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Oak Ridge National Laboratory

Health Physics Division

Date: 15 March 1950

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To: File - Reactor Safety

From: T. H. J. Burnett

Subject: Fission Products Dispersal - Estimated Hydrological Hazards

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Fission Products Dispersal -
Estimated Hydrological Hazards

Index:

Fission Products Dispersal -
Estimated Hydrological Hazards

Abstract

The disruption of an homogeneous reactor is considered and various palliative measures suggested for the control of the resultant released activity. Under a set of conservative assumptions the ingested activity at Chattanooga, without TVA aid, is computed to be 2.4 uc of mixed fission products of which 5.5×10^{-7} µc would be radiostrontium. This amount is shown emergency tolerable and a summary of White Oak Lake activity releases and a TVA sample control plan are appended.

Date: 16 March 1950

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From: T. H. J. Burnett

Subject: Fission Products Dispersal - Estimated Hydrological Hazards

Introduction

The discussion presented herein is directly related to the planned operation of an homogeneous reactor at the Oak Ridge National Laboratory site and refers throughout thereto. Certain aspects of the problems discussed may be applicable to other sites, at least in principle, and perhaps to atomic warfare defense as well.

This discussion will be primarily concerned with the problem of gross contamination of the drainage area of the reactor site and subsequent potential hazards to water users downstream. Only the hazards due to radioactivity will be tentatively evaluated.

Statement of the Problem

In general the problem at this time is how much harm would result to the public at large if an homogeneous reactor operated at Oak Ridge should suffer a catastrophe, either through accident or sabotage? In particular, since this may seriously contaminate the watershed, how will people living downstream, i. e. at Chattanooga be affected?

The first consideration is the catastrophe itself. The probability of a catastrophe ever occuring is a function of the reactor design, aside from sabotage, the possibilities for which also are affected by the intrinsic safety of design. An homogeneous reactor should be inherently relatively safe from disaster caused by sudden increases in excess reactivity through its negative power and temperature coefficients. It has been estimated (1) that the mechanical violence in such a case would be relatively small. Hence, if there is a disruption of the reactor containing shell, the contents probably can be safely contained by the biological shield, particularly if of a reinforced design with this in view. Upon the failure of the biological shield a reasonably designed gas tight building could still contain the products of such a catastrophe. However, it may be possible for sabotage to be so planned that these successive safeguards would all be ineffective. In such a case the reactor contents when liberated would in part become airborne and wind dispersed while the remainder might be locally splashed and splattered about the site vicinity and amid the ruins.

Granted a disruptive and dispersing catastrophe the next considerations are the means and extent of dispersal. In a previous unclassified paper (2) some simplified assumptions were made permitting a few estimates of the local immersion and inhalation hazards of that portion becoming airborne. Those were based on 6 months operation at an average power of 1000 KW and implied a sabotage disruptive agency, considering only the operationally accumulated fission products. In a

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(1) NAA-SR-31 "A Study of Reactor Hazards", M. M. Mills.
(2) CF #50-2-68 "Fission Products Dispersal - Partial Theoretical Consequences" Burnett to Ray.

catastrophe following reactivity induced runaway, the runaway short time fissions would produce an amount of radioactive fission products estimated (1) at two to ten times the normal shutdown level. This additional radioactivity would be of different proportional composition and relatively heavily weighted with short lived nucleides.

The airborne activity can be regarded in part as only transiently airborne, for the droplet and larger particulate components will begin at once to fall out. Subsequently dust absorption and agglomeration followed by rain will bring down much of the remainder of the activity. The resultant dispersal will be a function of the wind speed and direction and the time elapsed until it next rains. The subsequent course of the activity thus distributed over the landscape will be partly a semi-permanent adsorption by the soil, etc. on which it lands and partly a leaching into the ground water and thence into the area streams.

The splatter activity, certainly much the larger fraction, will be subject to the same partial adsorption and partial rain solution leaching. However, this fraction will be locally confined and more subject to behaviour prediction, to quantitative evaluation, and, as will be suggested later, to several possible control measures.

In either case the ultimate destination of such released activity, in the absence of control, is the rivers of the drainage area. The amount of potential hazard this might then represent is a joint function of the fission products concentration and composition, with possible hazards to humans internally from ingestion in drinking and cooking, and from external radiation, by bathing, swimming and contiguity. In addition, considerable property damage may be expected from the contamination of low-lying farmlands, of fish and livestock, of river cities' water plant equipment, and of boats, etc. However, the greatest harm would in all probability be psychological and lie in the curtailment of vital national research through public fear reaction pressure.

<u>Particular Aspects</u>

To estimate the magnitude and seriousness of any hazards to the downriver public, the necessary data are the activity concentration in the river, its qualitative composition, and the duration of its presence. The concentration is a function of the quantity of activity released, the elapsed time after the catastrophe, the rate of its entry into the river, and the dilution obtain therein. The respective fission products composition is a function of the elapsed time from the catastrophe to the potential exposure, and of the river borne silt quantity and its adsorption characteristics. The duration of the potential exposure, i. e. of the presence of activity in the river water, is a function of the total quantity released, of the elapsed time from the catastrophe, of the rate of its entry into the river, of the rates of river and tributary flows, and of the TVA dam operation characteristics.

Of these factors it is seen highly useful to maximize the time from catastrophe to exposure for this affords the greatest decrease due to radioactive decay and permits the longest soil and riverborne silt adsorption contact opportunities. Decreasing the rate of entry into the river would accomplish this and also reduce the concentration but with the possible disadvantage of increasing the exposure time. The river and tributary flow rates are fortuitously subject to limited manipulation by the mode of TVA dam operations but extreme demands for dilution would perhaps be very costly from navigation and power impairment. The degree of TVA river flow control is intricately related to the rainfall both before and after the catastrophe. With minimum rainfall, the natural flow is low, dilution is lessened, and the dam impounded volumes are needed for power, but this gives more decay through longer transit times for activity travel and permits longer holdup by downstream dams. Having heavy rainfall increases the total diluting volume available but reduces the possible hold up and decay time as well as minimizing the degree of dam discharge volume manipulations possible. Another effect of the prior rainfall histroy is on the soil retention; this is obviously less when the ground is saturated than in drougtht.

As the major quantity of rain leached activity will exit locally, it is imperative that the reactor site selected be one proffering maximum control possibilities, both physical and security, over the greatest downstream area. The lesser airborne activity portion will have a fall out area variable in location and extent with the whim of the wind and rain, but probably of highest specific contamination near the site vicinity. To màximize the control over this activity fraction, the site chosen should be back from the controlled area perimeter. Having at present a contaminated stream with a local dam for impoundment near its mouth, the logical choice for a site would be within the White Oak Creek watershed. Very much of the remaining airborne activity may still settle within the Clinch River watershed and be subject to the same control measures accorded activity discharged from White Oak Dam.

Preventive and Palliative Measures

Structural. In addition to the reinforced biological shield and gas tight reactor building mentioned above, the reactor could advantageously be constructed with its operating floor quite a bit below grade and have a generous basement. The local drainage adjacent to the ruins would thus initially tend to be towards the reactor site. Should heavy rains inundate the disaster area, the active solution thus accumulated could be tank trucked to the evaporator for treatment and storage, or otherwise tanked for recovery. In event of no rain, the same result could be accomplished by firehosing the site. Activity thus collected would be under control and to this extent lessen the downriver hazard.

Site. Having chosen the White Oak Creek watershed, it is of maximum advantage to get as near as possible to the creek headwaters. This multiplies the opportunities for effecting successive temporary hold back measures, such as earthen dikes, diversion ponds, etc. The nearness to the creek source results in a corresponingly smaller contaminated drainage volume to be controlled. This could be achieved by a low cost temporary log, dirt, and brush dam which would have a center opening adequate for normal rain. In event of disaster a simple gate could close this and impound the stream for up to several weeks, thus gaining, in addition to decay, precious time for further measures down stream, time for TVA lake level adjustments, etc. As an example if the reactor were situated at 2,502,300 E and 571,300 N (3) a highly effective emergency partial dam could be in readiness at 2,501,500 E and 569,800 N and hold back the drainage up to El. 960. Earthen reinforcement on the downstream side could be quickly borrowed from the adjacent slopes. This position, in a folded valley of Chestnut Ridge, places the site on a geologically less desirable formation, Knox dolomite, than an alternate site, say in the upper Melton branch valley, and thus it may be desirable to make special soil preparation of the area within a limited radius. Superior remoteness from the area perimeter and from the creek mouth outweigh this fault. Meterological features also favor this site choice.

Local Control. In the event of a catastrophe during a heavy rainstorm with further continuing rain predicted, the danger of loss of control of the scattered activity near the site could be met by the use of bulldozers, etc. to cover over the contaminated area with cleaner soil from nearby or at least the use of a blade to turn the top "hot" layer under. While this would not fully prevent rain leaching, it would minimize the loss and the high silt content added from the fresh turned earth would facilitate as much as possible adsorption removal (4). The time gained by an emergency dam local to the reactor site would permit manipulation of White Oak Dam so as to have maximum capacity, and the emplacement of auxiliary dikes, etc. so as to avoid hydraulic shock if the temporary reactor dam gave way.

Data on the comparative curies discharged from the Settling Basin and from White Oak Dam for recent months have been tabulated. (See Appendix 1). This shows that at present White Oak Lake is effectively a liability from the standpoint of being a radioactive waste decontamination agency. This is due to its considerable accumulation of bottom silt carrying several hundred curies of adsorbed activity. If at the time the homogeneous reactor is built, this contaminated silt were dredged from White Oak Lake bottom and cast upon the conveniently adjacent impervious Conasauga shale to the north with a retaining dike and well seeded, it would be effectively stabilized in a form of surface burial for years of decay. This would permit the opening of the lower dam gate and the drainage of White Oak Lake. The resultant standby dry lake would then become an added safeguard for better control when forced to release disaster dispersal activity into the Clinch River. By the time the reactor construction is completed the planned ecological survey of White Oak Lake will be essentially complete enough.

Cooperational. The water storage capacity of the TVA dams and the

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(3) The numerical location designation used refers to the 10,000 foot grid based on Tennessee rectangular coordinate system. See USC and GS Quadrangle map "Bethel Valley, Tennessee"

(4) See suggestion in memo "Increase in Mud Activity" Aug. 15, 1947, Burnett to Ray, not followed lest routine silting fill the lake, a consideration void in this type of emergency.

resultant control of river and tributary flows would be of considerable, but sometimes overrated aid in achieving a dilution of necessarily released activity to less serious concentrations. Certainly, collaboration with TVA would be invaluable in efficiently contacting downriver water purification plants and in navigational warnings to minimize exposure hazards.

Being subject to weather vagaries, the limitations imposed by the frequency and extent of watershed rainfall, the TVA could best plan activity dilution aid and handling if given immediate notification. A joint committee (5) with members from ORNL, AEC, and TVA could be selected to compose suitable alternate emergency plans in advance and to be impowered to act in event of such a disaster, or of atomic attack.

An operational philosophy is suggested to be based on maximum retention hold back time (for decay and adsorption) with minimum release rate (getting optimum dilution) until, having waited as long as possible, a final purge is effected with stored dilution volumes added in such a manner as to get speediest flow-thru rates past such a center as Chattanooga (minimizing population exposure times), unless weather permits continued hold back until it were possible to stay within a reasonable factor of tolerance by continuing minimum release rates. An illustrative example of such an emergency plan is presented in detail in Appendix 2. Control of river flow transit times can be utilized in some cases to give additional decay time.

When face to face with the eventuality of a limited populance having to use contaminated water for a few days, if this should be seen likely to exceed an arbitrary emergency level for ingestion, then auxiliary special temporary filtration or purification measures could be employed, as with army equipment and aid. Combined with the portage of beverage and cooking water, such temporary measures could achieve satisfactory protection, although at the cost of providing a situation illustrative of atomic warfare attack (having considerable compensatory practice value).

Hazard Evaluation

Safety is considered herein as being a relative concept. Hazards are generally probability functions and people in daily life are normally protected by the compounding of improbabilities. From this standpoint it is not thought feasible to unduly alarm a population group by the remote likelihood of sometime having to use for a few days water contaminated by a group of radioactive fission products, a few of which may be present therein to such a concentration that they may fix in the body to produce a few times the "tolerance" dose for a short time and a fraction thereof for somewhat longer. However, no reasonable precaution should be foregone to avoid such ultimate necessity and to palliate its consequences. Preferably the contingent hazards from reactor research should be relatively much less than the ordinary perils besetting normal living.

In making an estimate of the maximum level of water contamination in the Tennessee River at Chattanooga at some time after a reactor catastrophe, the average flow rate values will be used. A comparison then with the recorded minima will permit an estimate of the upper limit of hazard to be anticipated under adverse conditions.

(5) As initially suggested in "Emergency Dilution Volumes Available from TVA Reservoirs" a presently unpublished report by L. R. Setter.

In Table I is shown the successively increasing drainage areas as one progresses downstream illustrating the increase in dilution possible on the assumption of uniform rainfall. Much more valuable is the consideration of these relative areas with a recognition of the unlikelihood of uniform rainfall.

Table I (6)

River Basin	Drainage Area, Sq. Mi.
Clinch	4,413
Tennessee	40,910
Ohio	204,000

Table II presents the average unregulated river flow rates at several TVA dams, the minimum recorded daily natural flow rate (summer, 1925) and the distance from White Oak Creek to these dams. All except Norris are on the Tennessee River and the distances are in river miles downstream.

Table II (6)

Dam or Location	Average Unregulated Flow c.f.s	Minimum Daily Natural Flow c.f.s.	Distance
White Oak (7)	7.5	?	0.0
Norris	4,100	200	-59.2*
Watts Bar	26,400	2900	58.4
Chickamauga	36,500	3200	117.3
Chattanooga	-	-	124.2
Hales Bar	38,000	3300	164.1
Guntersville	42,000	3600	246.2
Wheeler	49,000	3900	320.3
Wilson	50,500	4000	335.8
Pickwick	54,000	4100	388.5
Kentucky	65,000	4500	572.8
Paducah	-	-	595.2

*upstream on the Clinch River

(6) Data presented herein is excerpted from TVA Technical Monograph No. 55 "Engineering Data"

(7) See ORNL-562, "Studies of the White Oak Creek Drainage System, I"
by Setter and Kochtitzky 1950

The estimate used for the quantity of activity entering the Clinch River after a reactor catastrophe is 60%. This is obtained by considering that one third of the 20% possibly airborne will fallout in the site vicinity and that of the remaining 80% at least a third will stay behind in the debris in such a manner that its release can be prevented. Only the most extreme circumstances of rainfall etc. following such a catastrophe could prevent the reduction of this estimated amount by a factor of three or better, through various control measures. The second hypothesis is that the release of the 60% reactor activity will be as a result of sabotage and that the quantities of fission products and decendants present are those as a result of 6 months operation at a megawatt. The third assumption is that the discharge of this portion of the released activity into the Clinch River can be deferred at least two days. Except for rather extreme adverse weather conditions it should be possible to hold back this activity more than a week with suitable action and the aid of precautionary structures and design. A fourth assumption is that the release of the activity can be extended over a period of 5 days. Certainly one can imagine a flood condition where the release is necessarily at a rate greater than this, but such a flood would give a compensatory greater dilution volume.

Using the Way-Wigner energy release estimate[2] there is present 10.7×10^{15} mev/sec gamma and 11.8×10^{15} mev/sec beta at time T = two days afterward. Considering just the beta and assuming 1 mev/disintegration this gives* 3.19×10^{5} curies, 60% of which, 1.91×10^{5} curies, is destined for the Clinch River. The first day of release one fifth of this, 3.8×10^{4} curies, is added to 10^{13} cc** giving an average concentration of 3.83×10^{-3} µc/cc. The fifth day of release, T = 7, this would be down to 2.44×10^{4} curies by decay, so it is seen that under those conditions the first day's discharge would give the highest concentration.

It is necessary to make two further estimates, to carry this study to Chattanooga. Estimate five is that the stream velocity is 2 miles per hour. This value is perhaps somewhat on the low side since Clinch River flows may often be in the range 2-4 mph and this would give a slower transit time and a lower exposure. However the rate of flow varies with the volume and the higher rates would be associated with larger volumes so that less transit decay is offset by increased dilution. As the larger reservoirs are entered the effective through flow rate is lessened, giving further delay time not here used. Estimate six is that a portion of the solution activity in the river will by natural clay ion exchange adsorb on the normal waterborne silt burden. Experience at White Oak Dam would suggest that ordinarily much more than 30% of the total waterborne activity is adsorbed on and associated with the silt content therein. In an emergency, such as considered here, it were reasonable and expedient to increase the silt content and improve as much as possible the adsorption removal. The river slows down on entry into an impounded dam pool, especially if through TVA cooperation, discharge is stopped and the turbine intakes closed. The result is that this velocity change causes part of the waterborne silt to settle and by skimming the dam pool for subsequent discharge such silt and its associated activity can be left in place until a later time. A reasonable guess we may consider 40% of the silt to settle.Further, one may wonder at the likelihood of partial release of the adsorbed activity from silt by pH

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(2) See CF #50-2-68 again.
*Using the project standard curie = 3.7×10^{10} dis/sec.
**4100 c.f.s. $\times 2.832 \times 10^{4}$ cc/c.f. $\times 8.64 \times 10^{4}$ sec/da. = 100.3×10^{11} cc/da.

change when taken into a water filtration plant. Some of the activity may be released, of which a part may be readsorbed on the treatment floc. For a safe value let us use a net of 60% activity release to solubility from silt. With these assumed values the interaction by the silt results in a reduction factor of 0.81***.

The volume change from increase in average flow rate (Table II) will reduce the first release day's discharge concentration from 3.83×10^{-3} µc/cc at the White Oak Creek entry point into the Clinch to 5.95×10^{-4} µc/cc at Watts Bar. The 1.21 days transit time decay (T = 4.21) will have further decreased this to 4.57×10^{-4} µc/cc. Ignoring any TVA hold up and dilution improvements the average flow rate increase will further reduce this concentration to 3.31×10^{-4} µc/cc at Chickamauga and the additive transit time decay at Chattanooga will be another 1.37 days (T = 5.58) which will bring it down to 2.97×10^{-4} µc/cc. Applying now the silt benefit factor, a resultant net concentration in the Chattanooga water would be 2.41×10^{-4} µc/cc. This ignores considerable reductions possible by control efforts at several different points. Extension of the same considerations of flow rate and transit time would yield a concentration of 8.8×10^{-5} µc/cc upon discharge into the Ohio River at Paducah.

Assuming a consumption of 2 liters per day (and neglecting decay reduction) five days usage of this water at Chattanooga would give a total ingestion of 2.4 uc of the mixed fission products. Just a few fission products have long enough radioactive half lives to potentially constitute an ingestion hazard at concentrations this low and of these few but a small fraction tend to be retained by the body. Strontium is about the only one of these and values agreed upon recently (8) for it by comparison with radium are 1.0µc for Sr^{89} or 0.5 µc for Sr^{90}. These amounts are based on the radiotoxicity of radium being 10 times that of $Strontium^{89}$. Thus to get 0.5 µc in the bone it would be necessary to ingest from 1.2 to 15.4 µc. Using the fission yield of strontium and considering only dilution by five days flow volume (ignoring decay and silt removal) the following data is obtained.

Table III

Fission Product Isotope	Total Curies at T = 0	River Concentration at Chattanooga	Ingested in Five Days
$Strontium^{89}$	40,600	5.5×10^{-11} µc/cc	5.5×10^{-7} µc
$Strontium^{90}$	667	9.0×10^{-13} µc/cc	9.0×10^{-9} µc

From the above it is seen that it would take a very long time to acquire a tolerance amount of Strontium by drinking river water. Similar demonstration can be made for other less hazardous elements with even more favorable results. If it is objected that the river flow would spread out the activity so that more than five days exposure results, this is offset by the concurrent dilution improvement. In spite of using average rather than minimum flows (which are less

***At first: 70% in solution, 30% in silt. Of the latter 40% settled, leaving 18% of the original total. 60% of this may go back into solution when treated adding 10.8% to the initial 70%.

(8) Minutes of the Permissible Doses Conference at Chalk River, Canada.

only by about a tenth) and assuming uniform mixing this is felt to be a conservative estimate not underrating any real hazard. Much real improvement in these figures would be realizable in any actual case by utilizing various of the suggested measures. Hazards from swimming and bathing in this water are of much lower magnitude than ingestion and the same is true of contamination resultant. Further study of algal accumulation would be merited and in any real case a survey would be needed for the final answer. Civilian defense radiological protection personnel would be afforded excellent practice thereby.

Conclusions

The hazard from waterborne activity, released by catastrophic destruction of an homogeneous reactor after six months operation at a megawatt, is seen to be controllable by structural design, site choice, auxiliary safeguards and cooperative temporary dam control by TVA. Evaluated on a conservative basis, it is seen that an activity level in the drinking water of Chattanooga is reached which is not harmful for a short period of beverage use. Special arrangements for intervening farmers, etc. would be required. It is possible to conceive a combination of simultaneous remote contingencies which together could increase this hazard, but not to the level of resultant fatalities. If such were to transpire alternate control measures would still be possible although more difficult.

T. H. J. Burnett

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FISSION PRODUCTS DISPERSAL

Estimated Hydrological Hazards

Appendix 1 - Figure 1 on reverse

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F. P. Dispersal - Estimated Hydrological Hazards

Appendix 1

Subject: A Study of White Oak Lake - Excess Curie Releases.

In the following Table IV the total curies discharged per week from the Settling Basin into White Oak Creek and Lake, and from White Oak Lake into the Clinch River are given. The difference is shown weekly as the amount by which the activity discharged from the lake exceeds that discharged into it, and a cumulative total of this weekly excess is presented, beginning with the week ending September 25, 1949.

Table IV

Week Ending	Curies Discharged		Excess Lake Discharge		
	Settling Basin	White Oak Dam	Weekly	Cumulative	CF#
9-18-49	41.19	12.12	-29.07		49-9-159
9-25-49	6.85	15.57	8.72	8.72	49-9-240
10-2-49	6.51	9.34	2.83	11.55	49-10-42
10-9-49	4.31	7.33	3.02	14.57	49-10-102
10-16	17.25	6.45	-10.80	3.77	49-10-177
10-23-49	12.14	13.45	1.31	5.08	49-10-202
10-30-49	6.01	7.84	1.83	6.91	49-11-66
11-6-49	6.93	17.91	10.98	17.89	49-11-142
11-13-49	7.26	3.17	- 4.09	13.80	49-11-191
11-20-49	3.64	2.91	- 0.73	13.07	49-11-264
11-27-49	6.45	2.35	- 4.10	8.97	49-12-23
12-4-49	8.89	2.95	- 5.94	3.03	49-12-31
12-11-49	4.80	3.55	- 1.25	1.78	49-12-73
12-18-49	1.75	10.87	9.12	10.90	49-12-135
12-25-49	2.44	11.48	9.04	19.94	50-1-3
1-1-50	2.76	4.53	1.77	21.71	50-1-34
1-8-50	2.73	12.75	10.02	31.73	50-1-105
1-15-50	2.71	13.93	11.22	42.95	50-1-119
1-22-50	3.95	15.91	11.96	54.91	50-1-152
1-29-50	7.68	8.61	0 .93	55.84	50-2-18
2-5-50	3.79	31.47	27.68	83.52	50-2-56
2-12-50	9.67	30.62	20.95	104.47	50-2-103
2-19-50	2.85	4.79	1.94	106.41	50-3-11
2-26-50	3.38	2.88	- 0.50	105.91	50-3-24
3-5-50	2.91	5.37	2.46	108.37	
Total	178.15	258.15			

Liquid Waste Disposal Weeklies

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It is seen that over the past five months White Oak Lake has discharged over 108 curies of its previous years' accumulation, the amount by which output exceeds input. This may be ascribed in part to the action of the winter rains, a cause also operative at other seasons. The justification for permitting the continuation of this controllable activity dispersal is the potential value to result from an ecological survey of the contaminated drainage area. Such a survey may give significant information of the precise effects of contamination in the aquatic environment on natural life forms and balance. This activity release could be prevented by dredging the silt accumulation from the lake bottom and seeding it heavily to prevent dust dispersal after putting it up on the nearby impervious shale bank to the north.

Figure 1 illustrates graphically the relative balance of input and discharge curies in the White Oak Lake.

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FISSION PRODUCTS DISPERSAL

Appendix 2 Figure 2 on reverse

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F. P. Dispersal - Estimated Hydrological Hazards

Appendix 2

Subject: Illustrative Emergency Plan - TVA Cooperative Dilution

The schematic diagram of the TVA major dams on the left facing page shows their relative position and their location in miles above the mouth of their respective rivers.

Based on an operational philosophy of maximum hold back time, minimum release rate and a final purge past major population centers the following details are illustrative of how a control plan might operate.

Immediately after the disaster, discharges from Norris would cease or be minimized in order to accumulate extra water for subsequent dilution and purge needs. At the same time, maximum discharge would be made from Fort Loudon, Fontana and Watts Bar dams so that the pool in Watts Bar dam could be lowered and later held. Discharges from Cherokee and Douglas dams would be minimized or cease to insure adequate subsequent additional dilution and purge flows. This would continue until it became necessary at ORNL to begin the release of activity. This release should be begun before White Oak Dam is overtopped lest a local rain destroy control at this point.

When the release of activity is begun the flow from Norris should continue to be held back until spillover. With the beginning of activity release the pool in Watts Bar is held stationery to minimize the flow rate in the Clinch, and Fontana and Fort Loudon continue their discharge rates controlled by the Watts Bar pool level and discharge. An activity monitoring point would be established at Clinch Mile 0.0 and when the arrival of released activity was observed further discharge from Ft. Loudon and Fontana would cease. The discharge from Watts Bar would continue until a new monitoring station 2 miles up-stream from the dam face indicated the certain arrival of the activity. Watts Bar would then be closed and the pool allowed to slowly rise. Meanwhile Chickamauga and Hiwassee would have been discharging at maximum but now Hiwassee is closed to accumulate water for the ensuing dilution and purge needs. Chickamauga is drawn down to minimum pool while the activity is held back by Watts Bar until the spillover point is reached. An activity monitoring station is then set up at Chickamauga and upon arrival of the contaminated overflow from Watts Bar the Chickamauga discharge is ceased. Hales Bar is reduced in level to minimize any flood effects from the subsequent purge operation and Chickamauga is allowed to slowly fill from Watts Bar and Hiwassee overflows. When the activity can no longer be held back at Chickamauga the Chattanooga water plant is alerted and Chickamauga is opened to maximum flow, drawn down as far as possible, then closed again for a survey of the needs for further flushing upstream. Watts Bar could then be opened, drawn down to a minimum and then closed to store the Clinch flow purged by releasing the Norris stored water. With dilution from Fort Loudon and Fontana, Watts Bar could then be reopened after Chickamauga had been drained

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again and flushed with the flow from Hiwassee in the meanwhile.

A disaster emergency dilution plan coordinated by ORNL, AEC, and TVA, such as the illustrative rough example above, could minimize any harm to a down stream community that might result from reactor sabotage, accident or warfare.

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F. P. Dispersal - Estimated Hydrological Hazards

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8. Minutes of the Permissible Doses Conference, held at Chalk River, Sept. 29-30, 1949.
9. Liquid Waste Disposal Weekly Reports - various, see Table IV for Central Files memo numbers.
10. Summary Report of the Reactor Safeguard Committee by Wheeler et al.
11. ORNL 527 "Homogeneous Reactor Preliminary Process Design Report"

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