the Clinch River Study (a comprehensive stream study carried out during 1960–64 by the AEC, ORNL, USGS, USPHS, TVA, the Tennessee Dept. of Public Health, the Tennessee Stream Pollution Control Board and the Tennessee Game and Fish Commission) indicates that the maximum accumulation of radionuclides entering the Clinch River from Oak Ridge National Laboratory operations which might concentrate in the biomass constitutes only an insignificant part of the radioactivity in the river. Thus the river system can be likened to a pipeline with little retention or concentration of radionuclides in either the bottom sediments or the biota.

If zinc-65 is to be released into or can be transported to a marine environment, special consideration must be given to its reconcentration. Zinc is concentrated by shellfish (1000–10,000 times); as an activation product, zinc-65 is present in the waste discharged by several light water reactor power plants and, where required, special limits can be applied to its release.

The gaseous wastes discharged by nuclear fuel reprocessing plants may contain small amounts (below permissible limits) of tritium, krypton-85 and iodine-131. Only iodine is capable of being concentrated by biological processes; however, the other radionuclides may be cycled by ecological processes. Iodine-131 appears principally in the food chain which leads through milk to man and the procedures for monitoring this food chain are well developed. Environmental monitoring data again indicate radioactivity concentrations well below those of public health significance.

THERMAL EFFECTS OF STEAM ELECTRIC GENERATING PLANTS

The generation of electrical power produces waste heat which must be discharged to surface water or to the atmosphere via cooling towers. The average thermal efficiencies of different types of steam electric plants vary approximately as follows:

	Net thermal efficiency (in percent)
Modern coal fueled plant	38
Modern light water reactor	32
Future fast breeder (calculated)	40

Therefore, at the present time, a nuclear plant of current design discharges more waste heat to surface streams than a conventionally fueled plant of the same size because of a lower thermal efficiency. Of course, about ten per cent of the waste heat from a coal-fired plant is discharged to the atmosphere with the combustion gases, whereas essentially all of the heat discharged by a nuclear plant is through the water cooling system. When fast breeder reactors become operational, this disparity will be reduced.

Generally speaking, the problem of "thermal pollution" is one of degree. An increase in water temperatures can be harmful, or in some cases, beneficial to certain fish and aquatic life. The questions that must be answered are—what are the effects of small increases of temperature in various situations, and if harmful, how can these effects be avoided? The world's electric power demand will continue to grow at an ever increasing rate. Increasing quantities of waste heat will have to be dissipated, regardless of the proportion of coal-fueled to nuclear-fueled plants that are built. Large quantities of condenser cooling water (several hundred thousands gallons per minute for a 1,000 NWe plant of either type) will be required. As a result, the availability of adequate condenser cooling water is becoming a major consideration in selecting sites for these plants. Proper site selection requires information on the physical dispersion of heat in the environment and the effects of small temperature increases on the biota.

Research in this area has been underway for some time—for example, the AEC has sponsored research on the physical and biological effects of temperature on Columbia River for more than fifteen years. As a result, mathematical models are now being developed for predicting the increase in temperature of the receiving water from heated effluents which are discharged into rivers, lakes, and tidal systems. The reliability of these models is being determined against known conditions. A model has been used to predict temperatures of the Deerfield River downstream from the Yankee Atomic Reactor, Rowe, Mass., for example, and the predicted temperatures have agreed very closely with temperatures actually measured. This mathematical model development is being followed with an application of the model to the prediction of temperature increases throughout an entire river basin. The upper Mississippi River basin has been selected for the pilot effort.