

~~SECRET~~

ORNL  
MASTER COPY

ORNL 165  
WASTE DISPOSAL

CLASSIFICATION UNCLASSIFIED

INTL (DOE/Office)

*[Handwritten signature]*

OAK RIDGE NATIONAL LABORATORY  
P.O. BOX 217  
OAK RIDGE, TENNESSEE 37831

LABORATORY  
INVESTIGATION  
100

MINUTES OF CONFERENCE ON LIQUID WASTE DISPOSAL

AUGUST 23-25, 1948

(HEALTH PHYSICS BUILDING)

~~SECRET~~

Per Letter Instructions Of

*[Handwritten signature]*

for E. L. ...  
Laboratory ...

~~SECRET~~  
THIS DOCUMENT CONTAINS INFORMATION OF A CONFIDENTIAL NATURE  
WHICH IS THE PROPERTY OF THE NATIONAL BUREAU OF STANDARDS  
AND MAY BE SUBJECT TO PATENT RIGHTS. IT IS TO BE KEPT IN A  
SAFE PLACE AND NOT TO BE LOANED, REPRODUCED, COPIED, OR  
DISTRIBUTED IN ANY MANNER TO AN UNAUTHORIZED PERSON OR  
ORGANIZATION AND MAY RESULT IN SEVERE CRIMINAL PENALTY.

P. S. EASLEY, CHIEF / O & A / 113060  
ENTRANCE BARR

OAK RIDGE NATIONAL LABORATORY

OPERATED BY  
CARBIDE AND CARBON CHEMICALS CORPORATION  
FOR THE  
ATOMIC ENERGY COMMISSION

POST OFFICE BOX 7  
OAK RIDGE, TENNESSEE

~~SECRET~~

~~CONFIDENTIAL~~

Report Number: CRNL-163

This document consists of 43 pages.

Copy No. 10 of 134 copies.

Series A. ISSUED *Central files*

MINUTES OF CONFERENCE ON LIQUID WASTE DISPOSAL

August 23 - 25, 1948

(Health Physics Building)

DATE ISSUED

NCV 2 - 1948

OAK RIDGE NATIONAL LABORATORY

operated by  
Carbide and Carbon Chemicals Corporation  
for the  
Atomic Energy Commission  
Post Office Box P  
Oak Ridge, Tennessee

This document contains restricted data within the meaning of the Atomic Energy Act and/or information on the National Defense Production Act. The transmission or the disclosure of this information in any manner to an unauthorized person is prohibited and may result in a civil or criminal penalty.

~~CONFIDENTIAL~~

DISTRIBUTION:

- |        |                                       |          |  |
|--------|---------------------------------------|----------|--|
| 1.     | G. T. Peubeck (C&CCC N.Y.-N.Y.)       | 59-66.   | Argonne National Laboratory                          |
| 2-4.   | 706-A Library                         | 67-68.   | AEC, Washington                                      |
| 5.     | 706-B Library                         | 69-76.   | Brookhaven National Laboratory                       |
| 6.     | Biological Library                    | 77.      | Bureau of Ships                                      |
| 7.     | Health Physics Library                | 78-79.   | Carbide & Carbon Chemicals Corporation, (K-25 Plant) |
| 8.     | Training School Library               | 80-86.   | General Electric Company, Richland                   |
| 9-13.  | Central Files                         | 87.      | Hanford Operations Office                            |
| 14.    | L. C. Bardwell                        | 88-89.   | Kellogg Corporation                                  |
| 15.    | C. F. Cagle                           | 90-93.   | Knolls Atomic Power Lab.                             |
| 16.    | R. A. Orr                             | 94-99.   | Los Alamos   |
| 17.    | E. B. Ashcraft                        | 100-107. | Monticello Laboratory                                |
| 18.    | A. Hollaender                         | 108-109. | National Bureau of Standards                         |
| 19.    | J. H. Frye, Jr.                       | 110-111. | Naval Radiological Defense Laboratory                |
| 20.    | E. J. Murphy                          | 112.     | New York Operations Office                           |
| 21.    | M. D. Peterson                        | 113.     | Patent Advisor, Washington                           |
| 22.    | C. N. Rucker                          | 114-128. | Technical Information Division, ORO                  |
| 23.    | J. C. Stewart                         | 129-132. | University of California Radiation Laboratory        |
| 24.    | A. V. Weinberg                        | 133-154. | University of Rochester                              |
| 25.    | E. M. Blanco                          |          |  |
| 26.    | H. N. Browder                         |          |  |
| 27.    | T. H. J. Burnett                      |          |  |
| 28.    | F. L. Culler, Jr.                     |          |  |
| 29.    | J. C. Hart                            |          |  |
| 30.    | I. R. Higgins                         |          |  |
| 31.    | B. H. Ketelle                         |          |  |
| 32.    | P. B. Orr                             |          |  |
| 33.    | D. G. Reid                            |          |  |
| 34.    | F. L. Steahly                         |          |  |
| 35.    | R. Stoughton                          |          |  |
| 36.    | J. A. Swartout                        |          |  |
| 37.    | F. Western                            |          |  |
| 38.    | C. E. Winters                         |          |  |
| 39.    | E. J. Wolkowski                       |          |  |
| 40-41. | R. J. Moxton                          |          |  |
| 42-43. | K. Z. Morgan                          |          |  |
| 44.    | S. R. Sapirie (AEC-Townsite)          |          |  |
| 45.    | H. M. Roth (AEC-Townsite)             |          |  |
| 46.    | W. B. Alford (AEC-Townsite)           |          |  |
| 47.    | J. Deal <i>L. B. Emlet</i>            |          |  |
| 48.    | A. H. Holland, Jr. (AEC-Townsite)     |          |  |
| 49.    | J. W. Ruch (AEC-Townsite)             |          |  |
| 50.    | H. G. E. Stoeckle, Jr. (AEC-Townsite) |          |  |
| 51-58. | Central Files (Far-Off Plant)         |          |  |

"This document contains restricted data within the meaning of the Atomic Energy Act of 1946 and/or information affecting the National Defense of the United States within the meaning of the Espionage Act, 50 U.S.C. 31 and 32 as amended. Its transmission or the revelation of its contents in any manner to an unauthorized person is prohibited and may result in severe criminal penalty.

~~SECRET~~

CONTENTS

- I. DELEGATES TO CONFERENCE.
- II. AGENDA.
- III. INTRODUCTION.
- IV. PURPOSE.
- V. LIQUID WASTE DISPOSAL SYSTEM AT OAK RIDGE NATIONAL LABORATORY.  
E. J. Witkowski.  
P. B. Orr
- VI. EFFECTIVENESS OF PRESENT WASTE DISPOSAL SYSTEMS AT OAK RIDGE NATIONAL LABORATORY.  
K. Z. Morgan
- VII. BURIAL GROUNDS FOR SOLID WASTE DISPOSAL.  
P. B. Orr
- VIII. RELATED RESEARCH ON ION EXCHANGE.  
J. A. Swartout
- IX. RARE EARTH SEPARATION STUDIES.  
B. H. Ketelle
- X. SCAVENGER TECHNIQUES.  
R. W. Stoughton
- XI. SUMMARY OF TECHNICAL DIVISION ACTIVITY ON LIQUID WASTE DISPOSAL PROBLEMS.  
F. L. Steahly
- XII. ION EXCHANGE DEVELOPMENT IN THE TECHNICAL DIVISION.  
I. R. Higgins - R. E. Blanco
- XIII. DEVELOPMENT OF AN EVAPORATION SYSTEM FOR OAK RIDGE NATIONAL LABORATORY LIQUID WASTE DISPOSAL.  
C. E. Winters
- XIV. DESIGN OF AN EVAPORATION SYSTEM FOR OAK RIDGE NATIONAL LABORATORY LIQUID WASTE DISPOSAL.  
F. L. Culler, Jr.
- XV. THE WASTE DISPOSAL PROGRAM UNDERTAKEN BY THE HEALTH PHYSICS DIVISION.  
Forrest Western
- XVI. PROPOSAL FOR A CENTRAL BURIAL GROUND FOR OAK RIDGE OPERATIONS  
J. Deal

~~CONFIDENTIAL~~

I. DELEGATES TO CONFERENCE

Argonne

Mr. W. A. Rodger

Dow Chemical Company

Dr. J. Grebe  
Mr. L. A. Mathison

Monsanto Chemical Company

Dr. M. N. Haring  
Dr. F. C. Mead

Oak Ridge National Laboratory

Dr. D. C. Bardwell  
Mr. R. E. Blanco  
Mr. F. N. Browder  
Mr. T. H. J. Burnett  
Mr. F. L. Culler, Jr.  
Mr. L. B. Emlet  
Mr. J. C. Hart  
Mr. I. R. Higgins  
Mr. B. H. Ketelle  
Dr. F. T. Miles  
Dr. K. Z. Morgan  
Mr. P. B. Orr  
Mr. D. G. Reid  
Mr. C. N. Pucker  
Dr. F. L. Steahly  
Dr. R. Stoughton  
Dr. J. A. Swartout  
Dr. F. Western  
Dr. C. E. Winters  
Mr. E. J. Witkowski

Carbide and Carbon Chemicals Corporation, K-25

Dr. F. W. Hurd  
Mr. S. Visner

DELEGATES TO CONFERENCE (Con't)

Carbide and Carbon Chemicals Corporation, Y-12

Mr. H. W. Saylor  
Mr. E. Struchness

AEC, Division of Engineering, Washington

Commander E. W. Hribar  
Mr. H. Noble  
Mr. R. S. Warner, Jr.

AEC, Schenectady

Mr. F. R. Lasche

AEC, Office of Research and Medicine, Oak Ridge

Mr. W. B. Allred  
Mr. J. Deal  
Dr. A. H. Holland, Jr.  
Dr. H. M. Roth  
Mr. J. W. Ruch  
Dr. H. G. E. Stoeckle, Jr.

II. AGENDA OF CONFERENCE

Monday, 10:00 A. M., August 23

Chairman: H. M. Roth

Part I - Waste Disposal Program Currently in Effect at Oak Ridge . . . . . L. B. Emlet or alternate

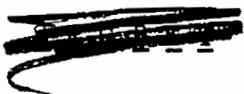
- A. Types of waste resulting from local plant operations.
- B. Methods of storage and/or disposition of these wastes.
- C. Types of waste received from other sites.
- D. Activity standards used as a guide in determining the ultimate disposition of waste materials.

Monday, 2:30 P. M., August 23

Chairman: A. H. Holland, Jr.

Part II - Effectiveness of Present Waste Disposal Systems at Oak Ridge . . . . . K. Z. Morgan

- A. Summary of results of tests of activity levels along the White Oak Creek and Lake.
- B. Natural ion exchange reaction of clay.
- C. Discussion on the burial grounds used for disposition of solid waste . . . . . P. B. Orr
- D. Type of stratification in the region.
- E. Discussion of analyses of soil samples for determining the degree of soil adsorption and degree of activity levels.
- F. Effectiveness of algae as a medium to concentrate activity.



II. Agenda of Conference - Con't.

Tuesday, 9:00 A. M., August 24

Chairman: D. C. Bardwell

Part III - Related Research and Development  
Programs at Oak Ridge

- A. Chemistry Division . . . . . J. A. Swartout
  - 1. Ion exchange . . . . . J. A. Swartout
  - 2. Rare earth separations . . . . . B. H. Ketelle
  - 3. Scavenger techniques . . . . . R. W. Stoughton
- B. Technical Division . . . . . F. L. Steahly
  - 1. Ion exchange . . . . . I. R. Higgins
  - 2. Concentration . . . . . C. E. Winters  
F. L. Culler
- C. Health Physics Division . . . . . F. Western
- D. Operations Division . . . . . L. B. Emlet
- E. AEC - Research and Medicine . . . . . J. Deal



III. INTRODUCTION

A committee consisting of representatives from Dow and Monsanto Chemical Companies, Argonne National Laboratory, and Division of Engineering, AEC, Washington, has been formulated to study the AEC-wide problem of disposing of process waste solutions. The members are:

- S. Lawroski, Argonne, Chairman  
(W. A. Rodger, Argonne, Alternate)
- J. Grebe, Dow Chemical Company
- L. A. Mathison, Dow Chemical Company
- W. Hurschkind, Dow Chemical Company
- M. N. Haring, Monsanto Chemical Company
- F. C. Mead, Monsanto Chemical Company
- J. H. Hayner, Division of Engineering, AEC,  
Washington
- (H. Noble, Division of Engineering, AEC,  
Washington, Alternate)

The committee, in its investigation of the problem, plans to visit the various sites which are confronted with disposing of process waste solutions and which have experience in handling them.

IV. PURPOSE OF CONFERENCE

It is proposed to ascertain the nature of the waste disposal problems confronting the Oak Ridge plants and to determine the scope and nature of the research and development related to the problem.

V. LIQUID WASTE DISPOSAL SYSTEM

at  
Oak Ridge National Laboratory

by E. J. Witkowski  
P. B. Orr

SUMMARY

This report is divided into two main sections. The first is a general review of the facilities available for handling liquid waste solutions with brief statements of mud and water contamination in White Oak Creek and the Clinch River. The second part includes a flow chart and a more detailed description of the handling of liquid waste solutions.

A. GENERAL

The liquid waste disposal system, commonly known as the Tank Farm Area, is divided into three sections, as follows:

1. The North Farm - consisting of two, 4400-gallon, and two, 40,000-gallon-Gunite tanks.
2. The South Farm - consisting of six, 170,000-gallon-Gunite tanks; one, 1300-gallon-Gunite tank connected to an 800-gallon, stainless steel tank.
3. Settling Basin Area - consisting of a large earthen-diked pond of 1,600,000-gallon capacity and a smaller, 32,000-gallon Retention Basin. Two other ponds are provided for emergency use only.

All of the Gunite tanks are of similar construction regardless of size. The tanks are constructed of reinforced concrete, five inches thick, with dome-shaped tops. The inside wall is painted with a water-proofing compound. Approximately six feet of earth is used as shielding on top of each of the tanks. The tanks are set on a concrete saucer four feet larger in diameter than the tank. The saucer is filled with crushed rock to the top of the side wall of the tank and thus provides a French drain which is piped to a drywell. The drywells of all tanks drain to the Retention Pond in the Settling Basin Area. The Retention basin is sampled at four-hour intervals. Any increase in the activity dictates an investigation of the individual drywells. To the best of our knowledge, the tank walls are intact.

The Settling Basin is a dredged pond about 200 feet square and six feet deep. The waste waters enter the pond through five, eight-inch lines to a weir box which spans the north side of the pond.

The water is discharged through a similar weir to White Oak Creek. Between the inlet and exit weir boxes are a series of floating surface baffles to insure effective mixing and to prevent algal growth from drifting into the exit weir. The Retention Pond is a dredged basin about twenty-five feet square and two feet deep. It is used merely as a hold-up basin.

In general, three types of wastes are handled in the Tank Farm Area:

1. Chemical waste solutions containing varying amounts of radioactive salts and particles. These waste solutions originate in the Chemistry labs, the processing plants, and the Pile Building. A flow of about 430,000 gallons a day with an average activity of approximately one hundred beta counts/min/cc is piped directly to the Settling Basin for disposal in White Oak Creek. A smaller volume (7,000 gallons/day) with activities in excess of 25,000 beta counts/min/cc is collected in the Granite tanks and allowed to decay for thirty to sixty days before being disposed of through the Settling Basin to White Oak Creek.
2. Metal waste solutions containing uranium, plutonium, and fission products are received at the rate of 5,300 gallons/month for storage in the Granite tanks. To conserve tank storage space these solutions are treated periodically with a fifty-percent caustic solution to precipitate the Source and Fissionable materials. The supernatant is then decanted to the chemical waste system for disposal in White Oak Creek. The precipitation treatment reduces the volume by a factor of two. At the present time approximately 132,460 kg of uranium are stored in a volume of 540,000 gallons.
3. Miscellaneous waste solutions from other AEC installations are received in drums and specially-designed, lead-shielded pots. These solutions vary in composition. Some contain Source and Fissionable materials which are handled in the metal waste system. Others are aqueous fission product solutions which are handled with the chemical wastes. Occasionally solvent solutions are received in which case the solvent is removed by steam distillation and the activity is transferred to the tanks.

White Oak Creek is a small stream running along the south boundary of the Settling Basin. Its flow varies from 0.7 cu. ft. to 24.5 cu. ft/second, depending upon the rainfall. About two and a half miles below the Settling Basin is a dam to retard the flow and allow further

settling of radioactive materials. The White Oak Creek empties into the Clinch River about a half mile downstream from the dam.

The amount of activity discharged from the Settling Basin to the White Oak Creek is limited to five curies/day. This limit is controlled by the flow rate and activity discharged from the Gunito chemical waste tanks.

Mud samples taken in the upper part of the lake formed by the dam on White Oak Creek range from ninety to 25,000 counts/min/gm of mud. The highest detected in the mud of the Clinch River below the mouth of the White Oak Creek showed 116 counts/min/gm of mud. Water flowing over the White Oak Creek dam averages ten counts/min/cc, while just above the K-25 plant side on the Clinch River the water measures 1.6 counts/min/cc.

## B. OPERATION

### 1. Chemical Waste Solutions:

The following facilities of the Tank Farm Area are used in handling the chemical waste solutions:

<u>Tank No.</u>	<u>Capacity</u>	<u>Location</u>
W-1	4,400-Gallon-Gunito	North Farm
W-2	4,400-Gallon-Gunito	North Farm
W-5	170,000-Gallon-Gunito	South Farm
W-6	170,000-Gallon-Gunito	South Farm
W-11	1,300-Gallon-Gunito	South Farm
W-12	800-Gallon Stainless Steel	South Farm
Settling Basin	1,600,000 Gallons	Settling Basin Area
Retention Pond	32,000 Gallons	Settling Basin Area

For ease in handling, the chemical waste solutions are divided into two groups:

- a. Large volume (average of 430,000 gal/day) and low activity wastes (average of 100 beta counts/min/cc) originate from the floor drains, laboratory sinks, canal overflow, and the operations in the Rolling Mill and Fan House. These waste solutions are for the most part piped directly to the Settling Basin.
- b. Small volume (average of about 7,000 gal/day) and high activity (in excess of 25,000 counts/min/cc) wastes originate in the various processing buildings, fan seals, stack drains, laboratory hot sinks, or as shipments from other AEC installations. These wastes enter either the catch tanks (W-1 and

W-2) or the diversion tank (W-12). The solutions collected in the catch tanks (W-1 and W-2) are neutralized with sodium carbonate and sampled. If the activity is less than 25,000 counts/min/cc, the solution is disposed of to the Settling Basin. If the activity is in excess of this limit, the solution is collected in one of the hold-up tanks (W-5 or W-6). The diversion tank (W-12) is equipped with an automatic steam jet which transfers the waste solution to one of the hold-up tanks (W-5 or W-6).

The collected solutions in the hold-up tanks (W-5 and W-6) are maintained alkaline by sodium carbonate. Under present conditions all solutions in the hold-up tanks are allowed to decay for approximately one month before disposing of to the Settling Basin. The alkaline condition of the solution in the hold-up tanks causes some precipitation of the various activities while additional decontamination of the waste solution is realized, due to the carrier action of foreign matter, as the supernatant is passed through the Settling Basin.

## 2. Metal Waste Solutions:

The uranium and plutonium waste solutions originate in the chemical processing buildings or the laboratories, while small quantities are received from other AEC sites. These metal bearing wastes are stored in the following tanks:

<u>Tank No.</u>	<u>Capacity</u>	<u>Location</u>
W-3	40,000-Gallon-Gunito - For Al, Pu, U Wastes	North Farm
W-4	40,000-Gallon-Gunito)	North Farm
W-7	170,000-Gallon-Gunito)	South Farm
W-8	170,000-Gallon-Gunito) - For Pu, U Wastes	South Farm
W-9	170,000-Gallon-Gunito)	South Farm
W-10	170,000-Gallon-Gunito)	South Farm

~~When the Tank Farm Area was designed in 1943, only three years' operation of the plutonium pilot plant was expected. The continuing operation of the Laboratory and increased uses of uranium indicated that the storage capacity of the metal waste tanks would be exceeded by 1949. To reduce the volume of the waste to be stored, the uranium and plutonium is precipitated in the Gunito tanks by the addition of fifty-percent caustic soda solution. After a settling period, the supernatant liquor containing about 0.005% U is decanted to the chemical waste system and to White Oak Creek.~~

3. Miscellaneous Waste Solutions:

The liquid waste solutions received from other AEC installations contain either Source and Fissionable material or radioactive salts. They are disposed of by jetting from the shipping container into the appropriate system in the Tank Farm Area.

NOTE:

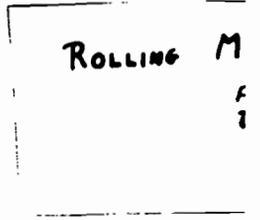
Development work is proceeding on a concentration process for the high activity chemical waste solutions. It is expected that an evaporator will soon be installed in the Tank Farm Area to treat about 7,000 gallons of waste/day to reduce the volume by a factor of twenty. This concentrated solution will then be stored rather than disposing of the activities through the Settling Basin to White Oak Creek.

The following reports give more detailed information about the disposal of liquid waste solutions:

1. Increase in Mud Activity from T. H. J. Burnett to W. H. Ray, dated August 5, 1947, Secret, (Discussion of factors-remedies).
2. Activity of Clinch and Emory Rivers (locations and values) from T. H. J. Burnett to W. H. Ray, dated August 11, 1947, Restricted.
3. Water Activity Measurements Near Y-12 (methods and values) from T. H. J. Burnett to Forrest Western, dated January 14, 1948, Restricted, Central Files No. 48-1-173.
4. Activity Values in the Body of a Wildfowl (location and values in tissues) from T. H. J. Burnett to R. H. Firminhac, dated January 15, 1948, Restricted, Central Files No. 48-1-368.
5. Measurement Method for White Oak Dam Discharge Volume (calibration and interpretation) from T. H. J. Burnett to R. H. Firminhac, dated December 1, 1947, Restricted, Central Files No. 47-12-116.
6. Preliminary Report - Efficiency of White Oak Creek (decontamination effected area-wise) from T. H. J. Burnett to R. H. Firminhac, dated November 3, 1947, Restricted, Central Files No. 47-11-554.
7. Water Activity Computations (calculations and variables) from T. H. J. Burnett to E. J. Witkowski, dated January 14, 1948, Restricted, Central Files No. 48-1-175.

TANK FARM CAPACITIES:

W-1	4400	GALS.	W-9	165,000	GALS.
W-2	4400	"	W-10	170,000	"
W-3	4,300	"	W-11	1,700	"
W-4	41,200	"	W-12	700	"
W-5	170,000	"	E. POND	293,200	"
W-6	170,000	"	W. POND	293,200	"
W-7	166,800	"	RET. POND	31,600	"
W-8	170,000	"	SETTLING BASIN	1,600,000	GALS.



SAMPLING:

ROUTINE SAMPLES ARE TAKEN EVERY FOUR HOURS FROM THE RETENTION POND, SETTLING BASIN OUTLET WIER AND THE SETTLING BASIN DIVERSION BOX.

LEAKS:

ONLY THE DRAINAGE FROM THE DRY WELL SYSTEM GOES INTO THE RETENTION POND, HENCE A HIGH ACTIVITY LEVEL IN THE ROUTINE RETENTION POND SAMPLES INDICATES A LEAK IN ONE OF THE TANKS OR VALVE PITS.

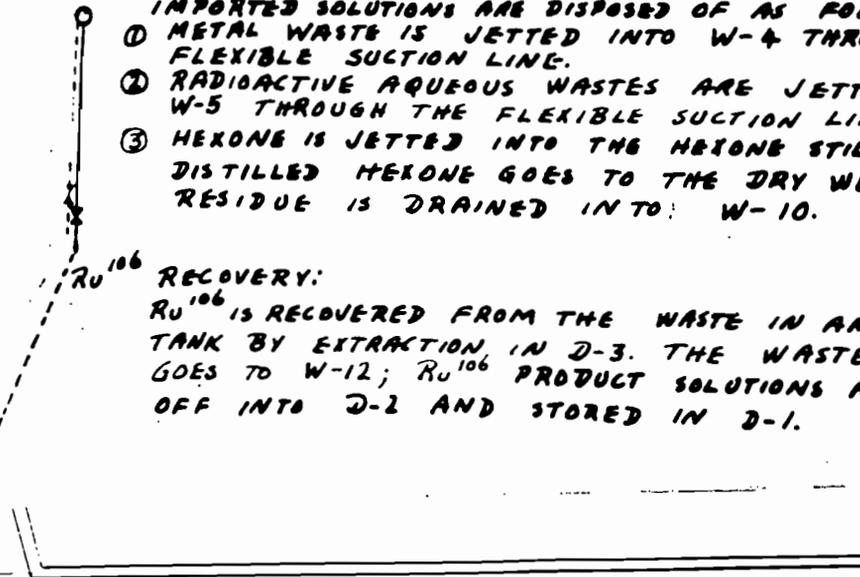
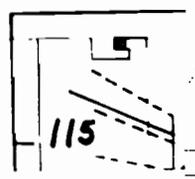
OFF-AREA WASTE DISPOSAL:

IMPORTED SOLUTIONS ARE DISPOSED OF AS FOLLOWS:

- ① METAL WASTE IS JETTED INTO W-4 THROUGH THE FLEXIBLE SUCTION LINE.
- ② RADIOACTIVE AQUEOUS WASTES ARE JETTED INTO W-5 THROUGH THE FLEXIBLE SUCTION LINE.
- ③ HEXONE IS JETTED INTO THE HEXONE STILL AT W-10. DISTILLED HEXONE GOES TO THE DRY WELL; THE RESIDUE IS DRAINED INTO W-10.

RECOVERY:

Ru<sup>106</sup> IS RECOVERED FROM THE WASTE IN ANY SUITABLE TANK BY EXTRACTION IN D-3. THE WASTE FROM D-3 GOES TO W-12; Ru<sup>106</sup> PRODUCT SOLUTIONS ARE DRAWN OFF INTO D-2 AND STORED IN D-1.



\* - SAMPLING POINT (3)

W.H.P. 7-16-47  
REVISED - W.E.T.  
8-30-48

SIA  
FL  
DRI



THIS DRAWING HAS BEEN CLASSIFIED AS

CLINTON NATIONAL LABORATORY  
OAK RIDGE, TENN.

D	C	A		
PER				

VI. EFFECTIVENESS OF OUR PRESENT WASTE DISPOSAL PROGRAM

by

Karl Z. Morgan

There are many things that we do not know about the Waste Disposal Program. Recognizing some of the limitations of the system we are using, the system of maximum dispersion, as contrasted to a system of concentration and control, we have taken some steps to better orient ourselves. Eighteen months ago we began efforts to get together a group to study our waste disposal problems. Sometime toward the close of 1947 we got a group together composed of men from the United States Public Health Service, Tennessee Valley Authority, United States Weather Bureau, University of Tennessee, and Vanderbilt University. This group has a meeting in Chattanooga today and for the rest of the week, and will not be here to discuss their plans. However, Dr. Forrest Western of our Health Physics Division will discuss the plans of this group with you tomorrow. I understand that I am to discuss what we are doing regarding waste disposal and how effective the system is. I did not have a chance to attend the meeting this morning, but I will try not to duplicate what I think may have been discussed.

We have three types of radioactive waste--liquid, solid, and gaseous. There is not much we can say about solid waste except to remind you that since 1943 we have had three burial grounds--south, east, and west. As yet we have not made a study of the geology of this territory, although Dr. A. H. Holland, Jr. has employed Dr. Stockdale of the University of Tennessee, who will make a comprehensive study of the geology of this area. Preliminary investigation has revealed many geological faults in the area; in fact, our burial ground is in about the worst possible place, because of its proximity to a fault. Solid waste gets into ground water and may show up many miles away.

Gaseous Waste: The Clinton Pile is air-cooled. We discharge about 800 curies per day of argon--fortunately, our bodies have no way of concentrating radioactive argon. Therefore, the damage done by argon is from the outside in, rather than from the lungs out. In the chemical separations processes at Oak Ridge National Laboratory we have iodine, phosphorus, barium, lanthanum, and possibly a few other radioisotopes that have introduced air contamination problems on some occasions.

In addition, we have a recent problem that has developed in that we have become aware of the serious consequences of small particles emitted from the pile due to ruptured slugs. This condition was first discovered in 1944 but was then thought to be of little consequence. Recent measurements indicate that there are large particles ranging from 1/2 micron up to 400 microns in diameter which are dispersed from the pile discharge stack. Some of the particles settle upon the area adjacent to the stacks. It is noteworthy that if the particles are inhaled into the lungs thousands of cells adjacent to the particle will be destroyed in a day. A large portion of the airborne activity ultimately finds its way in the liquid waste basins. It is known that more activity is introduced to the waste basins from the air than from the tank farm.

The remainder of the lecture is to be presented with lantern slides, as follows:

- Slide 1 - Table showing maximum permissible exposure to various types of radiation. (Note: The maximum permissible exposure has recently been reduced from 0.5 reps per week to 0.3 reps per week.)
- Slide 2 - X-22 chamber--large pocket meter for measuring gamma and some beta activity.
- Slide 3 - "Dog houses" - They are located out to distances of 10 miles from the Laboratory. They use Geiger counters for recording the air activity.
- Slide 4 - Continuous air monitor, precipitator, and metal can for collecting air samples.
- Slide 5 - Effectiveness of measuring system for measuring air activity.
- Slide 6 - Pile index and air activity.
- Slide 7 - Indicates changes in air activity. In general, there are two types of tolerances with which we are concerned--submersion tolerance, which is radiation coming in from the fluid outside the body, and internal tolerance levels. Some activity is selectively deposited in the body. Iodine of course produces a very high exposure to the thyroid and plutonium to the bone.
- Slide 8) - Computation of tolerance values for ingestion and submersion.  
Slide 9)
- Slide 10 - Ratio of activities from preceding table to tolerance values for ingestion and submersion.
- Slide 11 - **General** tolerance levels - we have a factor of safety of 100 above these figures.
- Slide 12)- No comment.  
Slide 13)
- Slide 14 - Effectiveness of our settling basin which varies with time.
- Slide 15 - Map of White Oak Creek and Lake.
- Slide 16 - Picture of White Oak Dam and fish gates. We maintain that a person could drink the water in White Oak Lake for the rest of his life without damage. The level of activity must be so low that persons or fish could swim in water for rest of life without damage.
- Slide 17 - Mud varies in White Oak system. In the light of studies made we believe that the activity tends to follow the course of the clay. We have made depth measurements, etc.

Slide 18 - Graph showing total radioactivity of White Oak drainage system.  
Lake holds up 70% of the activity.

Slide 19 - Methods of gamma counting.

Slide 20 - Alpha counters.

~~We do not claim that our waste disposal system is ideal. Our system was set up during the war during which our principal effort was to get a pilot plant into operation. Now we recognize its limitations. Some of the necessary changes in our pile arrangement and waste disposal system are underway. Studies are being undertaken for concentrating radioactive waste at the source of radiation. It will be some time before we have all the answers to our problems of waste disposal.~~

VII. BURIAL GROUNDS FOR SOLID WASTE

by

P. B. Orr

Material handled in the burial ground is separated into two categories. Alpha and beta-gamma trash are kept separate, and treated differently.

The beta-gamma material originates here at Oak Ridge National Laboratory and consists mainly of trash from the Restricted Area. This is placed in long, open trenches at the extreme west end of the burial ground. These trenches are usually about 20' x 40' x 10' deep. When they have been filled up to about two feet of the top, they are covered with earth.

About ninety percent of the alpha contaminated waste is received from other Atomic Energy Commission sites. Dayton sends the greatest amount. Each batch of alpha material is handled separately, i. e., a hole about 20' x 20' x 10' deep is dug for each shipment received. As soon as the waste is in the trench, a layer of dirt is placed on top and a layer of concrete poured on the dirt. The concrete is used to prevent anyone from digging up the relatively long half life alpha material in the future.

A maximum tolerance is maintained for the waste received from other locations. Alpha smears of containers should not exceed 10 counts per minute, and 200 counts per minute for beta-gamma.

Difficulty is encountered in the burial of alpha material, especially in the winter. The location of the alpha burials is not very satisfactory. Some rain water from the side of the hill north of the burial ground drains into the alpha burials. When a shipment is buried, it should be covered with concrete the same day to prevent any of the waste from floating to the top of the hole in case of rains. This has occurred in the past.

The treatment of solid wastes is very poor at best, and it is hoped that some other method of waste disposal can be developed in the future.

Question: Could the material be placed in containers so that it would not float out of the ground?

Answer: The material is in containers, but once or twice the containers have burst and black liquid has floated out of the ground.

Question: Would it be possible in case of future need to exhume these "dead bodies"?

Answer: It could be done but would require a jack hammer to do it.

Question: How much concrete do you use in covering?

Answer: About 10 inches. (We have had two or three special burials, such as radium, which are marked as to location.)

~~\_\_\_\_\_~~  
Question: How much is buried a week?  
Answer: We fill a beta-gamma trench 30-40' long and 20' wide about every two weeks.

Question: A lot of this material could be combustible?  
Answer: Yes - about 50%. We have received quite a lot of combustible material recently.

Question: Would it not be better to have the burial ground located on a hill rather than its present location? It seems that on a hill if any leaching occurs you would have more chance of washing it out.

Answer: Yes it would, as far as water seepage into the trenches is concerned.

Question: Is the present burial ground down to bed rock?  
Answer: Yes, it is. We have core-drilled north and west of the present burial ground and it appears that the future burial ground will be west of the present location.

Question: Did you find any activity in the section you core-drilled?  
Answer: We did not check for that.

Dr. Grebe: I am rather concerned about going to bed rock. It is limestone, isn't it? It seems that porcolation would be greater if it was not on clay. I have known of acid being put into an oil well that was only producing a barrel a day and it affected the wells as much as six miles away which were only producing two or three barrels a day. It is quite common for an oil well which was treated to show up 40 feet away before it has a chance to work where it was put in. Yet the well was capped so tightly with clay that the gas pressure was retained.

Question: Do you bury much liquid?  
Answer: Yes, we have quite a lot of liquids, mostly alpha. It is very hot at times, and in that case it goes to the tank farm rather than the burial ground.

Dr. Morgan: One should point out in passing that the system we are using in disposing of radioisotopes is becoming more and more dangerous because of the long life hazard.

Question: Do you plan to start monitoring as soon as you observe an increase in background?  
Answer: When we get that data it will be considered.

Unless we get your support and interest we cannot make further investigations along the lines outlined above.

~~\_\_\_\_\_~~

VIII. RELATED RESEARCH ON ION EXCHANGE

by

J. A. Swartout

Introduction:

Although the Chemistry Division of Oak Ridge National Laboratory has done little work directly aimed at the liquid waste disposal problem, there has been considerable research on principles of various extraction procedures and their application to specific processes.

In the case of ion-exchange, our back-log of fundamental information is appreciable. Before examining the potential applications of ion-exchange to the concentration and isolation of radioisotopes from liquid wastes, a few qualitative principles should be considered.

Qualitative Principles:

The extent of removal of radioisotopes from solutions by a given ion-exchanger is dependent upon (1) the state of the radioisotope and (2) the nature of the solutions.

1. State of Radioisotope.

a) Since a cation exchanger exhibits a high capacity only for cations, a lower and irregular capacity for colloids and no capacity for anions, the state of the radioisotope in solution is of prime importance.

b) The extent of exchange increases with increasing ionic charge, i. e.,  $4^+ > 3^+ > 2^+ > 1^+$ .

c) For ions of equal charge the extent of exchange increases with decreasing hydrated ionic radius. This is strikingly indicated in the data on rare earths separations which follow.

2. Nature of the Solution.

a) The extent of exchange of an ion present as a minor constituent is highly dependent upon the type and concentration of the bulk ion, in accordance with the exchange reaction,  $nX^{m+} + mY^{n+}R_n \rightleftharpoons nX^{m+}R_m + mY^{n+}$ .

b) The presence of complexing agents in the solution may greatly alter the extent of exchange by changing the effective ionic charge and/or radius.

Examination of specific waste solutions will illustrate the effect of these factors. For a detailed and quantitative discussion of principles, reference is made to a series of papers in the November, 1947, Journal of the American Chemical Society.

Specific Potential Applications:

The non-metal containing waste solutions presenting the greatest source of fission activities are the supernate from the first product precipitate at Hanford and the raffinate (IAW) from the proposed Redox process. In the case of the first by-product step at Hanford the activities are concentrated on a precipitate whose disposal should be relatively simple.

1. First Product Precipitation Supernate (Hanford).

- a) Composition - 0.6 M  $H_3PO_4$   
 1 M  $HNO_3$   
 0.02 M  $Fe$   
 0.05 M  $(NH_4)_2SiF_6$

with ~ 1% of the original fission rare earths, Barium and strontium, ~ 0.2% of ruthenium, ~ 0.05% of zirconium and columbium. (see CN-2876).

b) Possibilities - Since the zirconium and columbium are strongly complexes by  $SiF_6^-$ , the obvious application of ion-exchange is for the concentration and separation of the rare earths and possibly the alkaline earths. The rare earths will be considered in detail by Mr. Kotello.

2. Redox Raffinate (IAW).

- a) Composition - 0.7 M  $Al(NO_3)_3$  or 4 M  $NH_4NO_3$   
 0.6 M  $HNO_3$   
 0.05 M  $Na_2Cr_2O_7$

with essentially all of the fission products.

b) Possibilities - Preliminary laboratory experiments have indicated that Zr and Cb may be adsorbed from this solution on charcoal, then eluted with  $(NH_4)_2SiF_6$ . This behavior is to be expected since Zr and Cb are both probably present as colloids which are physically adsorbed by the charcoal. The strong complexing action of the  $SiF_6^-$  ion with both Zr and Cb permits their removal. The indications of these exploratory experiments that pure Zr and Cb are thus produced require confirmation in more quantitative tests. Other adsorbents and ion-exchangers such as sea sand, glass wool and Dowex 50, proved to be definitely inferior.

Since more of the fission products are present as cations which must compete with the very high concentration of  $Al^{+3}$  or  $NH_4^+$  ions, the prospects for directly adsorbing these on an ion-exchanger are not encouraging. Preferential complexing of the bulk ion, i.e.,  $Al^{+3}$  by fluoride, or the use of very large beds to adsorb all of the bulk ion and the fission ions followed by preferential elution are the alternates. The latter approach will be described by the Technical Division.

Separation of Radioisotopes:

Procedures are now available and in use for separating and isolating nearly all of the fission products by ion-exchange techniques. The efficiency

with which very similar ions may be separated will be indicated in the discussion of the rare earths. It is to be emphasized that in our radioisotope separations the feed solutions are as nearly ideal for ion-exchange separation as possible, i.e., low bulk ion and with the radioisotope in trace concentrations. In addition, the actual adsorption and desorption processes are conducted at near equilibrium conditions requiring long contact times.

#### Separation of Trans-Uranic Elements:

In addition to the fission products, the course of the trans-uranic elements in a separations process must be considered. In the Redox process small amounts of plutonium and of americium will be in the raffinate as a result of the incomplete extraction of Pu and the failure of Am(III) to extract. Depending upon the history of the material, some Np may be present. The amounts of curium can probably be neglected.

Experiments on the separation of these from each other have been conducted at Oak Ridge National Laboratory and at Berkeley. After adsorption of the trans-uranic elements on Dowex 50, elution with 5% citric acid at pH = 3 removes consecutively Pu(IV), Cu(III), Am(III), Pu(III) and Np(III).

In summary, ion-exchange is best suited to the concentration of trace ions from dilute solutions and to the separation of ionic species after interfering bulk ions and complexing agents have been eliminated.

IX. RARE EARTH SEPARATIONS STUDIES

by

B. H. Ketelle

J. A. Swartout has outlined above the basic principles underlying the use of ion exchanger columns and has indicated some of the applications to decontamination. The separation of rare earth fission products from one another will be discussed in some detail now.

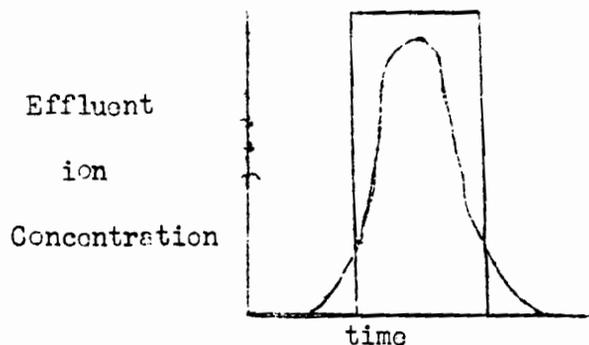
The strength of bonding of ions by an exchanger is related to the ionic charge and hydrated ion size. As Dr. Swartout indicated the order of decreasing bond strength as a function of charge is  $4 > 3 > 2 > 1$ . The order of adsorbability of fission products would be  $Zr^{IV} > La^{III} > Ba^{II} > Cs^I$ . Study of the relative binding of a series of equivalent ions has shown that other factors being equal the hydrated ion with the smallest radius will be the most tightly held by an exchanger. Evidence obtained from activity coefficient measurements indicates that the hydrated ion radii increase with increasing atomic number so we predict, and it is confirmed by experiment, that the order of binding of the light rare earths fission products should be  $La > Co > Pr > Nd > Gd > Sm > Eu > Gd$ . This difference in adsorbability is insufficient to yield good separations by simple displacement reactions.

It is known that rare earths form complex ions with acid citrate ions and that the stability of these complex ions increases with decreasing crystal radius. A slide was projected showing the relative crystal radii of the rare earths. This showed the well known decrease of ion size with increasing atomic number. Thus, if a column of exchanger holding a mixture of rare earths is treated with a buffer solution of citric acid and ammonium citrate, the rare earth of highest atomic number will be eluted first since it is not only held the least tightly by the exchanger, but it is also bound the most strongly by the citrate ions of the solution. By this process it is found that rare earth separation can be accomplished.

Two types of column operation are used. In what may be referred to as break through operation, a solution containing ions of type X is passed through the column. It displaces ions of type Y from the exchanger until the column approaches equilibrium with respect to the ratio of activities of ions X and Y in the feed solution. As equilibrium is approached, the concentration of ion X in the effluent solution will increase. This type of operation has not been found to give satisfactory separation of rare earth fission products. In the second mode of operation, known as chromatographic separation, a narrow band of the materials to be separated is adsorbed at the top of the column. This single band separates into its several components as the developing solution flows through the column because of the differences in the adsorbabilities and stability of the citrate complexes.

It is apparent that all factors which effect the width of the band when it is initially adsorbed at the top of the column will contribute to the final band width as it is eluted since a broad band cannot contract on moving down the column. Specifically high concentrations of bulk ion such as aluminum or iron will cause the initial band to be broad and the separations to be poor.

Ideally these bands would have sharp boundaries because in practice the leading and trailing edges of the effluent peaks are sigmoidal as shown in the figure. The successive bands tend to overlap and give cross contamination.



The several factors which contribute to this non-ideal behaviour are related to one another in the following equation which comes from the mass transfer theory of column operation.

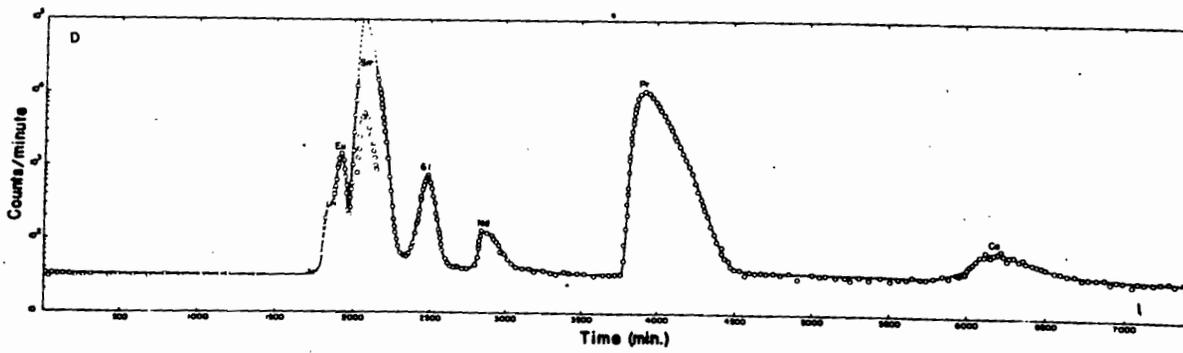
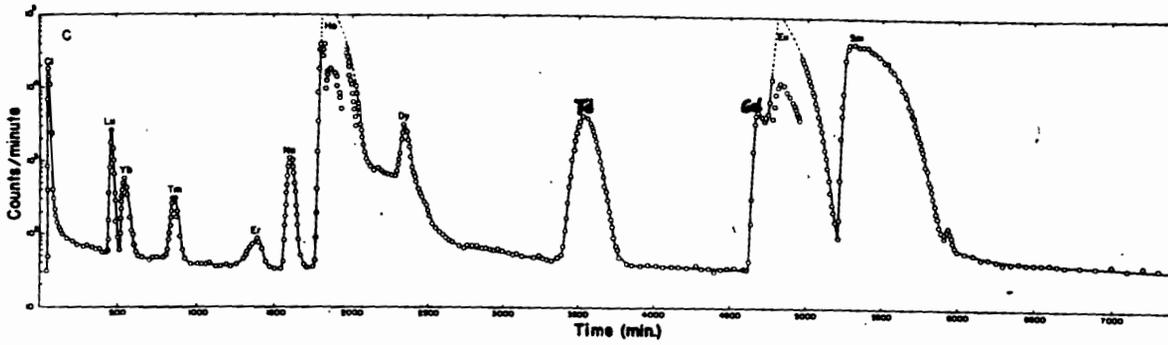
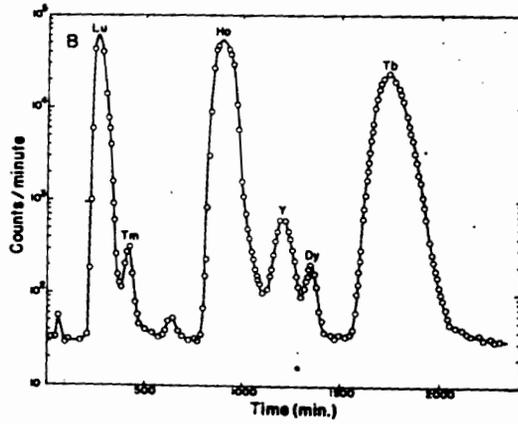
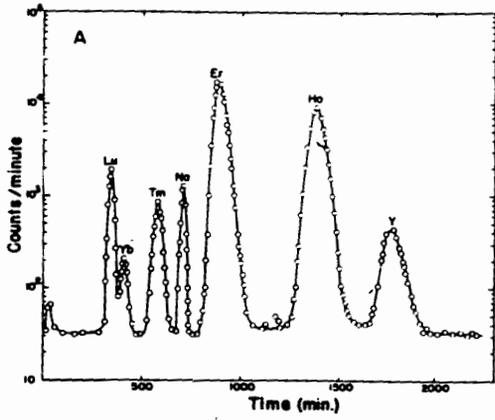
$$Y = \frac{3 D^1}{r_0 \Delta r_0 f} \left( \frac{X}{V} \right)$$

where  $D^1$  is the diffusion constant of the ion through the film of solution of thickness  $\Delta r_0$  which surrounds the particle of radius  $r_0$ . The fractional void space is represented by  $f$ , the column length by  $X$  and the linear velocity of flow of solution by  $V$ . The parameter  $Y$  is used to describe the sharpness of the boundaries of the band. Any change which increases the value of  $Y$  will sharpen the band. Those factors which can be controlled are  $D^1$ ,  $r_0$ ,  $X$ ,  $V$ . According to theory the band will be sharpened by increasing the diffusion constant, decreasing the particle size of the exchanger, increasing the length of the column or decreasing the solution flow rate. Experiments have confirmed the theory for each variable. The increase of diffusion constant is obtained by elevating the temperature of the column. Typical operating conditions for good rare earth separation are the use of a column of 270-325 mesh exchanger a meter long at a temperature of 100°C at a flow rate of 1 ml/cm<sup>2</sup>/min.

Several slides were shown to indicate typical separations obtained of both heavy and light rare earths. (See next page.)

The following example indicates the degree of separation which is possible. A sample of orbium from which adjacent rare earths had been removed by the ion exchange method was irradiated with neutrons in the pile. After irradiation, the sample was subjected to a second separation on a column. The amount of activity separated in the peak corresponding to thulium is a measure of the inactive thulium present during irradiation. Thus, it was possible to determine that the original material contained only 0.001% of thulium.

Such separations are possible only under carefully controlled conditions. As has been indicated, the presence of high concentrations of bulk ions or even moderate concentrations of ions of high charge makes such separations impossible. Therefore, in decontaminating solutions which contain inactive bulk ions, it would be necessary either to selectively convert such ions to poorly adsorbed complex ions or to preferentially separate the active ions by some other process. Such operations will be discussed later by Mr. Higgins and Mr. Blanco.



X. PRECIPITATION AND SCAVENGER TECHNIQUES

by

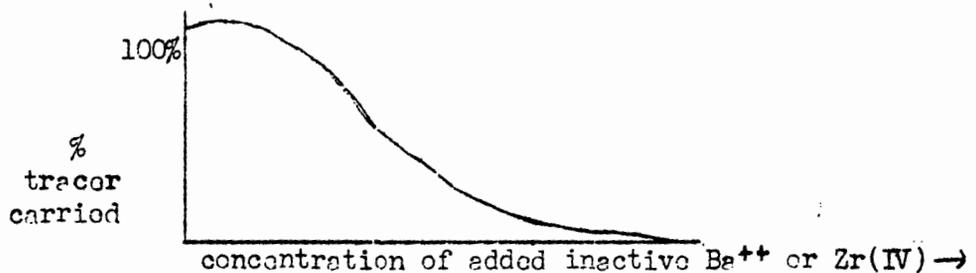
R. W. Stoughton

These methods in general are less predictable and less understood than certain adsorption and solvent extraction methods.

A. Carrier Mechanisms.

- 1) Colloidal particles are usually carried by entrainment.
- 2) Adsorption (surface or inner).

An example of carrying by surface adsorption is the carrying of  $Ba^{++}$  and  $Zr(IV)$  by lanthanum fluoride,  $LaF_3$ .



Here the carrying is due to surface adsorption and hence only that fraction of the  $Ba^{++}$  or  $Zr(IV)$  in solution is carried which will approximately cover the surface of the precipitate.

3. "Mixed Crystal" Carrying.

a) Isomorphous carrying (tracer and carrier have same crystalline form) example: carrying of  $Pu(III)$  by  $BiPO_4$ .

b) True mixed crystal formation (here we actually got a new substance, a double salt, being formed) examples: carrying of  $Pu(IV)$  by lanthanum fluoride and bismuth oxalate.

Here carrying is usually good up to some atomic ratio, "tracer"/carrier, of small whole numbers.

c) Occlusion - an example is the well known coprecipitation of small amounts of  $K_2SO_4$  with  $BaSO_4$ .

4. Molecular Adsorbors (as Charcoal, Silica, Alumina,  $TiO_2$ , Zeolites).

These scavengers remove salts from solution. A disadvantage for our work is that usually a large amount of material is needed, also in work on the Hanford process decontamination factors of only about 2 to 5 were obtained with the metal waste solution.

5.  $MnO_2$  - This substance is known to be a general scavenger at low acid concentration and becomes more specific as the acidity is raised; the

mechanism of carrying is not known. At 10 M HNO<sub>3</sub> this material is quite specific, carrying only Cb(V), Ta(V) and Pa(V).

B. Mathematical Formulas which hold for some types of carrying.

The first two hold for certain cases of carrying by crystalline precipitates and the third is more general.

1. Berthelot-Mernst equation (holds for some cases of rapid precipitation; equilibrium not attained continuously as precipitation occurs):

$$\frac{x}{a-x} = D \frac{y}{b-y}$$

or 
$$\frac{x}{y} = D \frac{a-x}{b-y}$$

where:  $x$  is the amount of tracer in the precipitate.  
 $y$  is the amount of carrier in the precipitate.  
 $a$  is the amount of tracer originally in solution.  
 $b$  is the amount of carrier originally in solution.  
 $(a-x)$  is the amount of tracer in the solution after precipitation.  
 $(b-y)$  is the amount of carrier in the solution after precipitation.  
 $D$  is a constant.

2. If we have a very slow precipitation, then this occurs as a differential process. (Equilibrium attained continuously between surface layer of precipitate and solution). In that case we get the so-called Doerner-Hoskins equation:

$$\log \left( \frac{a}{a-x} \right) = \lambda \log \left( \frac{b}{b-y} \right),$$

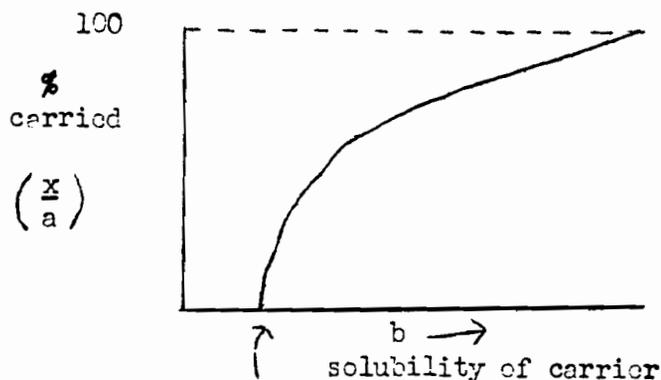
where  $\lambda$  is a constant simply related to  $D$ .

3. Another equation which is almost universally valid and is attributed to C. D. Coryoll:

$$\frac{x}{a} = 1 - e^{-k(b-\text{solubility of carrier})}$$

where  $k$  is an experimentally determined constant, and the other symbols have the above meaning.

This equation is derived on the assumption that the rate of "precipitation" of tracer is proportional to its own concentration times the rate of precipitation of carrier.



C. Some General Statements.

A few generalizations can be made concerning this method of conducting chemical separations and these may be used to some extent as working hypotheses, providing one always bears in mind that any conclusions must be checked experimentally before they are taken seriously.

In general, hydroxide precipitates will carry any tracer under conditions where the tracer element would itself precipitate if it were present in macroscopic amount.

Iodate precipitates seem to carry any trace elements which form "insoluble" iodates in macroscopic amounts. Differences in valences between carrier and tracer seem to be of little importance in this case.

In general, amorphous precipitates make better scavengers and are less specific in their carrying than crystalline precipitates.

It can be said that if the tracer element and the carrier form isomorphous solids and the tracer would precipitate if it were present in macroscopic amounts, then the tracer will definitely be carried. In this case if the trace element forms a less soluble compound with the precipitating agent than does the carrier element, then a greater percent of the tracer than of the carrier will be found in the precipitate; if the trace element forms a more soluble compound, then the reverse is true.

One objection to this method for general use in connection with fission product waste solutions is that in order to remove most of these substances, a number of different carrier precipitates must be used, providing it is desirable to leave the solution acidic. If the solution can be made basic and a hydroxide precipitate used, most of the long-lived fission products will be carried from solution; however, even under these conditions cesium should not be carried.

## XI. SUMMARY OF TECHNICAL DIVISION ON LIQUID WASTE DISPOSAL PROBLEMS

by

F. L. Steahly

Two general types of liquid process waste at Oak Ridge National Laboratory are: (1) Metal waste, and (2) Chemical waste.

Metal waste is waste which contains uranium obtained primarily from pile slug dissolution. This waste is being stored in underground tanks and is not of concern for us here.

Chemical waste solutions are derived from various process operations as the solvent extraction pilot plant, the Rala process, the isotopes processing, and the various chemistry research projects. Due to its high Al concentration, the solvent extraction waste is stored separately.

These wastes contain chemical salts and considerable fission activity; therefore, disposal presents a problem of considerable dimension.

Two lines of attack have been followed by the Technical Division:

### (1) Evaporation.

The volume reduction obtained by evaporation is limited by the amount of salt in solution. Chemical wastes, exclusive of the solvent extraction waste, do not contain much salt of any kind. Therefore, these wastes may be concentrated with some success. The maximum concentration factor is ca. 40. A factor of 20 has been selected for the current evaporation design. The decontamination factor obtained by evaporation is estimated to be  $10^3 - 10^4$ .

### (2) Chemical Treatment.

The best chemical treatment developed at X-10 to date utilizes the following two techniques:

- (a) Scavenging with  $Fe_2O_3 \cdot nH_2O$  and  $MnO_2 \cdot nH_2O$ .
- (b) Ion Exchange.

The chemical waste has been decontaminated by a factor of ca. 500 with a volume reduction of 1000:1.

Of particular interest is the high flux pile waste problem. The uranium in the pile fuel assemblies is recovered in a solvent extraction process. The raffinate from the extraction columns is a  $1.3M Al(NO_3)_3$  solution plus fission activity. The general purpose of the chemical treatment is to separate the bulk Al from the fission products. Three advantages for such a process are:

- (a) Re-use of the aluminum.
- (b) Cheaper storage of the fission activity.
- (c) A permanent method for disposing of the bulk (aluminum) of the waste.

Using the chemical treatment mentioned above, the X-10 "25" pilot plant waste has been decontaminated by a factor ca. 1000 with an attendant reduction by a factor of 50-100 in the volume needed for "hot" liquid storage.

## XII. ION EXCHANGE DEVELOPMENT IN THE TECHNICAL DIVISION

by

R. E. Blanco and I. R. Higgins

### A. "25" Aluminum Waste Treatment. - R. E. Blanco

The "25" aluminum waste as received from the pilot plant consists of a solution 1.3M  $\text{Al}(\text{NO}_3)_3$  containing all the fission products. It was originally planned to evaporate this solution to a slurry (maximum volume reduction of 3:1) for storage in stainless steel tanks. The cost of such a tank farm is estimated to be ca. \$2,000,000 for a 10 year operation of the high flux pile. A process has been developed to separate the aluminum from the fission products, resulting in a reduction in the volume needed for "hot" liquid storage by a factor of 50-100. If the Al can be decontaminated to an acceptable level it can be discharged into a stream. If not, it could be stored cheaply. In either event, the Al could be recycled in the solvent extraction processes. The steps in the Al decontamination process are as follows:

(1) Scavenging. Dilute the waste solution to 0.5M Al, bring to a boil, and add 0.01% Fe as  $\text{Fe}(\text{NO}_3)_3 \cdot 12 \text{H}_2\text{O}$  crystals to precipitate colloidal  $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$  and 0.006% Mn as  $\text{Mn}(\text{NO}_3)_2$  and 0.004% Mn as  $\text{KMnO}_4$  to precipitate  $\text{MnO}_2 \cdot n\text{H}_2\text{O}$ . The  $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$  carries up to 99% of the Ru while the  $\text{MnO}_2 \cdot n\text{H}_2\text{O}$  carries some Zr and almost quantitative amounts of Cb. The  $\text{MnO}_2$  also effectively carries the colloidal Fe so that after centrifugation or filtration a clear solution is obtained. The precipitate is dried and stored. The use of this scavenging technique results in decontamination factors of 1.5 for beta and 7-13 for gamma.

(2) The filtrate or centrifugate is diluted to 0.1M Al and 0.2%  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2 \text{H}_2\text{O}$  and passed through an ion exchange column containing Dowex "50" resin. After washing with 3 column volumes of 0.2%  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ , the Al is eluted with 5%  $\text{H}_2\text{C}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$ . The eluate is acidified with excess  $\text{HNO}_3$  and boiled down to  $\text{Al}(\text{NO}_3)_3$  for recycle or to dryness for storage or permanent disposal by dumping. The overall decontamination factor for the two steps is  $10^3$ ; Al recovery is 98-99%. The resin is reactivated with 6N  $\text{HNO}_3$ . (See Page 31.)

B. Chemical Waste - I. R. Higgins

Considerable research has been conducted, using ion exchange techniques, for removing fission activity from hot waste solutions at X-10. Dowex 50 resin has been found to be superior to other resins tried due to its high capacity and stability. We have found Dowex 50 to be stable in 6N HNO<sub>3</sub> so that this reagent may be used to reactivate the resin rather than 6N HCl thus avoiding the corrosive action of the latter. Scouting runs in both evaporation and ion exchange indicate that greater concentration and decontamination are possible by treating the waste before neutralization rather than afterwards. An ion exchange and precipitation procedure gave decontamination of about 20 for the neutralized waste compared to 200-1000 for the acid waste. By evaporation of the neutralized waste a volume reduction factor of about 10 is possible. Evaporation of the acid waste makes possible the fuming of the volatile acids leaving only sulfuric acid to be neutralized and stored. Evaporation and ion exchange may be used in conjunction with each other according to two schemes, A and B.

- A. 1. Evaporation and fuming of the acid waste to concentrated H<sub>2</sub>SO<sub>4</sub>. D.F. = 10<sup>3</sup>.  
 2. Ion Exchange and Fe(OH)<sub>3</sub> precipitation of the condensate. D.F. = 10<sup>2</sup> - 10<sup>3</sup>.

The total D.F. is 10<sup>5</sup> - 10<sup>6</sup> and the total volume reduction is determined largely by the amount of SO<sub>4</sub> present. The questionable factor is the material of construction of an evaporator that will resist the action of boiling HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub>, HCl, and possibly HF.

- B. 1. Ion exchange and Fe(OH)<sub>3</sub> precipitation of the acid waste. D.F. = 10<sup>2</sup> - 10<sup>3</sup>.  
 2. Evaporation of the HNO<sub>3</sub> regeneration acid.

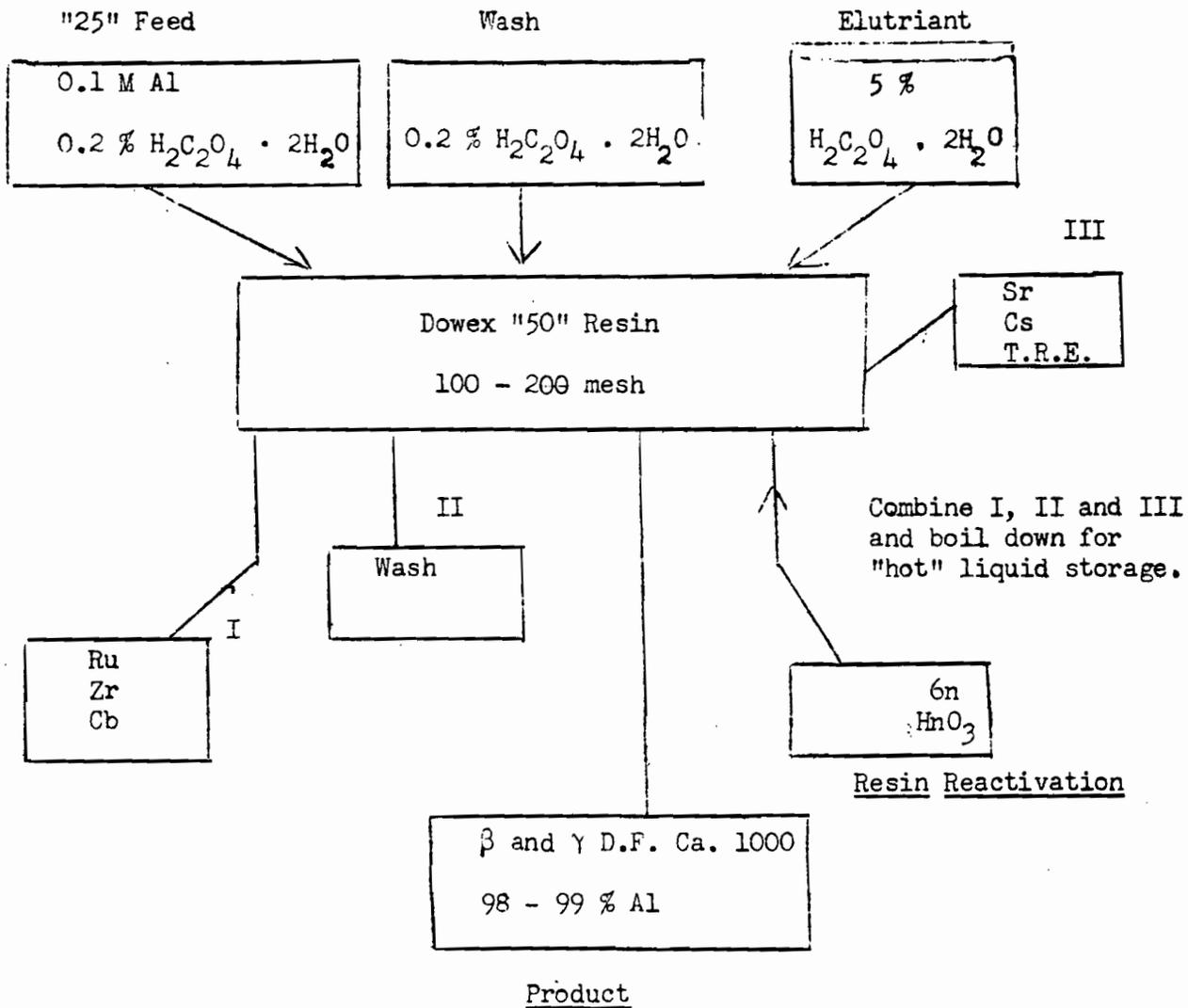
The total D.F. is 10<sup>2</sup> to 10<sup>3</sup>, yet a greater volume reduction is possible because the only acid to be evaporated is HNO<sub>3</sub>. Evaporator corrosion is eliminated since only HNO<sub>3</sub> is present. A decision between scheme A or B will be determined by (1) a satisfactory corrosion resistant material in the case of "A", or (2) 10<sup>2</sup> to 10<sup>3</sup> being sufficient decontamination in the case of "B".

The chemical waste solutions were analysed as follows:

<u>Ion</u>	<u>Tank W-6</u> <u>mg/ml</u>	<u>Tank W-12</u> <u>mg/ml</u>
U	0.05 - 0.2	0.0006 - 0.2
Na	2.7 - 10.3	0.08 - 5.0
Ca	< 0.01 - 1.65	< 0.001 - 0.02
Al	0.02 - 0.19	0.003 - 0.02
Fe	0.005 - 0.01	0.001 - 0.01
Cl	0.1 - 0.02	0.4 - 0.5
F	0.04	0.002 - 0.003
Co <sub>3</sub>	1.33 - 6.5	0.42 - 1.9
Sc <sub>4</sub>	2.5	0.2 - 0.6
Po <sub>4</sub>	0.0002 - 0.006	0.001 - 0.004
No <sub>3</sub>	3.82 - 12.0	0.4 - 11.3

Schematic Diagram of Ion Exchange Process  
for Decontamination of Al Wastes

Filtration from Scavenging Step



XIII. DEVELOPMENT OF AN EVAPORATION SYSTEM FOR OAK RIDGE

NATIONAL LABORATORY LIQUID WASTE DISPOSAL

by

C. E. Winters

The Engineering Development Section of the Technical Division has not been involved very long in the waste disposal problem. So far we have been involved only in the planning and investigation aspects, and no laboratory work has been done. (Note figure presented with Mr. Witkowski's portion of this report.) We believe that in the tank farm operations 95 percent to 99 percent of the activity in White Oak Creek originates from tanks W-5 and W-6. Tanks W-5 and W-6, therefore, will be first point of attack. Some waste solutions sent to these tanks are quite acid. Wastes from the D-Building runs have an excess of alkali; however, the long term average is alkaline. W-1 and W-2 waste, which has very low activity most of the time, is usually decanted to Settling Basin. When the activity is high it goes to W-5. All of the activity and volume of W-12 go to W-5 and W-6. The present hold up time in W-5 and W-6 is of the order of one or two months, after which the solution is decanted to the Settling Basin.

During a 21-week test period the minimum weekly flow into W-5 and W-6 was around 3600 gallons; maximum weekly flow was around 57,500 gallons; average was 30,600 gallons ( $\pm 7,000$ ). Approximately 50,000 gallons per week is considered as necessary capacity of design equipment.

Two principal objectives at present are:

- 1) Immediate short term solution to problem.
- 2) Long term solution to the chemical waste problem.

1) Immediate Short Term Solution to Problem.

Evaporation is only means at our disposal at present which has a reasonable chance of success without an extensive development program.

It is planned for the evaporator to handle all "concentrated" chemical waste and to provide data on scaling, entrainment, for the design of any future entrainment separators.

In this evaporator we hope to attain a 20:1 volume reduction ratio--and a  $10^3$  to  $10^4$  decontamination factor for the condensate.

The concentrate is to be either stored for decay or, as we are now planning, dried, probably with a spray dryer. If stored in W-6 the storage space would last -

- 1.4 years at maximum output of evaporator
- 2.1 years at expected output of evaporator

2) Longer Range Plans.

- a) Investigate entrainment separators to raise decontamination factor.
- b) Investigate submerged combustion type of **evaporation** where there is no scale formation and thus maintain ease of decontamination.
- c) Investigate dryers. No detailed consideration has been given to dryers at present.
- d) Investigate **crystallization** as means of separation of inactive salts from active salts.

XIV. DESIGN OF AN EVAPORATION SYSTEM FOR OAK RIDGE

NATIONAL LABORATORY LIQUID WASTE DISPOSAL

by

F. L. Culler, Jr.

A recent survey on the amount of radioactive materials being discharged to and adsorbed in ~~White Oak Creek~~ indicate that the creek mud is rapidly approaching its saturation point, and that considerable activity is being discharged to the Clinch River. ~~In order to alleviate this situation, several proposals have been made for processing all plant non-alpha emitting radioactive wastes prior to discharge to the creek. The processes studies include evaporation, ion exchange, and solvent extraction.~~

Evaporation was chosen as an immediately available method of reducing the amount of radioactive waste to be discarded. Plans are now being formulated to install simple evaporation equipment which will permit a 20:1 concentration of radioactive wastes for storage and which will provide a decontamination factor of approximately  $10^3$  in the condensate which is discharged into White Oak Creek. ~~It is recognized that this approach is only a temporary solution to the waste problem.~~ By the time that storage facilities are again reaching the point of exhaustion, additional methods for processing hot, non-metal-bearing wastes will have been developed.

The Oak Ridge National Laboratory is now producing an average of 30,000 gallons of active liquid waste per week with a peak load of 43,000 gallons per week (99.9 percent assurance). Present plans call for the erection of an evaporator system with sufficient capacity to evaporate a maximum of 300 gallons of water an hour or 50,000 gallons a week if run continuously. It is felt that the 65 percent excess capacity is warranted for several reasons; first, to

"get ahead" of the existing liquid waste now stored as well as to keep up with present production; second, to permit a certain amount of down time while the evaporator is being operated on an experimental basis; and last, to handle any unforeseen surges in waste production or additional sources of liquid wastes. The location of the evaporator with respect to tank farm tanks is shown schematically on Page 37.

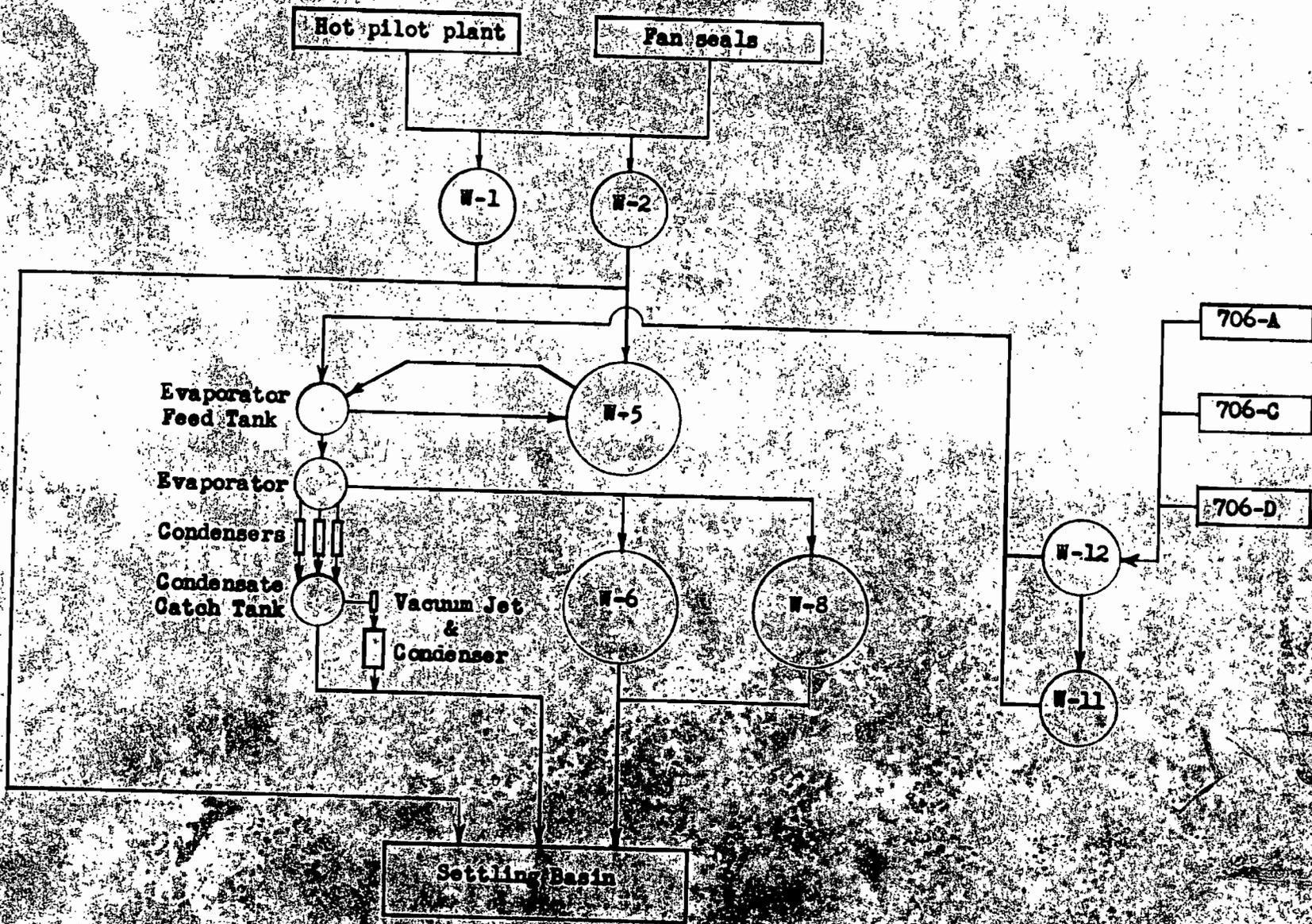
In so far as possible, existing equipment now in the Oak Ridge area will be used for the evaporator and its auxiliaries. Three tanks from the Oak Ridge National Laboratory burial ground and several condensers from the Midway Warehouse No. 8 are to be used. Items which will be fabricated or purchased include a cyclone separator and a vacuum jet and condenser. The tanks on hand are all Type No. 309 S Cb stainless steel; the condensers are Type 347 stainless steel.

The three tanks will be used as evaporator feed tank, pot evaporator, and condensate catch tank, respectively. The feed tank has a capacity of 2150 gallons and will be run at atmospheric pressure. The evaporator and catch tank each have 2350 gallon capacity, and will be run under 24 inches Hg vacuum. The cyclone separator for reduction of entrainment will be fabricated, and will be 15 inches in diameter by 5'6" tall. Eight condensers will be used in parallel, with two more used as after coolers for each bank four condensers. The vacuum jet to be purchased will have sufficient capacity to hold the evaporator system under a 24 inch vacuum during operation.

Page 28 shows a schematic flowsheet for the evaporator system.

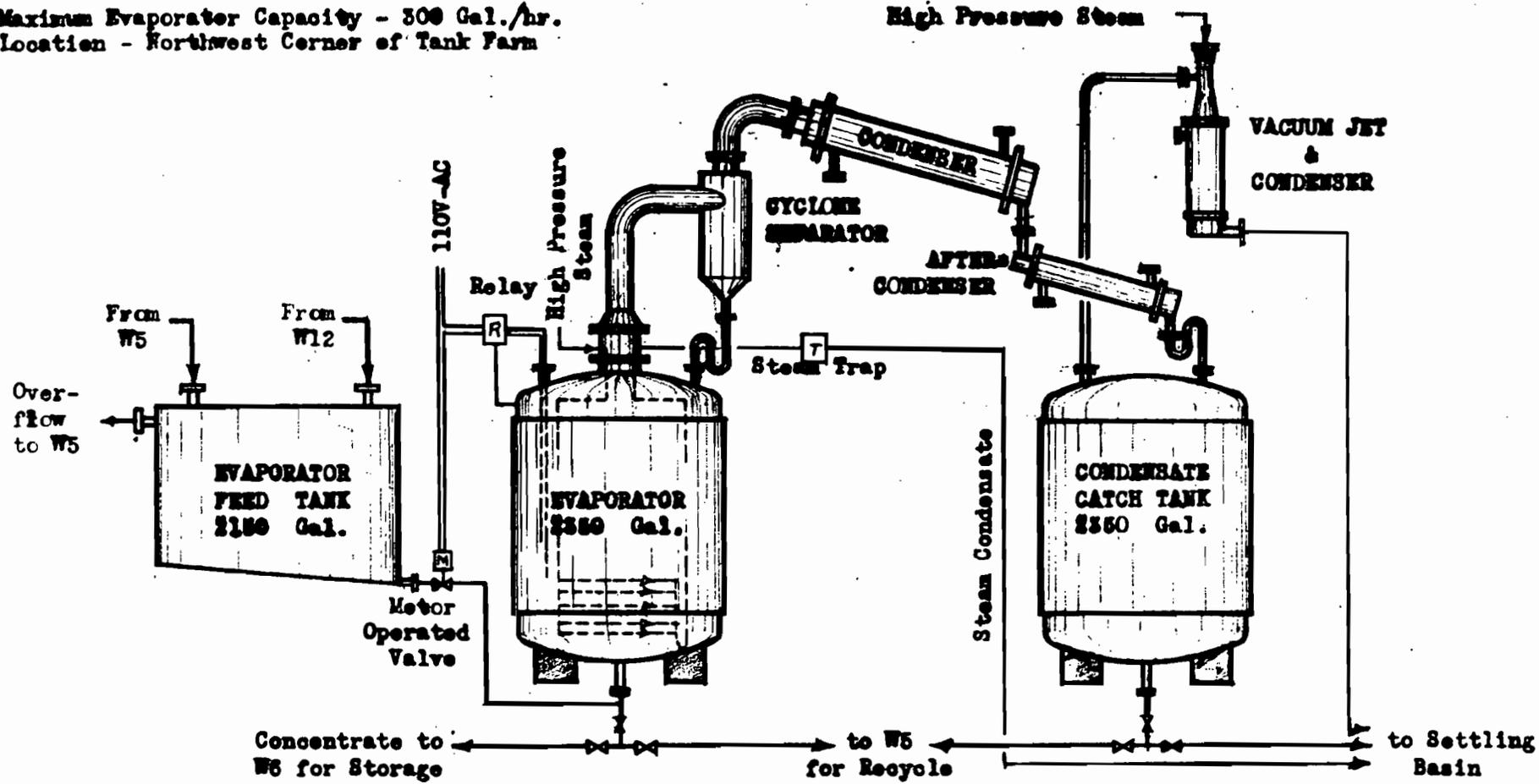
The vacuum facilities were added for evaporation because it was found that entrainment and the tendency toward scaling are both reduced when evaporation is conducted under vacuum.

Calculations on the cyclone separator indicate that under vacuum all particles larger than 140 microns in diameter will be removed. The pressure drop across the cyclone at 24" vacuum will be 5 inches of water. At the design inlet vapor velocity of 150' per second, a centrifugal force of 600 g will be produced in the entrainment separator.



Schematic Plan of Evaporator and Waste Tank Farm

Maximum Evaporator Capacity - 300 Gal./hr.  
 Location - Northwest Corner of Tank Farm



38

Proposed Tank Farm Evaporator and Auxiliaries

Drawing # 6093

## XV. THE WASTE DISPOSAL PROGRAM UNDERTAKEN BY THE HEALTH PHYSICS DIVISION

By Forrest Western

In trying to present our waste disposal studies to you, I am sure that I will make statements that are repetitions of things that you have already been told. I do so more or less consciously because I would like to make fairly clear our underlying philosophy in conducting these studies.

I am told that early plans for Oak Ridge National Laboratory called for operation for only a brief period of time and for the retention in storage of substantially all of the liquid radioactive wastes. Early changes in chemical processes required quantities of process liquids which could not be stored resulting in the adoption of an operating policy which provided for the dumping of quantities of radioactive wastes into the drainage system of the Clinch River at "safe" rates.

The maximum rates that were considered safe were arrived at by consultation between Dr. Simon Cantril, formerly medical advisor for this laboratory, Dr. J.G. Hamilton of the University of California Radiation Laboratory and Dr. R. S. Stone, at that time in charge of the radioactive wastes of the project. As a result of this policy, a number of devices have been used to keep the average rate of "dumping" well below the established maximum value.

With the development under the AEC of continued interest in operation at this site and with relief from wartime urgencies and more widespread knowledge of the nature of our operations there resulted increased tendencies to question the wisdom of continued dumping of significant quantities of radioactive wastes into the river.

In addition to a reluctance to raise the natural radioactive background by the accumulation of long life isotopes, our uncertainties involve such questions as possible physical and biological concentrations and effects of even existing levels on plant and animal life and indirectly upon man.

Unfortunately, as in many other cases, involving hazards from radioactive materials, we have no adequate information upon which to base a good evaluation of the hazards involved. The Health Physics Division of this laboratory has long been convinced of the desirability of an extensive, systematic study of the behavior of radioactive materials released into the drainage system which when combined with the results of needed biochemical research, would provide us with a much better basis for such evaluation. Not too long ago we considered that such a program might be necessary to determine the extent to which our present waste disposal practices should be improved.

More recently, plans to expand operations in the atomic energy field, together with expressions by the AEC of a cautious attitude with respect to radioactive waste disposal, have led to rather widespread feeling that new construction here and elsewhere should include provisions for the rather complete removal of such wastes. Acceptance of this view by technical groups planning new installations

has partly relieved the urgency for a program of study in our own drainage system as far as local needs are concerned. However, we feel that at least two additional considerations make such a program very important to the AEC and to the country as a whole. These additional considerations are:

- (1) The fact that most AEC installations are planned for regions of dense population and frequently involve higher levels of activity.
- (2) In the event of war involving the military use of radioactive materials, we may be confronted with problems arising from the dumping of large quantities of radioactive materials in heavily populated districts.

This is an ideal place to carry on such a program since through our current practices of waste disposal, we have during the past four years established in White Oak Creek, the Clinch River and possibly, the Tennessee River, radioactive conditions which may aid us in obtaining answers to many of our questions.

It is with these considerations in mind that, in cooperation with the Office of the Medical Advisor for ORDO, we have brought together a technical group from related fields for a concerted attack on the problem.

This group consists of the following personnel:

Roy J. Morton, Sanitary Engineer, Vanderbilt University, leader of the waste disposal group.

L. Setter, Tennessee Valley Authority, Stream Sanitation Engineer.

O. R. Placak, and C. P. Straub assigned to us by the U. S. Public Health Service.

Paris Stockdale, Consultant to AEC, Professor of Geology, University of Tennessee.

J. Z. Holland of the U. S. Weather Bureau - Consultant to AEC.

In trying to outline the program for the Central Coordinating Committee and some of the things that they plan to undertake I will first mention some of the things Prof. Stockdale intends to do in the field of geology.

1. A determination of the general geological characteristics of the area, through coredrilling, sampling, etc.
2. A study of subterranean water flow within a radius of 40 to 50 miles.
3. Determination of a safe location for a radioactive burial ground in the Oak Ridge Area.

The meteorology program with J. Z. Holland is not yet formulated.

The following outline is currently used as the basis for planning waste disposal studies in the Division of Health Physics, ORNL. It is expected that the Health Physics group will be primarily concerned with items listed in Column A., although it is planned to take advantage of opportunities to apply knowledge so obtained to items listed in Column B, so far as manpower and facilities permit. In Column B, it is anticipated that Item I will be done largely by technical design groups, and that Item VI may receive the attention of medical and biochemical groups elsewhere.

Waste Disposal Problem

- |  |  |
|--|--|
| <p>A. Fundamental Research to obtain detailed knowledge of behaviour of radioactive materials in<br/>1) air, 2) water, 3) soil, 4) plants, 5) animals, 6) man.</p> | <p>B. Development of Methods of Preventing radioactive materials from producing damage to a) Man, b) Animal or Plant Life.</p> |
|--|--|

I. Meteorological (J. Z. Holland, etc.)

II. Geological (P. Stockdale, etc.)

III. Gross behavior of radioactive materials in a) drainage systems, b) soil, c) plant life under conditions of discharge from ORNL and similar plants.

This includes a study of water filtration plants and sanitary sewage disposal plants.

IV. Specific behaviours peculiar to individual elements:  
a) Certain  $\beta$ - $\gamma$ 's, Pu, Po, U, etc.

V. Effects of radioactive materials on fish and animal life.

I. Methods of control at source. At ORNL it is anticipated that the technical problems involved will be attacked principally by the Technical Division.

The following problems are of current importance principally because of military possibilities.

II. Methods of removal from water supply.

III. Methods of removal from air by use of masks, filters, etc.

IV. Methods of decontamination of a) persons, b) clothing, c) equipment and buildings.

V. Methods of detection and survey under conditions of warfare.

VI. Methods of purging from interior of body.

IMMEDIATE PROGRAM FOR ORNL GROUP

- 1) Critical review of present routine waste monitoring operations to select or make available data of fundamental interest.
- 2) Program with TVA - Game and Wildlife Branch  
Stream Sanitation Branch

This fall - preliminary sampling for algae, plankton, sediment, and water at stations from Norris to Watts Bar Dam.

Large scale study of fish from 3 or 4 embayments of about 2 acres each. The fish in these embayments are to be immobilized and samples taken for study by both TVA and ORNL.

On the basis of this preliminary study, it is anticipated that a more complete cooperative program of stream studies may be planned for next year.

- 3) Water System and Sewage Plants
  - a) Studies in connection with existing plants here and elsewhere.
  - b) Cooperation with design engineers for new sewage plant to incorporate facilities for experimental study.
  - c) Pilot or large scale laboratory studies.

XVI. PROPOSAL FOR A CENTRAL BURIAL GROUND FOR OAK RIDGE OPERATIONS

by J. Deal

The question of burial as a means of disposing of radioactive waste has been investigated recently by the Atomic Energy Commission.

Some of the unknown factors involved in Burial Grounds are:

- 1) The Geology of the area.
- 2) Amount of radioactive material retained by the soil or the amount of waste material leached from the soil.
- 3) The biological concentration factors that may exist.

The committee investigating the status of burial grounds and methods used in disposing of radioactive scrap material found that scrap is retained in storage if it has any possible use or value even though it is only slightly radioactive. This is necessary because of the present policy of not allowing any material to go into the open market that has a detectable amount of radioactivity on it. Burial grounds are now being used primarily as a means of disposing of all radioactive garbage, regardless of the activity level, and secondarily, as a means of disposing of a small amount of material that is active to a degree that would create a health hazard.

The committee undertook to determine how much surplus radioactive material is now in Oak Ridge. For the purpose of the survey, the information was broken down into three general parts which were in turn broken down into five sub-divisions. They are as follows:

- A. Materials that are above the present allowable limits for release to industry.
- B. Materials that are below the health tolerance, but above any limit that may be released to industry, even if the present allowable limits are raised by several orders of magnitude.
- C. Materials that are above the allowable health tolerance.

The five sub-divisions are:

1. Serviceable equipment.
2. Ferrous metal scrap.
3. Non-ferrous metal scrap.
4. Combustible materials.
5. Non-combustible materials.

It was found that there is a total of about seven thousand tons of contaminated materials now being stored within the Oak Ridge Operations. It was also pointed out that the problem of disposal of scrap is chronic rather than acute, but that some action will be necessary within the next year or so.

Since there are three plants which are disposing of materials in Oak Ridge, it is proposed to give this problem to one central group for study and action. It is proposed that this group have a laboratory, an incinerator, a small smelter and permanent storage for those items that cannot be released or decontaminated.

It is further proposed that some research group be retained to canvas industry to advise the Commission as to what levels of radioactivity industry can tolerate. The functions and results of this research group would probably be coordinated and put into use by the proposed Centralized Disposal Group.