IN MEMORIAM

Robert Earl Selleck
Professor of Civil and Environmental Engineering, Emeritus
UC Berkeley
1926-2011

Robert Selleck played a critical if quiet role in the transformation of the sanitary and environmental engineering program within the Department of Civil Engineering at UC Berkeley. His contributions in teaching at the advanced undergraduate level and graduate level were long remembered by students and colleagues because of his insistence on rigorous analysis of fundamental processes and his reverence for carefully collected experimental data. His individual attention directed at PhD students set exceedingly high standards leading to their future advancement, contributions to the profession, and general fearlessness in approaching challenges in water quality engineering.

Robert Selleck was born in Chagrin Falls, Ohio on October 10, 1926. He graduated from high school in 1944, served briefly in the military, and then attended the Case Institute of Technology (BS degree in Civil Engineering in 1951). He remained at Case until 1956 having served as an instructor and completing the MS degree. His research interests were in sanitary engineering and hydraulic modeling. He also gained broad experience in teaching at the lower division general engineering courses and upper division courses in fluid mechanics and water quality engineering.

Robert Selleck enrolled in the PhD program at UC Berkeley in 1956, supported with an instructorship, public health graduate fellowship, and as a graduate student researcher. Given his prior college level teaching experience, he played a critical role in upper division and graduate level teaching in sanitary engineering. His PhD thesis research was supervised by Professor Erman Pearson and was part of the most influential study of water pollution in San Francisco Bay. River pollution had received considerable attention, but there was limited data and analysis on pollution within estuaries where mixing processes were complicated by tidal action and river discharges. The necessary level of wastewater treatment was uncertain given the then prevalent attitude that pollution problems were solved by dilution. Robert Selleck's research contributions were to quantify the mixing in South San Francisco Bay. In that research, he contributed to the development of tracer techniques leading to a rigorous approach to quantifying wastewater sources and mixing rates in coastal waters. He completed his thesis requirements in 1961 following a yearlong internship at the Department of Sanitary Sewers of the City of Rio de Janeiro, Brazil, where he successfully applied the tools and techniques developed in San Francisco Bay to minimize shoreline pollution to coastal waters near Rio de Janeiro.

In Fall 1961, he was hired as an assistant professor in the Sanitary Engineering Program within the Department of Civil Engineering at UC Berkeley and retired in 1990. His classroom teaching contributions were broadly based in water resources engineering, sanitary engineering, design, hydraulic measurements, process engineering theory and laboratory, and advanced reactor engineering. What characterized those courses was an emphasis on relevant theory, application of engineering tools of analysis, and where

appropriate, collection and analysis of experimental data. While it was common in those days to hire graduates of the program on to the faculty, having rather strong- willed senior colleagues discouraged assertiveness but Bob (as he was universally called) successfully focused on his classes and individual research student supervision throughout his career.

As the field of sanitary engineering at the second half of the 20th century became sufficiently removed from its origins within hydraulic engineering most sanitary engineering programs were based on water chemistry, microbiology of wastewater treatment and disinfection, and pilot plant studies for process engineering design. Selleck's background in fluid mechanics and mixing processes brought new insights into the research efforts. In all his research contributions there was a common approach of picking an important problem of the day; understanding the limitations in the literature; undertaking careful experimental measurements in the laboratory, at a pilot plant scale, or in the field; and then integrating the measurements into a model that could be extended for water quality improvement at the field scale.

Research on marine pollution by wastewater was continued by research students who were driven by issues of contaminant accumulation at the air- water interface, something he first addressed during his stay in Rio de Janeiro. The research required the design of sampling systems that could collect a thin layer of water at the air- water interface and analyze those samples for microorganisms, oil, grease, and particles. The sampling efforts were deployed at coastal wastewater outfalls in Southern California to quantify the benefits associated with advanced treatment systems coupled with new ocean outfall designs.

In the early 1970s research students studied advanced treatment systems necessary for the elimination of wastewater toxicity and the management of industrial wastes. Experimental systems were designed for measuring toxicity from co- occurring contaminants that required specialized pilot plant studies, use of multiple organisms for toxicity assessment, and extensive modeling efforts. These studies introduced the concepts of kinetic modeling of toxicity along with continuous biological monitoring to quantify treatment system reliability. Particle and droplet removal from industrial and municipal wastes was addressed in two theses during this period; these studies expanded Robert Selleck's research interests to include particle surface chemistry, and particle aggregation methods where new mixing regimes were influenced by stronger coagulants.

The early 1970s also saw Selleck initiating research in the area of wastewater chlorination for disinfection and contaminant removal. The initial efforts were sparked by examination of wastewater disinfection results that were dominated by poor mixing conditions that did not maximize microorganism removal. The research utilized tracer studies developed in Selleck's own thesis to understand chlorine reactions with wastewater components, including microorganisms. There were direct applications to improved design of chlorine disinfection reactors, predictive modeling of chlorine reaction kinetics with ammonia naturally present in wastewaters, and application to chlorine disinfection of drinking water. The production of selective disinfectants when chlorine and ammonia reacted had broad application to drinking water disinfection, while avoiding the formation of toxic byproducts. Additional reactions of chlorine with other water constituents were investigated such as bromide and nitrate added to the complexity of the reaction chemistry but were necessary for application to disinfection reactor design. The research program questioned conventional wisdom and backed up analysis with experimental data and mechanistic modeling.

In the 1980s, Selleck's research included studies of interfacial mass transfer rates necessary in the design of treatment systems for emerging contaminants. Reverse osmosis membrane reactors were evaluated for the treatment of known and suspected contaminants present within agricultural drainage waters, thereby leading to direct consideration of the critical issues of membrane fouling and contaminant selectivity. Oil shale was proposed as an alternative energy source but oil recovery generated unique solid and aqueous wastes. Membrane reactors were investigated for ammonia recovery from aqueous waste streams utilizing an intermediate gas phase. Contaminant leaching from spent oil shale waste materials required the early development of models with multiple mass transfer resistances. Full- scale analysis of aeration tower performance for volatile contaminant removal identified the importance of non- ideal mixing within the reactor and quantified its deleterious effect on removal efficiency. A final research effort addressed the problem of synthetic organic contaminant transport through plastic pipe driven by observations that soil contamination compromised drinking water. Throughout, the problems evolved, but the there was always a rigorous approach to problem definition, experimentation and analysis.

At a professional level, Bob shared the 1971 Rudolph Hering Medal of the Sanitary Engineering Division of the American Society of Civil Engineers with one of his advisees for the most valuable contribution to the

profession that year. In 1977 and 1978, two of his advisees won achievement awards for the best PhD dissertations in water treatment and wastewater treatment from the Association of Environmental Engineering Professors. Individually, Selleck received the 1962 Prize Medal for a paper presented as the VII Congress of Inter- American Association of Sanitary Engineers for his work on marine pollution in Rio de Janeiro. In 1980 the American Society of Civil Engineers awarded him a certificate of appreciation for special service to the National Environmental Engineering Division conference.

Above all else Robert Selleck was extremely proud of the accomplishments of his PhD students through their dissertation research and future professional accomplishments in consulting engineering, government service, and academia. He had a unique personality that was reserved and modest, but demanding in honesty and rigorous analysis. His advisees found to their amazement his full engagement in their research at every step. While the scope of the research accomplishments are broad, the approach always included his attention to detail, but was combined with spilt coffee, an inability to find an ashtray, and devotion to his cat. If you were fortunate enough to gain his respect, you were awarded the classification of "he is a process man", even if the gender- specific terminology had long since passed from common usage. The University of California is a stronger place for the contributions made by Robert Selleck.

James Hunt
Slawomir Hermanowicz