

Rex Alfred Elder (1917-2018)

Rex A. Elder was a truly talented hydraulic engineer, whose career spanned decades of the 20th century critical to the development of hydraulic engineering. When it came to the hydraulics of hydro- and thermal-power systems, few (if any) engineers could match his perceptive, seasoned expertise and down-to-earth manner. Countless hydraulic engineers became acquainted with his contributions, and many engineers had the enriching experience of working with him.



Rex Elder at TVA in 1967

Rex passed away on February 24, 2018 at the remarkable age of 100. He was born on October 4, 1917, in the small town of Laquin, in northern Pennsylvania, where his father managed the local lumber mill. Rex grew up in the practical setting of a community centered on the regional lumber industry, which was struggling due to declining availability of timber and economic consequences of the Great Depression. His pragmatic disposition began early as he learned the lumber-mill trades and drove lumber trucks. In due course, he went to Pittsburgh's Carnegie Institute of Technology (now Carnegie Mellon University) where in 1940 he earned the bachelor's degree in civil engineering. He then attended Oregon State College (now Oregon State University (OSU)) where in 1942 he attained the master's degree in hydraulic engineering. That same year, Rex joined the Tennessee Valley Authority's (TVA) Hydraulics Laboratory.

By the end of WWII, TVA (created by the 1933 TVA Act) had completed a 1,050km navigation channel along the length of the Tennessee River, and had become the U.S.'s largest electricity supplier. During the ensuing years, Rex's career spanned major developments at TVA and in hydraulic engineering. These developments included TVA's substantial growth and milestone advancements in hydraulics theory, the use of hydraulics laboratories, associated instrumentation and modeling techniques, and methods for field investigation. The range of topics investigated played a critical role in TVA's Hydraulics Lab becoming the U.S.'s leading non-university, hydraulics lab during the years that Rex served as its director (1948-61).

At first, Rex was involved in a variety of technical activities engaging TVA's Hydraulics Laboratory. Then in 1948, he became the lab's director. Subsequently, in 1962, he was appointed Director of TVA's Engineering Laboratory, which investigated a broad range of engineering concerns. These promotions signified his talents as an engineer and ability to work with people. During Rex's thirty-one years at TVA (1942-73), TVA completed extensive studies for more than ten dams, a major pump-storage facility, six navigation locks, and sundry other hydraulics facets of TVA's expanding operation. His work on TVA's hydropower dams extensively involved the design of spillways, and inlet and outlet works. A project of which he was particularly proud was the spillway for TVA's Fontana Dam, a gravity-arch dam on the Little Tennessee River in North Carolina. The spillway, built during 1942-44, involved a tunnel through rock forming an abutment of the dam, and a flip-bucket ejecting flow emerging at the end of the tunnel. This project, addressing site difficulties, stimulated Rex's expertise in cavitation, flow resistance in tunnels, and overall aspects of spillway design. His work with locks along the Tennessee River led to a novel approach for filling and draining navigation locks. This new design, a multi-port manifold system, reduced lock filling time and lowered the cost of lock construction.

In 1952, TVA started on a huge program of power generation by coal-fired thermal-power plants, such that by 1955 coal surpassed hydro as TVA's main power source. Economic and environmental challenges began to emerge with widespread coal use, and energy demand was projected to keep expanding. Thus, in the mid-1960's TVA began to develop the use of nuclear reactors for generating electricity. TVA undertook the construction of Browns Ferry Nuclear Power Plant on the Tennessee River in Alabama. This power plant was TVA's first nuclear power plant and, at the time, one of few commercial nuclear power plants in the USA.

TVA's growth in the use of thermal-power led Rex to conduct early studies regarding various aspects of the interdisciplinary field now known as environmental hydraulics. With colleagues, he investigated the hydraulics of thermally

stratified reservoirs and the design of water intakes to withdraw cooler water; they also conducted pioneering work on density currents, and on the hydraulics of diffuser-pipes for managing thermal-effluent discharges. The efficient operation of Browns Ferry Nuclear Power Plant motivated some these studies.

Rex retired from TVA in 1973 and joined Bechtel in San Francisco where he expanded and managed Bechtel's Hydraulics and Hydrology Group, which supported the design of multiple projects. In 1973, Bechtel had projects with approximately 20% of all of the U.S.'s new power-generating capacity and was extensively involved with overseas projects. Rex

oversaw a sizeable number of engineers and hydrologists involved in a broad range of projects associated with hydro- and thermal-power plants, and hydraulics issues related to large-scale mining and industrial facilities.

These projects engaged Rex with talented Bechtel engineers and connected him to hydraulic laboratories and various hydraulics experts in the U.S., including those in academia. Throughout his career, Rex worked closely with hydraulics luminaries, such as Don Harleman (Massachusetts Institute of Technology), Jack Kennedy (University of Iowa), Norm Brooks (California Institute of Technology), Vic Streeter (University of Michigan), Bob Dean (University of Florida) and many others. Rex remained with Bechtel until he retired in 1985, though he continued to consult on sundry projects that interested him.

His concern for the advancement of hydraulic engineering led Rex to take on leadership roles in the U.S. and internationally. Rex was a Vice-President of IAHR (1984-87), and chaired several IAHR committees as well as committees of the American Society of Civil Engineers (ASCE). On a personal level, he easily befriended and mentored (capable) hydraulic engineers. Rex received multiple recognitions for his contributions to hydraulic engineering. In 1978, he was elected to the U.S. National Academy of Engineering, which cited his innovations in hydraulic research, design, and operation of large water reservoirs, river navigation facilities, and hydro- and thermal-power systems. ASCE bestowed on him its Rouse Award (1984) and Hydraulic Structures Medal (1991). In the 1980s, Rex became an Honorary Member and Fellow of ASCE, and in 2009 he became an Honorary Member of IAHR. Additionally, he became a member of the Hall of Fame at OSU's College of Engineering (1999) and a distinguished alumnus of Carnegie Mellon University (2007).

Several of Rex's publications have had substantial impact. In 1949, Rex, along with TVA colleagues Alvin Peterka and George Hickox, received ASCE's James Laurie Prize for their paper Friction Coefficients in Large Tunnels. This prize is named for ASCE's first president and is awarded annually to authors whose papers make a significant contribution to civil engineering. Rex's 1965 paper, coauthored with Don Harleman, Withdrawal from Two-Layer Stratified Flow, led to improvements in water-intake design for thermal power plants on lakes and reservoirs. His 1970 paper, Internal Hydraulics of Thermal Discharge Diffusers, written with TVA colleague Svein Vigander and Norm Brooks, substantially evolved the design of diffusers for wastewater effluents. An extensively referenced publication is a chapter that Rex and Bechtel colleague, Jack Cassidy, wrote for the book *Developments in Hydraulic Engineering* (Vol. 2, 1984); the chapter, titled *Spillways for High Dams*, remains widely consulted. By the way, the book was edited by IAHR Honorary Member Pavel Novak (1918-2018), who passed away on the same day as Rex; Novak too was a major figure in the engineering of hydraulic structures.

Rex's remaining family includes his four children: Jack, Carol, Susan and Will, as well as eight grandchildren and seven great-grandchildren. He was preceded in death by his wife of 66 years, Janet Alger Elder, and by his dear companion Mary Mackey. His son Will has established a website celebrating Rex's life: <https://rexelder.life/>, which depicts the many facets of Rex's enduring legacy to his family, friends and colleagues.

Pat Ryan, Duncan Hay, Angelos Findikakos, Jack Cassidy, Jacob Odgaard, Larry Weber, Suzanne Kennedy and Rob Ettema