands and riparian buffers, and the use of new approaches to stormwater treatment such as low-impact development techniques. The value of an integrated watershed approach to water-quality management has been demonstrated during this project. The number and variety of sources for bacterial pollution throughout the study area does not support a conventional “end-of-pipe” approach to pollution control. In addition to ecological concerns, the link between human health and water quality is extremely strong. Therefore, the detection, quantification, and correction of existing sources of microbial pollution should be a high priority for watershed and water-resource managers, as should the development and implementation of an effective prevention program.

Finally, the integrated watershed-receiving water model developed during this project has been invaluable in analyzing a variety of water clean-up plan (TMDL) scenarios. This has enabled watershed managers to prioritize problems and focus resources in the most cost-effective manner, while implementing actions that provide the most effective water-quality benefits.

Additional Information:

May et al. 2005. [An analysis of microbial pollution in the Sinclair-Dyes Inlet Watershed](#), Ecology Report 05-03-042, December 2005.

Link to Animations: [CH3D-FC Animation page](#)