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Using Systems' Thinking and Waste Materials to Improve the Sustainability Footprint of a Cleanup: The Drive for a Zero Footprint Cleanup Technology

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Background/Objectives. The two most common approaches for implementing sustainability into cleanup projects are: 1) evaluating and selecting best management practices, and 2) performing a footprint analysis to compare cleanup options or identify opportunities to reduce the footprint of a specific remedy. These approaches are typically applied after a remedy has been developed, and miss some opportunities to develop a more sustainable remedy. Applying sustainability approaches after a remedy has been developed could be considered a “top-down” approach since sustainability is considered after the alternative is developed. The upside for implementing sustainable remedies is much higher when the remedy is developed with sustainability in mind. This can be considered a “bottom-up” approach, and allows for systems thinking to be included in the technology development and result in new or different technologies being considered. By coupling systems thinking with an objective to maximize utilization of waste or non-refined materials, the sustainability profile for a cleanup can be improved.

Approach/Activities. The use of waste materials in successful cleanup preojcts is not a new concept in the remediation industry. The Air Force has implemented bioreactors. A mulch/vegetable oil biowall was installed by the Navy. Green pozzolans have been used to reduce the impacts related to Portland cement. By taking elements of industry experience, and leveraging the power of systems thinking to improve engineered outcomes, more sustainable remedies can be developed. The use of Life Cycle Assessment (LCA) can help identify many sustainability impacts for remediation projects and shine a light on the opportunity to reduce those impacts through material substitution and optimization while not compromising the effectiveness of the remedy. The design of an insitu solar powered biogeochemical reactor (SBGR) to treat chlorinated ethenes in groundwater is used as an example to demonstrate how systems thinking can be used to identify sustainability impacts and minimize their negative impacts. The SBGR technology is also compared to a recognized sustainable remediation technology, emulsified vegetable oil (EVO) injection, to demonstrate the sustainability benefits of system thinking.

Results/Lessons Learned. The design for the SBGR used a bottom-up approach to maximize the use of locally available waste materials in the remedy construction. While this approach resulted in a low sustainability footprint technology, the LCA identified some hot spots for improvement. For example, the gravel used as structural media in the reactor and manufacturing of solar panels have high water footprints. Options to address these issues will be discussed. The comparison of the SBGR to EVO showed the former to have a significantly lower sustainability footprint across all the impact categories evaluated. Opportunities to improve the sustainability footprint of EVO projects will also be presented based on the LCA findings. By using LCA, it is possible identify sustainability impacts of remediation technologies, minimize their contribution, and – maybe in the future - nearly drive them out of the technology. The approaches presented in this presentation indicate the promise of developing zero, or near zero, sustainability footprint treatment technologies.