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Memorandum

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RE: Executive Summary of Investigations by Hull & Associates, Inc. in Maumee Bay State Park, Wolf Creek and Berger Ditch, 2008

The investigations performed by Hull & Associates, Inc. (Hull) pursued several lines of inquiry. Hull investigated preliminary design considerations and potential constraints for construction of a sub-surface flow research wetland at Maumee Bay State Park. Hull also performed a study related to sediment transport and delivery within the Wolf Creek and Berger Ditch system. Finally, through a subcontractor, Hull performed a study of the factors affecting sediment transport from the Wolf Creek and Berger Ditch system and subsequent sediment distribution and deposition in the near shore area of Maumee Bay.

Preliminary subsurface wetland design and constraints

This study reviews information gathered from multiple sources including literature and field data, and assesses the initial feasibility and design constraints of sub-surface flow (SSF) wetlands proposed for installation at Maumee Bay State Park (MBSP). Construction of SSF wetlands is proposed at MBSP to research questions related to pollutant removal by SSF wetlands, focusing on pollutants of importance to Berger Ditch, MBSP, and the near-shore area of Maumee Bay. The pollutants of interest include pathogens associated with fecal material, sediment and plant macronutrients including nitrogen and phosphorus.

Design criteria for SSF wetlands related to the pollutants of interest are discussed to the extent known from previous published work, and site constraints for implementation of an SSF design at MBSP are also discussed. SSF wetlands can function in winter if soil freezing depths do not exceed the depth of subsurface flow, an obvious advantage over surface flow constructed wetlands. However, UV radiation, a primary removal mechanism for pathogens in surface-flow wetlands, is not available in SSF wetlands. Other pollutant-removal mechanisms are at work in SSF wetlands, including filtering, adsorption and biofilms. Maximizing these removal mechanisms in a SSF wetland drives designs that maximize exposure of water flow to substrate surface area and relatively small pore sizes.

A preliminary geotechnical investigation of the site on the west bank of Berger Ditch just north of North Curtice Road shows that the site is dominated by very fine particle sizes (clay soils), which, while ideal for maximizing substrate surface area and filtration, have prohibitively low hydraulic conductivity. However, on-site materials will serve as an excellent base for an SSF wetland and will likely not require a liner due to very low infiltration rates relative to probable SSF wetland design flow. Pea gravel as an SSF substrate best addresses the intended uses of the SSF wetland, and is relatively inexpensive and easy to acquire.

A series of three in-stream flow scenarios (10-20 cfs, 10-50 cfs, and 50-100 cfs) were examined to help guide initial conceptual designs. Approximate duration of these flow events was determined from USGS records at the Berger Ditch gauging station (Station No. 04194085). The goal of treating a portion of these flow events was examined within three conceptual design scenarios. Scenario A utilizes pumps to move water from Berger Ditch to a pond that is constructed primarily above surrounding grades. This should use the bulk of the soil that needs to be excavated for the construction of the wetlands and the excavated portion of the pond. In addition, this scenario allows the wetlands to be fed from the pond by gravity rather than pumps. Scenario B assumes the pond is constructed completely below existing grade. In this case, the amount of soil that would need to be excavated increases significantly and there will be a positive soil balance to use as part of the project and other potential uses. In Scenario B, it is possible to use gravity to divert water from Berger Ditch to the pond by using culvert pipes, a siphon, or other coarse drainage material to move the water into the pond. However, a pump would be needed to move water from the pond into the wetlands. Scenario C is a hybrid system consisting of a partially excavated pond and shallow excavated wetlands in an effort to avoid using any pumps. It appears that this scenario is not technically feasible due to the depth of Berger Ditch.

The study concludes that construction of an SSF wetland is technically feasible at MBSP.

Stream morphology and sediment transport study of Wolf Creek and Berger Ditch, and hydrodynamic model of Maumee Bay

This study was conducted to establish baseline stream morphological data for the Wolf Creek/Berger Ditch system, and to develop empirical estimates of the total annual sediment loading to Maumee Bay through Maumee Bay State Park (MBSP). Hull completed ten cross sections, three longitudinal profiles, bank-erosion hazard index and near-bank stress assessments, and sediment characterization of three representative reaches of Berger/Wolf. A study reach within MBSP is heavily influenced by backwater effects from Lake Erie. A second reach adjacent to the Oregon, OH Water Treatment Plant is located in a zone of transition between reaches of the stream affected and unaffected by lake level. A third reach in Wolf Creek is located above all lake backwater effects. Hull used the unaffected reach as a basis for performing a Rosgen Level II classification of Wolf Creek (C5). The morphological and sediment data were used by LimnoTech in their sedimentation model for the mouth of Berger Ditch and Maumee Bay, discussed below.

Hull used suspended sediment data gathered independently by two different entities (USGS and the University of Toledo, UT) to estimate total 2007 sediment discharge to Maumee Bay. In 2008, UT gathered total suspended solids (TSS) data from a multi-stage sediment sampler installed at the MBSP gauging station, which Hull used to develop a correlation between flow and TSS. In 2007, USGS published work from 2006 which gathered suspended sediment concentration (SSC) data from the same gauging station. Using the USGS data, Hull developed a correlation between flow and SSC. These two correlations were then applied to flow data collected at ten-minute intervals between May and December 2007 to estimate total sediment delivery to Maumee Bay in 2007. The estimates of total sediment delivery were 311 and 1845 metric tons for the UT and USGS correlations, respectively. The discrepancy between these two estimates is discussed in terms of the different and apparently non-correlated sediment concentration collection methods used, TSS and SSC. Hull also provides an estimate of the amount of sediment being generated by the system from eroding stream banks based on observations along 400 feet of Wolf Creek, and discusses ditch cleanout as an unquantified and possibly significant watershed sediment sink.

Hull's subcontractor, LimnoTech, calibrated a USEPA SWMM model against an actual 250 cfs flood event in August 2007 using USGS gauging station data. Successful calibration of the model was developed after several model iterations. The calibrated model was found to predict the hydrograph of larger storms reasonably well, but tended to over-predict flow of smaller storm events. The potential causes of this over-prediction are discussed in the report.

LimnoTech also used USEPA's Environmental Fluid Dynamics Code (EFDC) to develop a hydrodynamic model of Maumee Bay to simulate sediment transport and particle tracking, as a way of simulating bacterial transport within the Bay. Data inputs to the model included Hull's cross-section, profile and sediment data from Berger Ditch, USGS gauging station instantaneous discharge data, NOAA data on Maumee Bay water level, wind speed and direction, and inflow suspended sediment concentration data collected by USGS and correlated with discharge. LimnoTech considered these data sets to be sufficient to develop a conceptual understanding of sediment transport through the system. LimnoTech intends the modeling analysis as a screening level assessment, since calibration data was not available.

The EFDC model runs by LimnoTech address three areas of inquiry: sediment export from Berger Ditch, short term sediment transport into Maumee Bay during storm events, and long term sediment transport within Maumee Bay using a particle tracking simulator. Sediment export from Berger Ditch was simulated using a USGS correlation between suspended sediment concentration (SSC) and discharge. The modeled predictions of sediment export from Berger Ditch appear to far exceed empirical estimates of sediment export developed by Hull based on 2007 discharge data from the USGS gauging station and the published USGS correlation between SSC and discharge (see above). Calibration of the sediment export model would probably allow a closer match between predicted and actual sediment export from Berger Ditch.

The short-term sediment transport model showed that even under peak flow conditions (250 cfs), velocity and shear stress are largely dissipated within 1000 feet of shore as Berger Ditch flows into Maumee Bay. Within this zone, suspended particles come out of suspension and transition from a sediment transport process driven by Berger Ditch to one driven by Maumee Bay. The long-term sediment transport model shows that within a few hours of entering the Bay, sediment transport within Maumee Bay is entirely dependent on Bay hydrodynamic processes including wind-driven currents.

Conclusions and Recommendations

- Two of three preliminary design scenarios for SSF wetlands were found to be feasible at the MBSP. The choice between feasible alternatives would need to be made on the basis of several factors, including cost and further investigation on pumping directly from Berger Ditch.

- Baseline fluvial morphological data for Wolf Creek and Berger Ditch reveal an extensively hydrologically modified stream system with high restoration potential in areas where residences or other structures are not immediately adjacent to the channel. The reach of Wolf Creek above seiche influence is a Rosgen Type C5 channel.

- Overall the stream system is fairly stable due to dominance of clay subsoils with low to moderate erosion hazard, low near-bank stress, and good to very good vegetation reinforcement of stream banks. An estimate of total sediment contribution from stream bank erosion is provided which is about 57% of the estimate for total sediment export from the stream system to Maumee Bay. The remainder of sediment export is assumed to originate from surface runoff. Regular ditch maintenance is potentially a significant sediment sink in the Wolf Creek and Berger Ditch watershed, decreasing the total sediment export from the watershed.

- Maumee Bay quickly dissipates velocity and sheer stress during high flow events from Berger Ditch, and Bay hydrodynamic processes become dominant in sediment transport within 1000 feet of the stream mouth.

- Several areas of further inquiry are recommended:
    - Additional empirical estimates of sediment export from Berger Ditch should be made using the UT data set from other years.
    - The study should incorporate results of a UT effort to develop a usable correlation between suspended sediment concentration and total suspended solids in Berger Ditch flows.
    - After several years of flow data is gathered from the Wolf Creek gauging station installed in 2008 at Seaman Rd., a new model of sediment transport using Powersed/Flowsed should be developed for this non-Lake affected reach.
    - The working assumption that bedload transport is an insignificant proportion of total sediment transport in shallow gradient Ohio streams should be empirically tested using bedload sampling of fine sediments.
    - Further refine SWMM model using rainfall data collected from the watershed.
    - Calibrate the sediment export and transport models with empirical data including Maumee Bay hydrodynamic data and bathymetric data.
    - The potential for resuspension of sediments to result in increases of bacterial concentration during low-flow events should be further investigated.