Oro Loma Horizontal Levee: Cell Reconfiguration Project

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Acknowledgements:

This report was prepared by San Francisco Estuary Partnership staff, and includes content provided by the Sedlak Research Group (UC Berkeley) and Oro Loma Sanitary District.

Water quality research at the Oro Loma Horizonal Levee is conducted by the Sedlak Research Group (led by Dr. David Sedlak; current Ph.D. students: Jono Uhler, Anthony DeSalvo). The site is managed by the Oro Loma Sanitary District.

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Project Description:

The San Francisco Estuary Partnership (SFEP) and Oro Loma Sanitary District (OLSD) recently completed the Oro Loma Horizontal Levee Cell Reconfiguration Project, funded by the Clean Water State Revolving Fund. This two and a half year, $1,000,000 project involved reconfiguration of a portion of an existing pilot horizontal levee and associated water quality and materials research.

A horizontal levee is a gentle, vegetated slope that protects from storm surge and rising sea levels (similar functions to a traditional levee) and uses treated wastewater for upland plant irrigation. These projects can also be designed to incorporate additional benefits like providing space for wetlands to move upland as sea levels rise, transitional habitat between tidal and upland areas, and more. The Oro Loma horizontal levee was originally constructed in 2016 as a living laboratory to study the ability of horizontal levees to further remove nutrients and contaminants from secondary wastewater effluent. Findings from the first several years of research by the Sedlak Research Group at UC Berkeley showed that treatment occurred in only the upper third of the horizontal levee, indicating that the levee had greater treatment capacity than what was tested. OLSD, UC Berkeley, and Valley Water began collaborating to study the effectiveness of the horizontal levee for treating reverse osmosis concentrate (ROC).

The Cell Reconfiguration Project involved redesigning a portion of the original horizontal levee to test different slopes, materials, and size (thickness) of the water treatment layer. This project will provide valuable information on the potential to scale up horizontal levees around the Bay and use them to treat ROC. Construction of the redesigned horizontal levee finished in 2023, and water quality studies are underway by UC Berkeley researchers.

Cell Reconfiguration Summary:

A collaborative team including OLSD, UC Berkeley, SFEP, and other interested partners met with consultants at Environmental Science Associates (ESA) between May and September 2022 to redesign two of the original 12 treatment cells. Construction was performed from February to August 2023 by Brannon Construction. UC Berkeley was involved throughout the project in water quality and materials testing.

Construction consisted of reconfiguring two existing horizontal levee cells into eight smaller sections which included excavation, salvage of topsoil and levee fill, adding HDPE liners and geotechnical fabrics, and feed and drainage piping. Testing of shorter cells, a steeper slope (15:1), and thicker treatment layer in this redesign will examine ways to treat a greater volume of water with improved space efficiency so that the horizontal levee design can be scaled up at other sites. Addition of an HDPE liner and treatment layer geotechnical separation fabric, and testing of different blends of fill for the treatment layer, will examine designs expected to be effective over a long period of time, and that can treat multiple different water sources (wastewater and ROC).

Recommendations and Lessons Learned:

Materials: When selecting materials, the project team recommends conducting leaching tests on gravel for the treatment layer to assess potential metal leaching from sediments. This may only be necessary in areas with ambient levels already close to/approaching aquatic toxicity thresholds.

Vegetation: Proactive maintenance on the wetland cell vegetation is crucial for controlling weeds early on, before they become well-established. The project team recommends working with local organizations that have expertise in native plants to determine the best times of year or other strategies for planting the site to give native plants a competitive edge over invasive species.

Research & Monitoring:

The Sedlak Research Group has been conducting water quality research at the Oro Loma horizontal levee since its original construction in 2016. Past research indicated that nitrate-N is completely removed within the first ~20% of the levee slope provided that water is flowing underground. Trace organic compounds (e.g., pharmaceuticals, urban use pesticides) are also well removed within this zone. Initial experiments in a sub-section of the horizontal levee indicated that these same contaminants are removed from reverse osmosis concentrate (ROC) produced by a potable water reuse demonstration facility.

In support of efforts to reconfigure test cells to improve system performance, members of the UC Berkeley research team participated in design meetings with ESA and other project partners in 2022. Two of the original 12 cells were redesigned to explore new research questions that emerged from earlier monitoring findings.

The finding that nitrate-N removal occurs in the first 20% of the ecotone slope indicates that a steeper slope may allow equal treatment and less costly construction. Therefore, the cell reconfiguration enables comparison of treatment effectiveness on a steeper 15:1 slope with the 30:1 slope used in the original design. This updated design will be informative to other projects that are challenged with a lack of space to accommodate a 30:1 slope. A 15:1 slope may also be advantageous if resource agencies continue to require mitigation for the installation of these natural systems.

Similarly, successful nitrate-N removal indicates that the horizontal levee may be able to accommodate increased flow. This question is of interest to other projects looking to scale up the horizontal levee design to fulfill greater wastewater treatment needs. A thicker gravel treatment layer was incorporated into some of the reconfigured cells to examine the ability to accommodate increased flow.

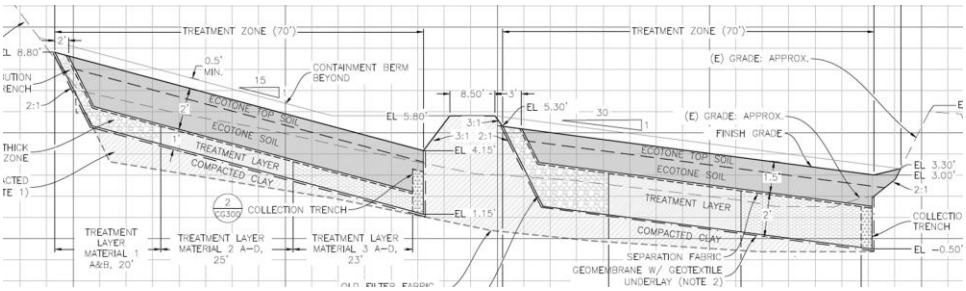
The research team also investigated potential materials for the cell reconfiguration project. This included identifying treatment materials that can remove per- and polyfluorinated alkyl substances (PFAS) from wastewater and ROC. Removal of PFAS from wastewater sources is a growing concern as these compounds are becoming increasingly regulated and monitored in drinking water and waste streams. Incorporation of activated carbon and a PFAS-specific geomedia into the reconfigured cells will enable researcher to examine the ability of these systems to remove PFAS from a variety of waste streams via sorption processes. Researchers also procured samples of gravel to assess its potential for metal leaching, as monitoring findings to date revealed some instances of higher nickel concentrations in the effluent than those in the influent water. Additional research is needed to fully understand nickel mobilization in the subsurface.

The research team continues to monitor the fate of contaminants in the wetland and to develop new methods for tracking contaminant partitioning between water, soil and plants. This includes analyzing samples of porewater for trace organic contaminants, metals and water quality parameters, and conducting experiments to assess partitioning of metals between sediments and porewater.

Construction Activities:

Construction activities began in February 2022 and consisted of reconfiguring two existing horizontal levee cells into eight smaller sections. Prior to construction, wildlife was excluded from the cells planned for reconfiguration, followed by vegetation clearing using hand tools and monitoring by a project biologist.

Topsoil was removed and placed in a different area of the site for reuse at the end of construction. The original treatment layers were removed from the two cells and earthwork was completed to divide the two cells into eight smaller cells. This involved grading the 15:1 and 30:1 slopes and separating the upper and lower cells with a new berm, so water cannot flow from the upper to the lower cells.



The upper four cells and lower four cells were separated from each other with plywood and lined with an HDPE liner. Treatment blends were mixed onsite using different combinations of gravel, wood chips, activated carbon, and Fluoro-sorb (the PFAS-specific geomedia). Treatment blends were added to the cells as specified by the research team and treatment layers were separated from upper soil layers with geotechnical separation fabric.

Piping and collection trenches were added to deliver wastewater and ROC to the top of the cells and collect the effluent at the bottom of the cells, ensuring a closed-loop system. An electronic system was also set up to enable researchers to remotely control the flows of wastewater and ROC to each cell.

Finally, soil was added on top of the treatment layers and geotechnical separation fabric, with reused topsoil tilled back in. Wooden boards were installed on the sides of each cell to serve as walkways for researchers conducting future sampling along the length of the horizontal levee. Sprinklers were installed to assist with vegetation regrowth from the reused topsoil, which contained plant rhizomes.

Environmental Compliance Summary:

Permits with the appropriate agencies remain in place from the last time work was completed on the horizontal levee. Vegetation clearing was performed using hand tools and monitored by a project biologist. The horizontal levee is a standalone experiment at the Oro Loma wastewater treatment plant, not connected to the waterway, and functioning as a closed-loop system. All wastewater going through the horizontal levee is collected and sent back to the main treatment plant.