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Final Narrative Report

WASTE PESTICIDE MANAGEMENT

July 1, 1969 - June 30, 1972

Conducted Under Demonstration Grant

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Division of Demonstration Operation,  
Office of Solid Waste Management Program,  
Environmental Protection Agency

ROBERT L. GOULDING

Project Director

Environmental Health Sciences Center  
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August 1973

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Individuals Directly Participating in  
The Waste Pesticide Management Project.

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- A. Isley, Lake County Agricultural Extension Agent, Agricultural Extension Service, OSU.
- W. Kondo, Consultant to Chem Waste, Inc., Portland, Oregon.
- B. Wilcox, Klamath County Agricultural Extension Agent, Agricultural Extension Service, OSU.
- J. M. Witt, EHSC, Department of Agricultural Chemistry and Agricultural Extension Service, OSU.

## INTRODUCTION

This program was involved in development of solutions to specific waste pesticide management problems. One of these activities, at Alkali Lake in eastern Oregon, involved field studies directed toward eventual safe disposition of approximately 1¼ million gallons of waste by-products of 2,4-D and MCPA synthesis in storage at this site. The other portion of the program consists of development of a system for management of spent pesticide containers accumulating in large numbers in one of Oregon's more concentrated agricultural centers.

Although these two waste management problems contrast rather markedly in terms of numbers of containers and volumes of toxic materials which must be managed, approaches to the problems had enough elements of commonality to warrant a coordinated research program. The basic problem in both these situations was to develop some method of rendering these toxic materials harmless, or at least compatible constituents of the environment. In degrading these chemicals, studies have been directed toward utilization of the same biophysical factors in the soil and other elements in the environment which degrade pesticides in the agricultural practice.

Both phases of the Waste Pesticide Management Project arose initially through concern on the part of individuals involved in the agricultural chemicals industry in the one case and individuals involved in crop production in the other case. In spite of this support both phases were severely limited in their implementation by adverse reactions on the part of local citizens intensely concerned about hazards associated with pesticides.

Before initiating the Alkali Lake soil biodegradation program, it was necessary to undertake a series of public hearings in which the entire program was vigorously opposed with considerable publicity. Ultimately application for a permit to operate the experimental studies was made by the Grantee to the Lake County Planning Commission. After a denial, the permit was finally granted on September 9, 1969 and work was immediately initiated on development of the experimental area. A second permit was also secured from the Oregon State Department of Agriculture for conduct of the experiments. Facsimile copies of these permits follow. Both permits were subject to annual renewal.

-Facsimile-

September 9, 1969

Dr. R. L. Goulding, Research Coordinator  
Waste Pesticide Management Program  
Environmental Health Sciences Center  
Oregon State University  
Corvallis, Oregon 97331

Dear Dr. Goulding:

On the evening of Monday, September 8, the Lake County Planning Commission held its second meeting to consider your application of August 27, 1969, for a permit to conduct a Waste Pesticide Management Experiment program at Alkali Lake. Since our first public hearing on this request, held on Monday evening, August 25, two visits have been made to the Chemical Waste, Inc., site by commission members and interested local persons.

At our September 8 meeting a number of questions were expressed, and it was finally moved and carried after a motion for denial was rejected, that action on granting the permit be further delayed until we receive additional information and assurances from you. These were in the following areas:

- 1) Infiltration tests. Members of the commission feel that data on infiltration of the chemical wastes through the Alkali Lake strata, and also on chemical reaction to the various strata, can be gained through tests made in your laboratories at Oregon State University, and they feel these laboratory tests should be made before application of the chemicals so the Alkali Lake test plots.
- 2) We request a detailed map of the area showing wells, springs, exact location of test plots and drilled test holes.
- 3) We request reports on the test holes that have been drilled, showing earth strata, water tables and water movement, if any.
- 4) We request that this Commission be kept informed of all activities of your program and those of your cooperating agencies, in writing.

It was also recommended that we request that the Department of Agriculture refuse any further storage permit, and that no additional stock of chemical waste materials of any kind be allowed to be stored at the Chemical Waste, Inc., storage site until completion of all testing programs.

Further meetings of this Commission to consider granting the testing permit will await your reply and comments on this matter.

Sincerely,

N. R. Smith, Secretary  
LAKE COUNTY PLANNING COMMISSION

CC: Carlson  
Freed  
Hiatt  
Hunt  
Witt

-Facsimile-

STATE DEPARTMENT OF AGRICULTURE

September 5, 1969

Oregon State University  
Environmental Health Sciences Center  
Corvallis, Oregon 97331

Attention: Dr. R. L. Goulding  
Research Co-ordinator

Gentlemen:

In response to your written application under date of August 27, 1969 for a permit as provided by Section 14 (2) of Chapter 268 of the 1969 Legislature (H.B. 1335), I wish to advise that this letter shall act as a temporary permit for you to engage in experimental and research activities subject to the following conditions.

1. The general protocol and criteria for carrying out the permitted activities shall be in accordance with the description of such as set forth in the "Waste Pesticide Management" documentation under date of February 1, 1969. The principal experimental area shall be located on not more than 15 acres of Section 18, T30S, R23E, with two additional experimental areas of not more than two acres to be located in either Sections 12 or 13 and Sections 5, 6 or 7, respectively, of this same township.

2. Since there are occasions when a scientific investigator is unable to fulfill all of the aspects of a proposed program, certain contingencies should be considered and take precedent over other proposed activities. Therefore, the following guidelines and activities are set forth.

(a) The experimental activities to be carried on shall consist of small-scale application rate experiments involving 2,4-D waste liquor, MPCA Tar, and other pesticide residues.

(b) The application of more than 50 drums of any of such materials shall not be allowed under the terms of this permit.

(c) The State Department of Agriculture and its State Chemist may, upon the request of the permittee, consider the allowance of additional quantities during the permit period.

(d) Domestic and livestock water supplies, as well as ground water obtained from test wells, in and adjacent to the experimental areas shall be monitored monthly for pesticide levels. Dust and other airborne particles shall be also monitored monthly for pesticide levels so as to determine the effect, if any, upon soil and forage in the experimental areas and areas adjacent thereto.

Page Two  
Oregon State University  
September 5, 1969

3. Reports shall be submitted to the State Department of Agriculture and its State Chemist in the following respects:

(a) A quarterly progress report, including monitoring data, methodology, amounts of materials utilized in the experiments and the nature thereof, and any site improvements.

(b) Accident reports of any spillage, leakage or other accidental contamination of soil, water or air upon discovery of such, including therein the time, place, causation and corrective measures taken.

(c) Reports of any complaints received by the permittee from any person, agency or group on account of the experimental activities undertaken hereunder.

This temporary permit shall continue until the regular annual permit provided for by Section 11 of Chapter 268 of the 1969 Legislature (H.B. 1335) is issued, unless and until this permit be suspended or revoked prior thereto in accordance with the applicable statutory provisions. Such temporary permit may be modified or amended during the permit period as the State Department and its State Chemist shall deem necessary or expedient. This temporary permit shall become effective as of the date of this communication.

Very truly yours,

VIRGIL G. HIATT  
State Chemist  
State Department of Agriculture  
State of Oregon

VGH:GH



This problem was exacerbated by the fact that after award of the grant was announced the firm operating the Alkali Lake facility began shipment and storage of large numbers of 55-gallon drums of the 2,4-D waste material. In cooperation with the Oregon State Department of Agriculture, a set of operating criteria were developed for use by the firm, Chem. Waste, Inc. At this time no state law requiring a permit for this activity existed. Jurisdiction of the Department of Agriculture was based upon pesticide control statutes. The operating criteria agreed upon were as follows:

Outline of Operating Criteria for Loading, Transport, Inventory  
and Ultimate Disposition of Industrial Residuals of Pesticides  
and Other Hazardous Chemicals.

I. Procedures at Point of Origin

A. Container Criteria (containers used for both shipping and storage.)

1. Size of containers should be sufficient for economical handling with a 10% void remaining after fill. This criterion will apply specifically to drums for transport or storage of wet material.
2. No plugs or bungs should be present except above the void portion of any drum or container. All plugs or bungs should be capable of a complete seal for the life of the container.
3. Minimum standards for drums and other containers. This section should be developed from material secured from the packaging industry, the PUC and DOT.
4. All containers must be free of stress points or crimps with no evidence of structurally significant rust or corrosion.
5. All containers must, if previously used, be decontaminated or the residual content must be compatible with the planned re-use.
6. All old labels and product identities must be obliterated and residual content, if any, identified on the new label. (At this point, immediately prior to filling, all containers should be inspected for compliance with these criteria.)

B. Fill Procedures

1. Filling will take place under conditions meeting all standards of personnel safety including minimum spill hazard.
2. 10% of the total volume of the container will remain void.

3. All bungs and plugs must be tightened with the use of a standard bung wrench. When gaskets are used, their composition must be compatible with the contents.

(Inspection step: All bungs and plugs will be inspected for tightness and drum surfaces for visible contamination at this point.)

4. Identifying labels of durable composition will be applied to each container at this point. Each label shall clearly indicate content by trade name(s), if available, and in every case by chemical name(s) and approximate concentration(s). Batch number and other production information together with identity of the source will be included as will the address and telephone number of a competent source of emergency information.
- C. Loading procedures. This section will be rewritten in cooperation with the PUC and/or DOT. Emphasis will be placed upon loading of drums or other wet containers but appropriate procedures for bulk transport of wet or dry material and particularly bladder transport will also be investigated.

## II. Procedures in Transit.

### A. Compliance with existing regulations.

1. Transport and load will meet all PUC requirements pertaining to movement of waste materials or, where applicable, hazardous chemicals.
2. No foodstuff or agricultural commodities should be back-hauled on vehicles used for hauling toxic materials.
3. Regular transport routes will be designated and filed with the appropriate agencies. Pull-out and inspection points will be indicated.

### B. Safety procedures.

(Inspection step: Should more than two hours elapse between loading and departure, the load will be re-inspected before moving to the public highway. In transit, not more than fifty miles shall elapse before the first inspection and not more than 100 miles between subsequent inspections.)

1. Documents pertaining to detailed identity of components of each load will be carried with the normal transport documents. Should the contents be determined to have a high hazard potential,

specific written instructions relative to emergency action will be included.

2. Appropriate materials and equipment for managing in-transit spills or seepage will be carried and will be readily available on each vehicle. These should include, when appropriate: absorbent materials; plastic bags, neutralizing chemicals; and shovels. A personnel safety kit will also be included in the spill management package. This should contain as a minimum, protective garments, neutralizing chemicals and appropriate rinsing solutions.
3. Instructions for emergency action in cases of critical loads will be supplied to authorities on the shipping route.

### III. Management site operations.

#### A. Off loading procedure.

(Inspection step: The load shall be inspected upon arrival at the site and prior to off loading. Any faulty containers will be segregated for special handling.)

1. Off loading will be carried out directly to inventory areas where load components will be held until further processing is required. At this point, bungs of drums will be loosened to permit equilibration of internal pressure unless contra-indicated by the nature of the contents.
2. Bulk containers, when emptied, will be cleaned of any hazardous residual. This residue will be collected and held with the original bulk load.

#### B. Site Management Procedures.

1. Security.
  - a. All management areas containing hazardous chemicals will be fenced, posted to all but authorized personnel and under 24-hour surveillance.
  - b. Inventory areas will be located so as to reduce detrimental scenic effects and to minimize hazard of vandalism.
2. The management area will be surveyed and plotted with specific usages assigned to specific areas to facilitate product inventory, stock control and efficient space utilization.
3. Chemical wastes will be inventoried separately in unit areas such as pits, ponds or container pads which will be of appropriate

size and design to allow all necessary inspection and monitoring procedures and to facilitate management of emergencies and control of deterioration of containers or other holding facilities.

IV. Plans for Ultimate Disposition of Residual Products.

- A. No material or no quantity of material shall be introduced to the management site which cannot be properly handled by the management resources available at the time of introduction. Judgement of this capability must be the result of the consensus of site management personnel and officials of the appropriate public agencies concerned.
- B. Plans for ultimate disposition of each material or class of materials must be prepared and be approved by the appropriate public agency.
- C. In the event no existing technology for ultimate disposition is available, certain critical pollutants may be accepted for on-site storage. A protocol for storage and inspection must be developed and submitted to appropriate public agencies. The protocol should also include projection of the research required for development of ultimate disposal technology. Approval for storage should be based upon:
  1. Critical nature of the problem.
  2. Feasibility and security of the proposed storage protocol.
  3. Probability of timely development of ultimate disposal technology.

The spent container phase of the program initially received strong support from the Klamath County Commission. It was developed through the Klamath County Agricultural Chemicals Committee under the guidance of the County Extension Agent. The program received broad support within the agricultural and business community. Once the award of the grant was announced and site selection studies were initiated, however, a small but very vocal group began voicing objection, and concern. A summary of this situation, prepared by a member of the Extension Service fellows.

-Facsimile-

Cooperative Extension Service  
Oregon State University  
Corvallis, Oregon 97331

November 23, 1970

Dr. James Witt, Secretary  
Oregon Council on Environmental  
Science and Technology  
Weniger 237  
Campus

Dear Dr. Witt:

Since a degree of hostility to the Waste Pesticide Management Program in Klamath County was evident at a meeting held in Klamath Falls Thursday, November 19, 1970, I thought it appropriate to set down in brief form the course of events leading to the implementation of the program there.

The closed meeting was attended by members of committees and sub-committees formed in the early stages of the development of the program, relatives, State Legislators Hurd and Boivin, and a few others including myself.

The prime objections to the programs as I heard them voiced are as follows:

1. A lack of awareness of the program.
2. A fear that the program is unsafe.
3. Objection that Klamath County be the scene of the program.
4. That the agricultural chemical industry should assume or be forced through legislation to mitigate the problems.
5. Fear that Klamath County might be the depository for the state or region's toxic pesticide waste and empty containers.

A Brief Summary of Events Leading to the  
Klamath County Waste Pesticide Management Program

In the fall of 1967, Mr. Bert Wilcox, County Extension Agent, organized a Klamath County Agricultural Chemicals Committee, consisting of himself, local farmers, chemical applicators, and chemical retail dealers; as well as the County Vector Control Manager. Also members of the original committee was a veterinarian, a consulting entomologist, and a representative from the U. S. Public Health Service. This committee undertook an evaluation of agricultural chemicals usage in Klamath County and as a result, suggested that serious consideration be given to establishment of storage sites in the County for the management of waste pesticide chemicals and empty containers.

In the spring of 1968, a sub-committee consisting of local pesticide applicators, dealers, and a representative of the Oregon State Department of Agriculture, was organized to further develop plans for management of waste

pesticide and containers. Following the initial meeting of the committee, in which concepts of the problem were developed, it was decided to meet jointly with the County Commission and County Engineer to further consider the problem. The Commissioners offered the cooperation of the County government and with the support of the Extension Service and the County, a base for the program was established. In July of 1968, members of the sub-committee, the County Commissioners, and others in the area concerned with the problem, met with representatives of the Oregon State Board of Health, the Oregon State University Environmental Sciences Center, U.S. Public Health Service, Klamath County Sanitary Board, and Oregon State University Extension chemistry and pesticide specialists. The problem was further defined during the course of this meeting on the basis of comments by the various specialists, and also on the basis of estimates of numbers of pesticide containers generated each year in the Klamath County area. At this meeting, it was estimated that between 6,000 and 8,000 empty containers, ranging from five to fifty gallons in size, were generated in the area each year.

As an outgrowth of this meeting, the Extension Service pesticide safety specialists set up a survey of his counterparts in the 50 states, to determine what other areas were doing in an attempt to solve this problem. Replies were received from 32 states and the responses revealed that there were few formal and no acceptable procedures for disposal of containers. The results of this survey were returned to the sub-committee and the County Commissioners where it was decided to seek assistance in development of a pilot project. The Commissioners expressed willingness to involve the County in the program.

The Environmental Sciences Center at Oregon State University undertook development of a research-demonstration grant proposal, which was submitted to the Bureau of Solid Waste Management. During the course of development of this request, the sub-committee continued to meet and study the problem and attempt development of guidelines. It was apparent that at least one, and possibly two, sites would be needed to carry on the program as planned. One site would serve as a collection area where empty containers and pesticides could be sorted and handled in various ways for ultimate disposition. It was also considered that a second site would be required to provide an area in which some of the waste materials or rinses or washes from the containers could be applied to soil for purposes of biodegradation of chemicals which were considered suitable for this process.

At this point, it was decided that it was time to begin to acquaint more of the local farmers with plans for the program and to get their support and their understanding of the program. As an outgrowth of this, a site-finding committee of local farmers, commercial applicators, the County Engineer, the County Extension Agent, and soil scientists from the Soil Conservation Service was formed. It was the responsibility of this committee to survey the County, looking for sites which met the general specifications which had been established. Members of this committee worked several days and finally decided on the site near Merrill as a collection site, and eventually upon a basin, approximately nine miles from this site, as a potential degradation area.

Effective July 1, 1969, the three-year pilot project, supported by a Research-Demonstration grant from the Bureau of Solid Waste Management, was initiated. At this time, steps were taken to secure the land required for the site.

A geologist from the State Department of Geology and Mineral Industry, took core samples on both areas, and site development at Merrill was begun.

Up until this time, the work and planning was done without involvement of the news media. Once the sites had been selected and were generally agreed upon by leaders in the agricultural community and the County government, information concerning the program was made available to the local newspapers, radio and T.V. stations. Local aspects of site development and management are under the supervision of the County Engineer, while the Oregon State University Environmental Sciences Center has the overall program under its direction.

The local committee is currently assisting in development of a program for collection of empty containers which has been underway since mid-December of 1969. A more intensive program of collection of containers was undertaken in the 1970 agricultural season.

Because of the extent of the local involvement is considered a key to the success of this program to date, some indication of the numbers of people involved and their occupations may prove helpful. In all, eight ranchers and six retail pesticide dealers, or commercial applicators, have been directly involved in planning and implementation of the program. In addition, a local consulting entomologist and a practicing veterinarian also played prominent parts in development of the program. County government was represented by the four Commissioners, the County Engineer, the County Weed Control and Vector Control Supervisors, and members of the County Health Department. At the State level, representatives of the State Board of Health and State Department of Agriculture were active participants in development of the program, as was the local representative of the State Game Commission. The Oregon State University Environmental Sciences Center and County Extension Agent, were involved in key roles in the program. Federal representatives involved in Klamath County programs were also consulted. These included representatives of the Federal Water Pollution Control Administration, U.S. Public Health Service, Soil Conservation Service, and Bureau of Land Management. Coordination of the local activities has been largely the function of Mr. Wilcox, the County Extension Agent for Klamath County.

Announcement of the Federal Grant was made in nationwide news releases in July and August of 1969 by Governor Tom McCall and by the OSU News Bureau. (See Enclosures.) Mr. Wilcox wrote five newspaper articles which were printed by the Klamath Falls paper. He also appeared on Klamath radio to discuss the plans for the program.

At OSU, Mr. Capizzi prepared spot announcements and visuals which were broadcast on a number of occasions on Klamath TV. Posters announcing the program were prepared and placed at appropriate locations where commercial pesticides are sold in Klamath Falls.

In retrospect, the local legislators should have been personally apprised of this program development.

Perhaps a series of formal public sessions at Klamath Falls is indicated in order that misconceptions and rumors be dispelled and the situation be ameliorated. It is my understanding that the recent political climate in Klamath County has caused some of the present adverse reaction.

The Waste Pesticide and Container Program in Klamath County shows promise of serving as a model for the management of user waste pesticides and containers nationwide. It was conceived of locally to solve a local (Klamath County) environmental problem. Its development does not presuppose adoption in Klamath County nor was there ever any intention of committing Klamath County to area, state, or regional pesticide/container management.

Note: There has apparently been a small quantity of containers trucked to the Merrill site from the Tule Lake, California area. This movement can be avoided by exercising more rigorous control at the site.

The past casual disposal of toxicants and containers poses an ever-present threat to the environment in Klamath County. As future development of a management system is threatened by lack of a successful educational effort we need consider increased participation in this important aspect of the overall program.

Sincerely,

Joe Capizzi  
Extension Specialist  
Pesticide Education

JC:lm  
Enclosures

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During this interval the management site at Merrill was selected and basic site development activities were completed in cooperation with the Klamath County Engineer and Road Department. Shortly after completion of the site development program the existing Board of Commissioners was defeated in the County election. One of the first acts of the new Commission was to halt all cooperation with the program. Two of the three members expressed strong opposition to the program. Since County cooperation on the part of the Engineer, the Extension agent and the weed control specialist were an integral part of the plans for conduct of the program this resulted in a revision of plans which certainly limited the achievements of the project.

If there is a lesson to be learned from these developments, it is perhaps that support of groups most directly concerned with the problem of hazardous waste management is not enough. Wide segments of both the private and public sections are also concerned and are ready to act in response to their concerns, or even apprehensions. This is widely recognized today, but not in 1969, when this project was conceived.



## Project Objectives

The broad objectives of this project were to develop technical information and management systems for reduction of waste pesticide problems. The following was extracted from the grant application.

"The basic strategy underlying the program will be to utilize the potential of the soil for biological and physical degradation of chemicals. Suitable land is available with low use potential and with geological features assuring restriction of chemical wastes to the site of application, providing air borne transport is adequately restricted.

"To be acceptable, any system developed must be proved capable of degrading a given chemical waste to non-toxic products within a useful time interval permitting reapplication of additional waste or diversion of the land for other use.

"The product of two principal waste sources will be studied: (1) The by-products of pesticide manufacturing and formulating industries and; (2) The accumulations of containers generated by agricultural usage of pesticides. Solution of the latter problem requires decontamination and re-use or disposal of the containers as well as degradation of their unused residual content."

Specific projectives were:

"A. Pesticide Industrial Waste Management. The prime objective will be to develop a management system for reduction of 2,4-D and 2,4,5-T waste process liquors to biologically inactive compounds by means of application to and degradation in the soil surface. Other pesticide wastes as well as other kinds of industrial or domestic waste will also be assayed for use in this reduction process.

"B. Management of Pesticide Containers. The prime objective will be to develop a management system for effective decontamination of containers, safe disposal or reclamation of the container itself and, degradation of the residual pesticide content by chemical and/or biological means with ultimate disposal of this component by application to the soil surface.

"C. Land Utilization. Soil surface application techniques will be studied for maximum utilization of the degradative features of low use potential land in basins in the alkaline areas of eastern Oregon. Studies on the potential for surface or air borne transport will be carried out as well as assessment for any effects on plants and animals on the sites."

**THE ALKALI LAKE PROJECT**

**Soil Biodegradation of Pesticide Manufacturing Work  
Lake County, Oregon**

**ROBERT L. GOULDING**

**August, 1973**

**Environmental Health Sciences Center  
Oregon State University  
Corvallis, Oregon 97331**

THE ALKALI LAKE PROJECT  
Management of Wastes Derived from the Manufacture  
of 2,4-D and MCPA.

Manufacturing Properties of 2,4-D and MCP.

The phenoxy herbicides and, particularly, 2,4-D and MCP are well established pesticides for the control of weeds in agriculture. The plant growth regulating activity is primarily against broad-leafed plants at levels of 2 lbs/acre or less for many weed species.

Both MCP and 2,4-D are prepared by the same general reactions. The starting material for manufacture of MCP is o-cresol, or 2-methyl phenol, rather than phenol. The cresol is chlorinated to produce primarily 4-chlorocresol. However, as in the chlorination of phenols, other isomers are formed such as, small amounts of 6-chlorocresol and 4,6-dichlorocresol, in addition to the 4-chloro isomer. MCP is prepared by the condensation of 4-chlorocresol with chloroacetic acid.

In addition to the chlorinated phenols and cresols and chlorinated phenoxy acetic acids, there are some other polycyclic compounds in the waste material. These are formed by the condensation of the phenols under the hot alkaline conditions of the reaction mixture. If there is one point of attachment between rings, the resulting compound is an ether phenol. If there are two points of condensation, the resulting compound is a dioxin.

The dioxin formation was the cause for concern, initially, over the use of 2,4,5-T. 2,4,5-trichlorophenol is employed in the manufacture of 2,4,5-T. It can condense to form 2,3,7,8-tetrachlorodibenzo-p-dioxin. This compound is extremely toxic and elicits teratogenic effects.

Because of the nature of the starting materials, it is highly unlikely that any tetrachlorodioxin will be formed during synthesis of 2,4-D. However, since the dioxin is quite toxic, samples of 2,4-D waste were analyzed for its presence. The analyses were performed on a gas chromatograph attached to a mass spectrometer. Thus, it was possible to determine the nature of many of the impurities present in the waste, as well as the dioxin.

Analysis of this waste product indicated that there were no detectable amounts of tetrachlorodioxin or the trichloro derivative of dioxin. There was a small amount of dichlorodioxin present. This is what could be expected from the condensation of 2,4-dichlorophenol molecules. In addition, a number of

other chlorinated compounds were also detected. The molecular weights of these compounds indicated them to be various isomers of chlorinated phenol-ethers.

The toxicity of these chemicals with respect to mammals is relatively low. LD<sub>50</sub> dosages range from 300 to 1,000 mg/kg body weight, depending on the species and sex of the animal tested. The LD<sub>50</sub> dosage for MCP in rats can be given as 700 mg/kg and, if this is extrapolated to man, the dosage would lie between 1.75 - 2 oz. of pesticide. On a similar basis, the LD<sub>50</sub> dosage for 2,4-D in man, would be in the order of 0.75 to 1 oz. By way of comparison, a single dose of about 1 oz. of aspirin is usually fatal. While these chemicals cannot be considered innocuous compounds in terms of drugs and other chemicals man commonly uses, they certainly are not considered highly toxic materials.

The primary reactions in the synthesis of these herbicides are essentially the same for both 2,4-D and MCP. The starting material in the manufacture of 2,4-D is phenol or carbolic acid, which is similar to the materials found in some common household disinfectants. The first step in the reaction is performed by chlorination of the phenol with chlorine gas. This process results in a number of isomers, depending on the location and number of chlorine atoms which become attached to the phenol ring. Thus, we can get 2- or 4-chlorophenol, 2,6-dichlorophenol or 2,4,6-trichlorophenol. By close control of the reaction, the primary product, however, will be the desired 2,4-dichlorophenol.

The second and final step in the formation of 2,4-D is the condensation, or coupling, of the 2,4-dichlorophenol with chloroacetic acid, a chlorinated derivative of acetic acid. In the manufacture of this compound, as in nearly all organic synthesis, all of the desired product cannot be recovered from the reaction mixture. Thus, the waste developed from the reaction contains 2,4-D, but in addition, it will also contain 2-chloro-, 4-chloro-, 2,6-dichloro-, and 2,4,6-trichlorophenoxy-acetic acid from the condensation of the by-product phenols that did not react to give the respective phenoxyacetic acids. Since the condensation reaction is carried out under alkaline conditions, the waste mixture will contain various phenols and phenoxyacetic acids as their sodium salts.

The only standard compound available for comparison to the constituents of the waste products was dichlorodioxin which was present at approximately 300 ppm. Toxicity of this compound is quite low compared with the tetrachloro

isomer. In addition, it does not produce chloroacne in man, as does the tetrachloro isomer.

#### Rationale for Biological Degradation of Pesticide Wastes

There are many possible ways to handle the problem of chemical waste. In the past, non-destructive methods such as dilution in surface water and the ocean, or simple storage, have been widely used. Current concerns for environmental quality have resulted in standards which are no longer compatible with these approaches to management of the hazardous chemical wastes of our industry.

In order to effectively reduce the problem of management of hazardous chemicals, it is necessary to degrade or alter the toxic molecules through some type of chemical or biological degradation. The waste chemicals from production of phenoxy herbicides are relatively stable to chemical treatment. For this reason, chemical degradation would most reasonably be accomplished by oxidation through incineration. This method is complicated, however, because most incinerators have the potential for contribution to air pollution.

At least until sophisticated incineration or pyrolysis techniques become technically and economically feasible, the alternative of biological degradation holds considerable promise. This is certainly not a new concept, since we rely on the process of microbiological degradation to prevent build-up of pesticides used in crop production. The primary difference between agricultural use and a chemical waste management operation lies in the amount of chemical applied. Obviously, much larger amounts of chemical would have to be involved in a feasible chemical waste management operation.

In order to use soil as a receptacle of waste chemicals, two primary criteria must be met. The first is that the soil microorganisms must be able to degrade the chemical wastes to environmentally acceptable entities at relatively high rates of waste application. This means that the soil microorganisms must not be inhibited by the waste and they must be able to decompose the waste components. The second criterion is that the characteristics of the site of application of waste materials must have a minimum potential for the chemicals leaving the site in any way or form that would result in their becoming environmental pollutants.

Nearly all organic pesticides have been shown to be degraded in soil when applied at normal rates of application. The extent of soil life varies from a few days to several years with the more persistent materials. It is known that the phenoxyacetic herbicides do not persist from one growing season to

the next, when used in normal agricultural rates. The primary route of loss of pesticides is considered to be microbiological rather than chemical in nature. The microbiological nature of the decomposition is indicated by:

- 1) Soil and climatic factors that are conducive to high microbiological activity result in the most rapid rates of decomposition.
- 2) The rate of herbicide decomposition in biologically sterile soils is greatly inhibited.
- 3) There is a "lag" period before herbicides in soil begin to decompose.

This lag period is considered to be due to adaptation of the micro-organism populations to the chemical or to the time required to build a population of species of organisms which are capable of decomposition of the constituents of the pesticide. After this lag period, there is a relatively rapid decomposition of chemical. This adaptation of the chemical may consist of induction of enzyme systems capable of utilizing the chemical as a carbon source, or some other energy source, or to selective enrichment of the soil, with respect to the organisms that are already present in the soil and capable of metabolizing the herbicide. In any event, after the soil is enriched, subsequent additions of the chemical persist for a much shorter interval of time.

A survey of the literature indicates 2,4-D persists no more than a few weeks and MCPA up to three months following application at normal use rates. Subsequent additions of the chemical, in the course of management of weed populations, frequently result in residues of only a few days duration. There also appears to be evidence of an inter-relationship in the response of microorganism to both 2,4-D and to MCP. Thus, after soil has gone through a lag phase of enrichment by 2,4-D, there is no corresponding lag period where MCP has subsequently been used. The reverse also appears to be true where MCP is first employed. These facts certainly appear to favor utilization of soil for repeated applications of phenoxyacetic waste materials.

The mechanism of phenoxy acid degradation involves cleavage of the ether substitute and hydroxylation of the ring. Ether cleavage of the ring produces 2,4-dichlorophenol, which is also present in the 2,4-D waste material. The 2,4-dichlorophenol is hydroxylated and, subsequently, the ring is opened with the result that there is little chance of toxic or persistent metabolites resulting from microbial metabolism of 2,4-D or dichlorophenol.

An important consideration in biodegradation of chemical wastes is the effect of the waste upon the microorganisms. All the available literature indicate that there is no inhibitory effect of 2,4-D on microorganisms at normal rates of application. At high rates, the effect is variable, depending upon the species of organisms. Certain species are reported stimulated by as much as 1000 ppm of 2,4-D in the soil. It is reasonable to expect that many organisms can adapt to the chemical and utilize it at least as a carbon source.

With these concepts in mind, we proceeded with some bench scale studies to determine the ability of soil from the Alkali Lake site to metabolize the 2,4-D waste. Soil was treated with approximately 100 ppm 2,4-D and analyzed periodically to determine the amounts residual. The results of this study agreed with those of other investigations of rates of degradation of 2,4-D in soil. In soil from two areas of the test site, there were lag periods of from 8-13 weeks before the chemical started degrading. After this time, there was rapid degradation resulting in complete loss of the chemical. Subsequent to these initial observations, test plots were then established to determine the rate of 2,4-D and dichlorophenol degradation under actual field conditions at the Alkali Lake test site.

#### BIODEGRADATION STUDIES AT ALKALI LAKE

Studies on the use of soils surrounding Alkali Lake in Lake County, Oregon, for biodegradation of industrial waste derived from production of 2,4-D and other phenoxy herbicides have matured to a point permitting a comprehensive, but not final, report.

#### Alkali Lake Site Physical Features

The Alkali Lake site consists of an alkaline playa of approximately 3500 acres and land immediately surrounding; bring the total holding to approximately 6000 acres. The playa constitutes a base level for surface drainage within a closed basin approximately 300 square miles in area. The Alkali Lake basin was the site of an ancient lake, some 20,000 years ago, so that the playa has been the terminus of regional drainage at least for that length of time. The disappearance of the ancient lake is considered to be the result of climatic changes rather than due to breaching of restraining rock formations. Faulting and tilting of rock units in the Alkali Lake vicinity are thought to form surface barriers to movement of deep ground waters.

FIG. 1. Some of nearly 25,000 drums of chemical waste from 2,4-D and MCPA manufacture in storage at Alkali Lake.



FIG. 2. Small plots with and without plastic covers. Note sparse vegetative cover typical of area.



The Alkali Lake area has been the subject of geological investigation for many years because of interest in potential mineral resources. Most recent investigations have been undertaken by the Oregon Department of Geology and Mineral Industries, in connection with the current studies evaluating the use of the site for management and degradation of specific chemical wastes. The results of these studies are available in an Open File Report prepared by this agency entitled, "Geologic Evaluation of the Alkali Lake Disposal Site" which is appended herein. These studies determine that the north end of the property adjacent to the playa is unsuitable for use because sediments are porous near the surface and a considerable amount shallow subsurface drainage was entering the basin at that end. Sediments on the land adjacent to the southern portion of the playa were found to be less porous and associated ground water was very salty, stagnant and lay at a much greater depth. This portion of the property was judged to be more suitable for establishment of a biodegradation program.

A brine pool was found to underlie the present dry lake extending to a depth of more than 100 feet, but with diminishing salt content below 40 feet. Fresh water occurs approximately 130 feet below the lake basin on the north end and at 260 feet on the south end. This fresh water zone is separated from the saline waters of the lake by 50-100 feet of impermeable rock. There are deep artesian wells at the north and south ends of the lake which flow fresh water and there are several springs seeping out at the surface on the north and west sides of the playa.

The playa evaporites in the brine pool contain high concentrations of arsenic. The springs found seeping around the lake also contain high concentrations of arsenic except the large spring on the north side of the lake which flows fresh water with only a trace of arsenic. This spring is believed to be connected to the deep fresh water aquifer. Analysis of water from the two wells showed high arsenic content but this may be due to mixing with saline waters during ascent through the well bores. Water movement, both surface and subsurface, is directed into the basin.

Alkali Lake basin is judged on basis of geologic evaluation to meet the requirements for disposal of waste chemicals since: a) the site is remote, b) land has a low-use potential, c) water resources will not be contaminated.

Disposal of chemicals, however, should be confined to the southern half of the property on the basis of geological studies to date. Addition of chemicals directly to the playa or to the underlying brine pool, is considered

to be undesirable. Neutralization or alkaline degradation of the chemical waste should be accomplished on higher ground without contact with naturally occurring surface or subsurface water which drains into the playa.

The western quadrant of the lake shows evidence of the extensive wind erosion which has been a predominant feature in the development of the modern Alkali Lake. At least 30 feet of the original lake bed sediments have been removed by this means since the original lake disappeared. The weather is typical of the arid semi-desert of eastern Oregon with temperature extremes in excess of 100°F in the summer to subzero occasionally during the winter. The soil commonly freezes to a depth of from 3-6 inches. Annual precipitation varies from 6-12 inches and an annual evaporation rate of in excess of 70 inches prevents any appreciable accumulation of water on the alkaline playa surface.

#### Small Plot Studies - Preliminary

The initial segment of the program to assess the potential of these alkaline soils for biodegradation of the phenolic wastes and herbicide residuals was conducted in a series of small 10' X 10' plots. Plots of this size were selected in order to minimize any unexpected impact on this environment in the event unfavorable reactions developed following reduction of the waste material.

Initial tests were concerned with the possibility of vertical movement of the pesticide in the soil following addition of water. Approximately six inches of water, equal to two-thirds of the annual rainfall, were applied to plots treated with waste at a rate equivalent to 300 lbs. of 2,4-D per acre. Soil samples were taken on these plots and in all subsequent plots by means of a three-inch soil auger. The soil profile was sampled in increments so that vertical distribution of the waste could be ascertained. This sampling procedure was continued in all the subsequent small plots studied. Samples were then returned to the laboratory where they were extracted and analyzed for 2,4-D and dichlorophenol content expressed in terms of ppm of soil.

The data summarized in Table 1, represent a comparison between a plot receiving the normal annual rainfall and a plot flooded with a total of six inches of water immediately following treatment and then exposed subsequently to the normal rainfall of the region. The data appearing in Table 1 represent a summary of eight sampling intervals over a period of a little more

than one year expressed as an average concentration per unit inch of profile segment.

Table 1.

Distribution of DCP Bleed Waste in Soil  
300 lb/Acre 2,4-D Equivalent Surface Application

	PPM per unit inch of Soil Profile Segment							
	0-2"		2-6"		6-12"		12-18"	
	2,4-D	DCP	2,4-D	DCP	2,4-D	DCP	2,4-D	DCP
Normal Annual Precipitation	92	85	5	7	2	7	1	1
Normal Pptn and Flooding to 6"	5	28	20	12	34	31	41	29

It can be seen that where flooding did not occur, the concentration of waste material, in terms of 2,4-D and DCP, remained at, or very near, the surface of the soil. Flooding contributed immediately to a vertical distribution into the lower depths of the soil which was retained throughout the one-year interval of observation. These observations indicate that while this waste may be highly mobile, under conditions of flooding, or high rainfall, that the more normal annual precipitation results in minimal vertical movement. The data also suggest that use of intensive irrigation to promote more rapid biodegradation or to support a cover crop may be contra-indicated.

In addition to the observations on vertical movement, subsequent small plot studies involving material applied to narrow trenches also indicated very little horizontal movement beneath the surface of the soil. In summary, these observations indicate essentially no migration of the waste in the soil once it has been applied; unless excessive water is added.

Particulate Transport and Movement of Volatiles

Although there appears to be a rather minimal chance of migration of the waste chemical within the soil, the wind erosion occurring in the area clearly indicated the likelihood of particulate transport from soils subject to surface application. Additionally, it is also perfectly obvious to those working the small plots that a volatile fraction is continually being removed from soil receiving surface applications.

Observations were initiated to determine the significance of movement of components of the waste material on particles, or as a volatile fraction in the air. Five 2' X 2' glasswool filters were installed around the vicinity of the experimental area and the drum storage area, in what was normally downwind exposure. Initial observations indicated no detectable levels of 2,4-D on short-term exposure of one week or less, in any of the filters. Subsequently, exposure was carried out between the interval of 12 May and 15 July, or nearly two months. Amounts of 2,4-D accumulated in these 2' X 2' glass filters are summarized in Table 2.

Based upon this small number of collection stations, a mid-point concentration of 2,4-D at 400 yds. appears to be in the order of 20  $\mu\text{g}/4$  sq. ft. of filter surface. An extrapolation from this, in terms of pounds per acre, would be in the range of .002 lbs. of 2,4-D/acre deposited over a two-months' interval across the full 800 yards downwind from the source sites. This represents a 2,4-D exposure of about .00001 - .0002 of the usual single 2,4-D application for control of undesirable range plants in this portion of eastern Oregon.

Air samples have been collected on two occasions during the summer months over the surface of the small plots, as well as within the drum storage area. Two Gelman microimpingers, connected in series containing ethylene glycol, were used as a collection system. Air was bubbled through this system at a rate of one liter per minute for intervals up to six hours without detection of chlorinated phenols. Calibration in the laboratory indicated the sensitivity of the method to be in the order of 7 ppb. The odor of chlorinated phenols in the air at the time the samples were taken was perfectly obvious, indicating that concentrations of phenols were relatively small and that the human olfactory threshold was also in very low order of magnitude.

#### Small Plot Studies

The primary series of small plots were set up to determine rates of degradation of 2,4-D waste. Results of these plot studies are summarized in the figures which follow in terms of ppm 2,4-D or Dichlorophenol per unit inch soil profile over the entire depth of 0-18 inches. With a few exceptions, samples were taken at 6-8 week intervals, over a period of a little more than 600 days.

It should be borne in mind while interpreting the figures which follow, that the expression, ppm 2,4-D or DCP/unit inch of soil profile is, in effect, an average of concentrations along the profile and that much higher values

Table 2.

PARTICULATE TRANSPORT

2' X 2" Glasswool Filters, Exposed 12 May-15 July, 1970.

<u>Location</u>	<u><math>\mu</math> 2,4-D</u>
100 yds SE of Drum Storage	80
300 yds SE of Drum Storage	28
800 yds NE of Drum Storage	3
50 yds SE of Small Plot Area	83
100 yds SE of Small Plot Area	40

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Fig. 3  
HYPOTHETICAL DEGRADATION CURVE

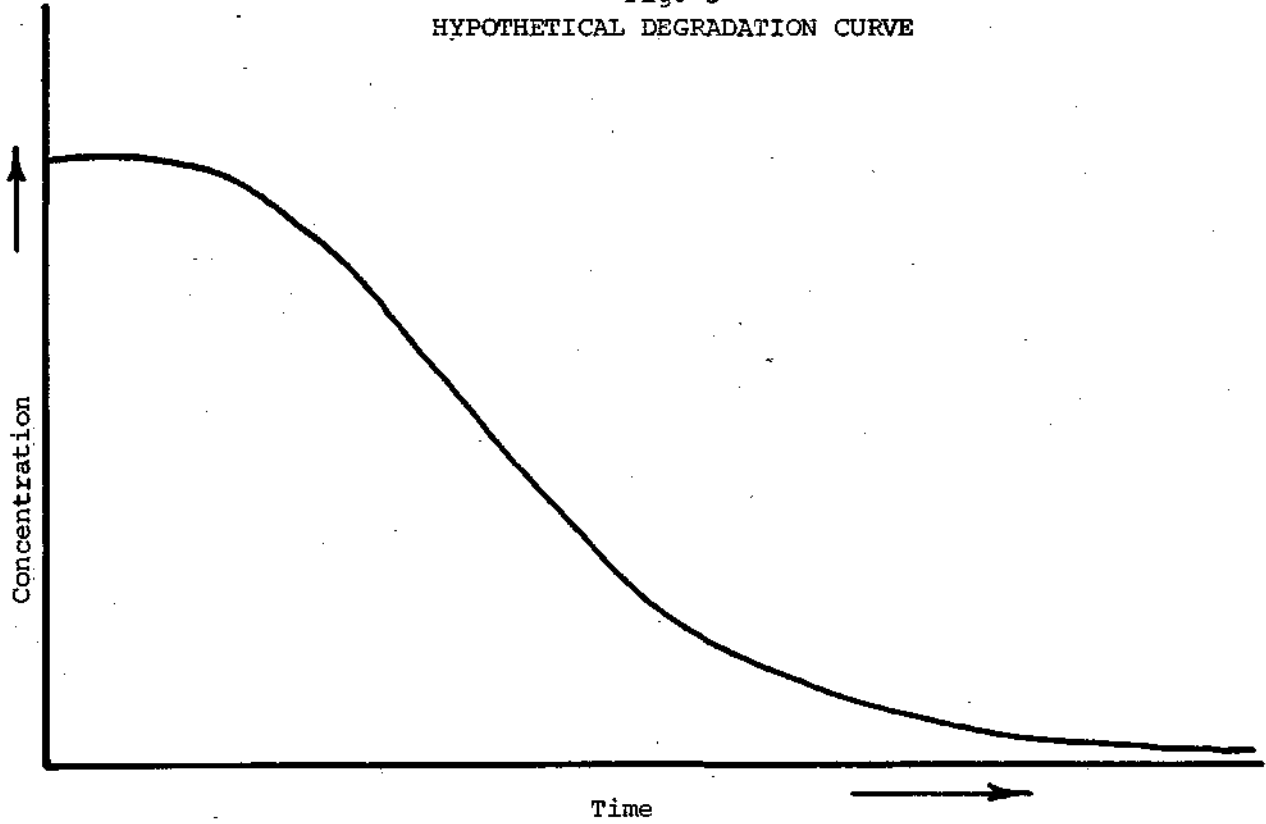
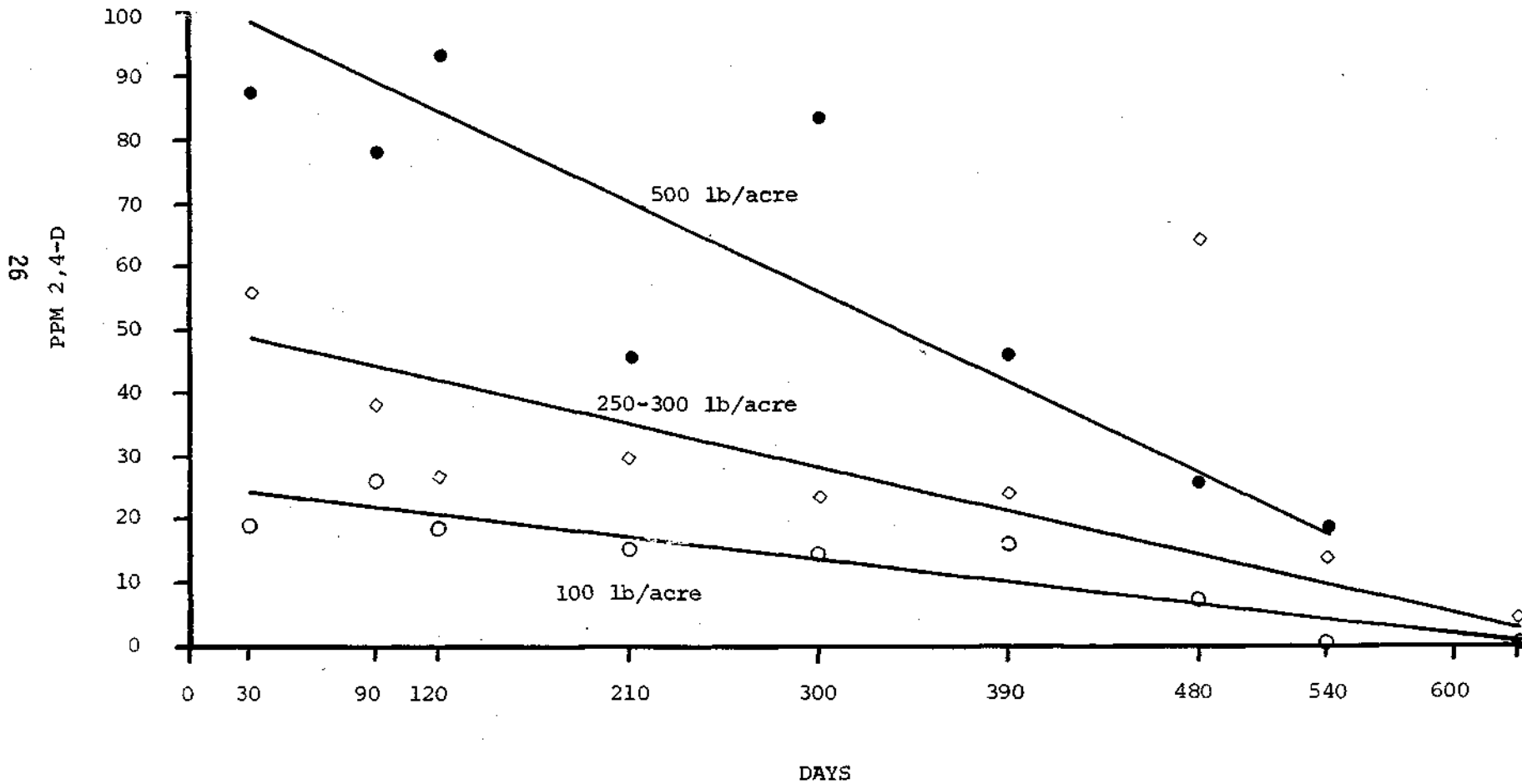
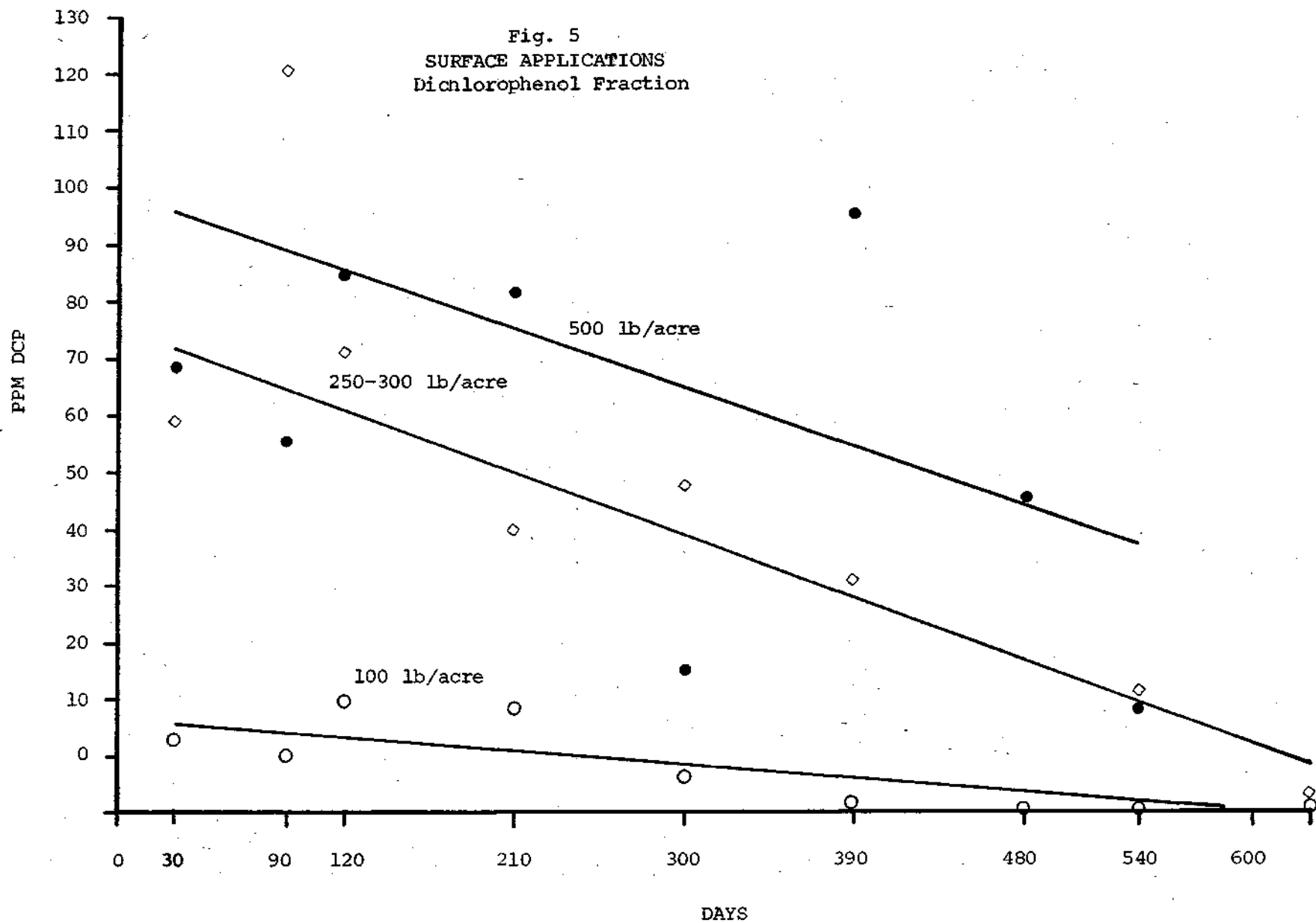


Fig. 4  
SURFACE APPLICATIONS  
2,4-D Fraction







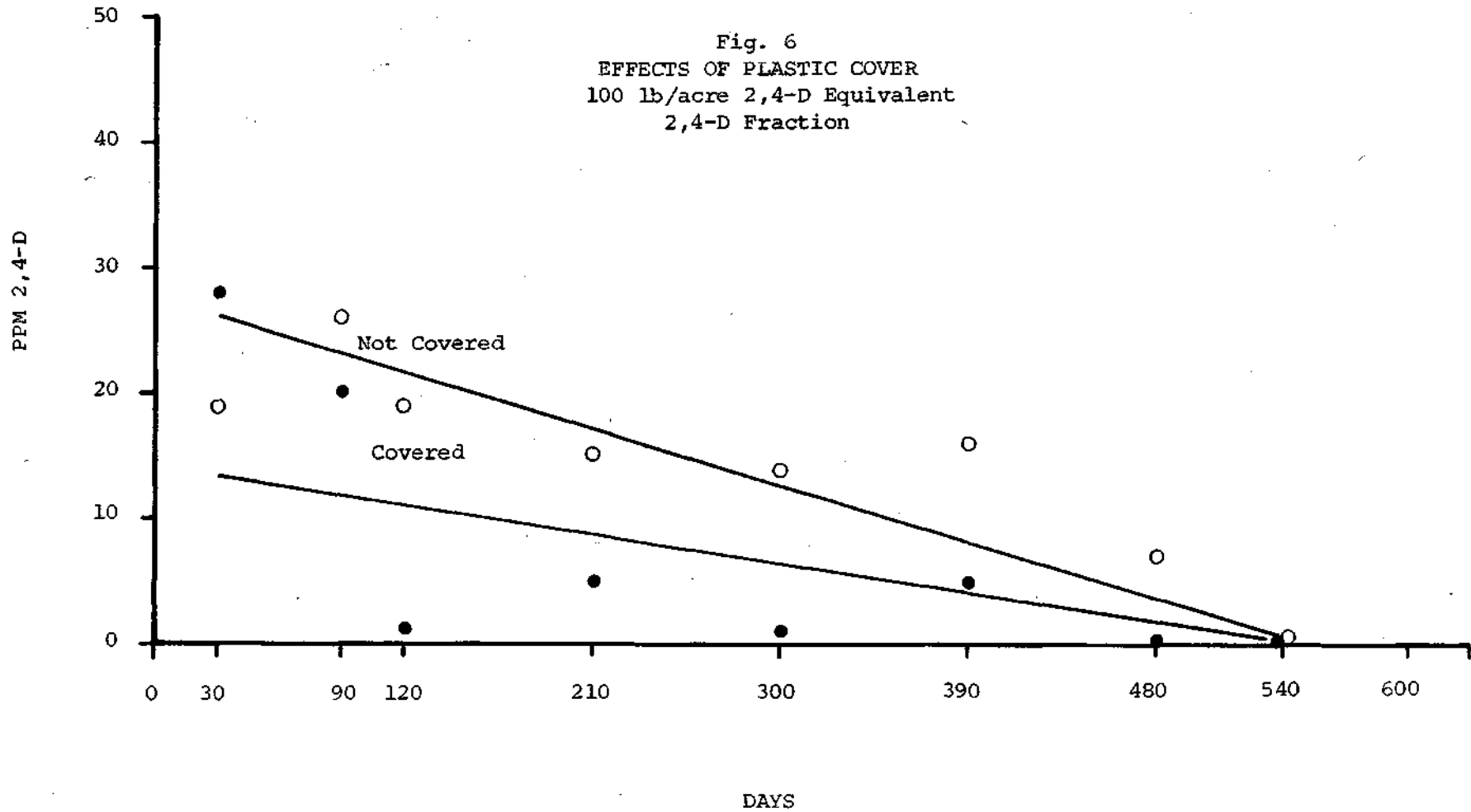


Fig. 7  
EFFECTS OF PLASTIC COVER  
100 lb/acre 2,4-D Equivalent  
Dichlorophenol Fraction

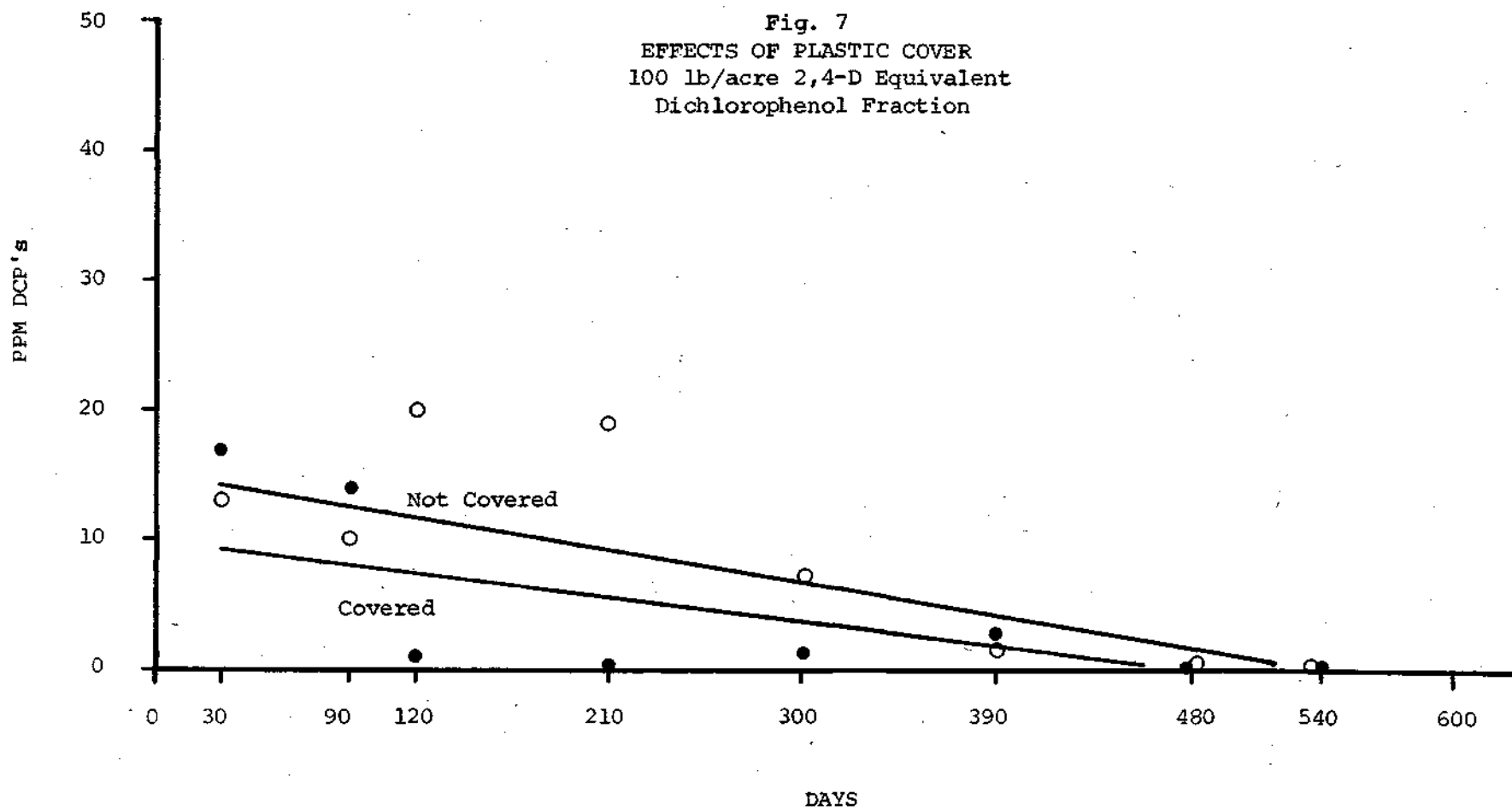
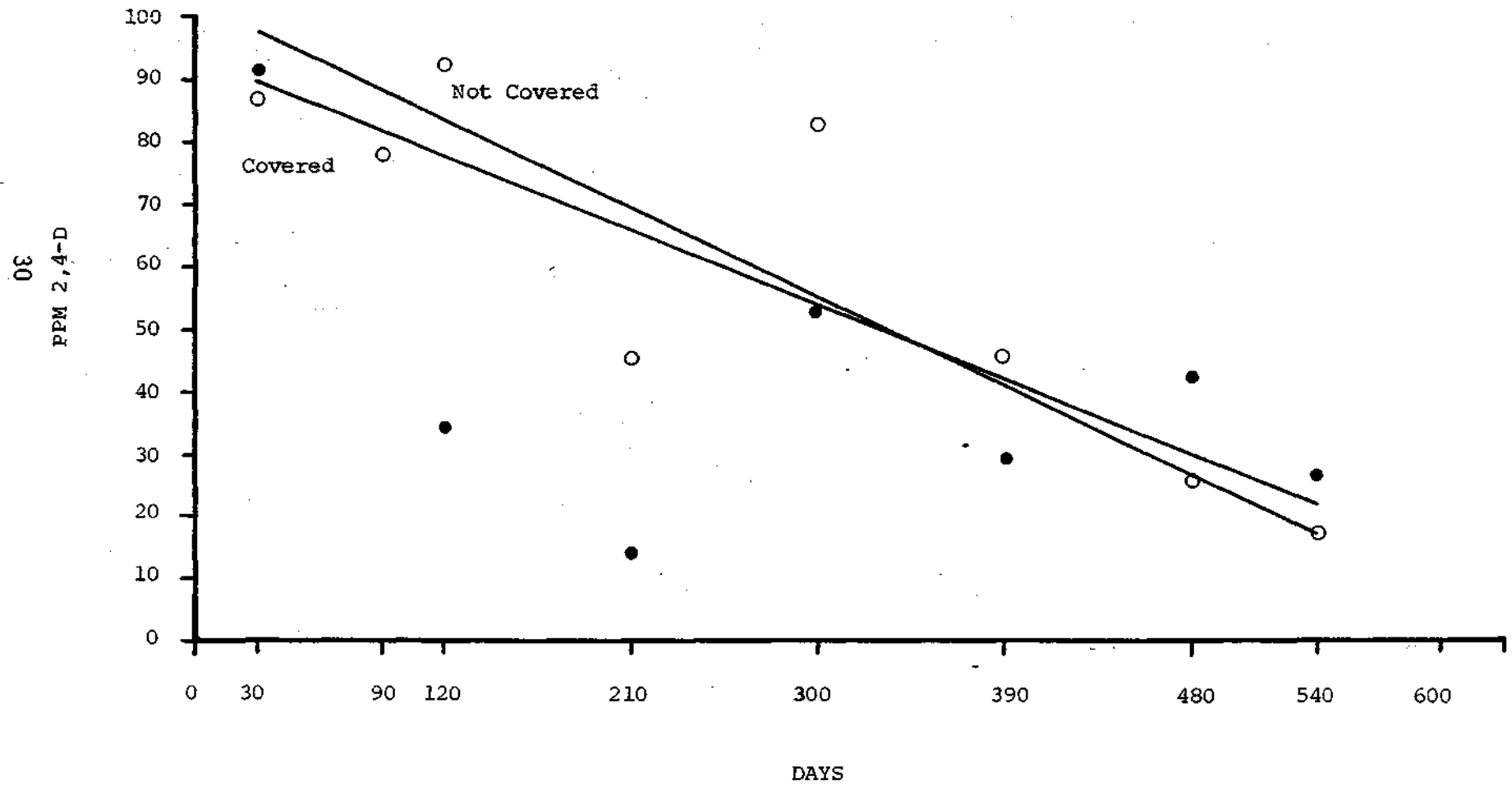
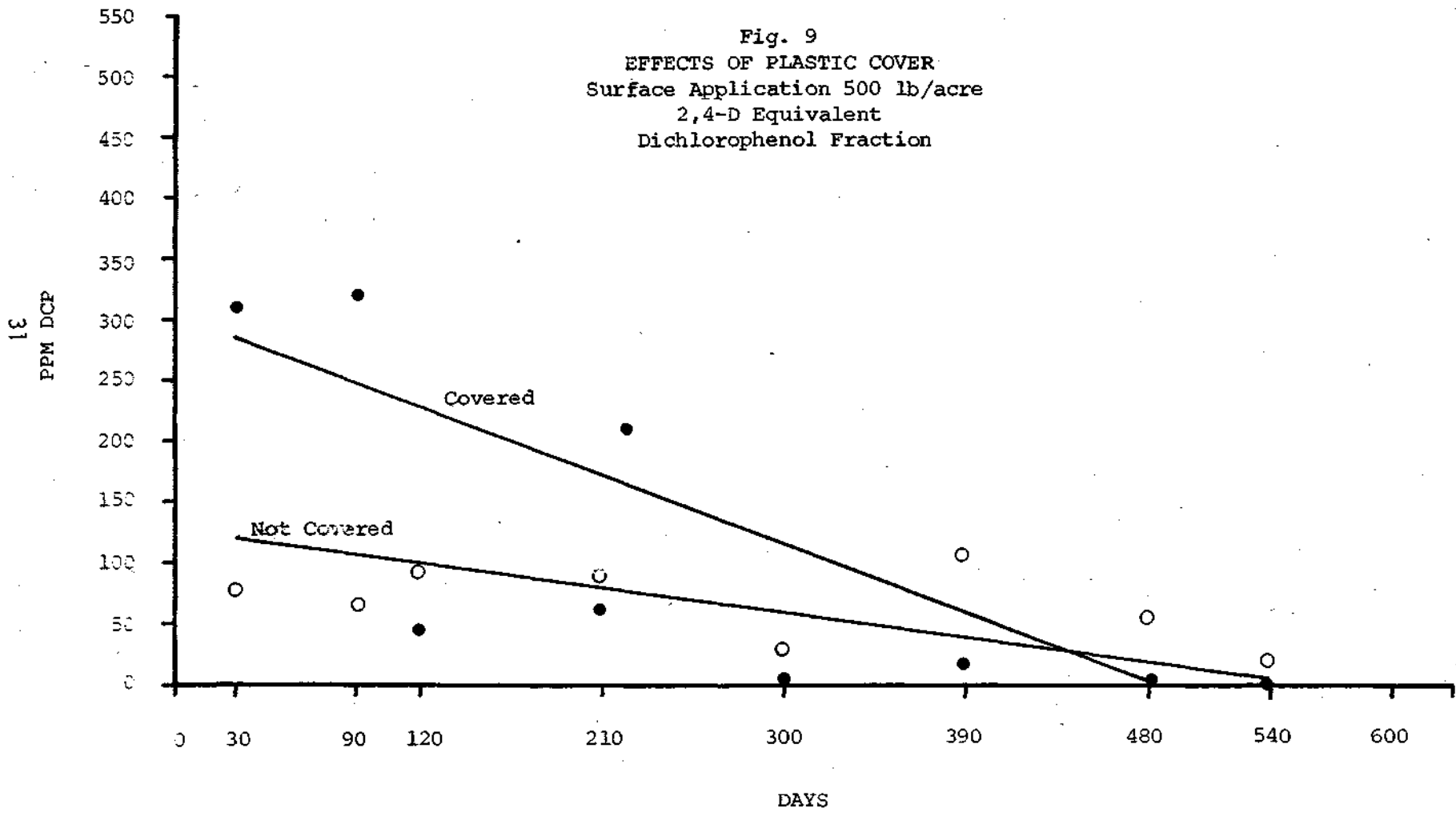


Fig. 8  
EFFECTS OF PLASTIC COVER  
500 lb/acre 2,4-D Equivalent  
2,4-D Fraction





PPM 2,4-D  
32

Fig. 10  
2,4-D DEGRADATION RATES  
Surface vs Trench Applications  
100 lb/acre 2,4-D Equivalent

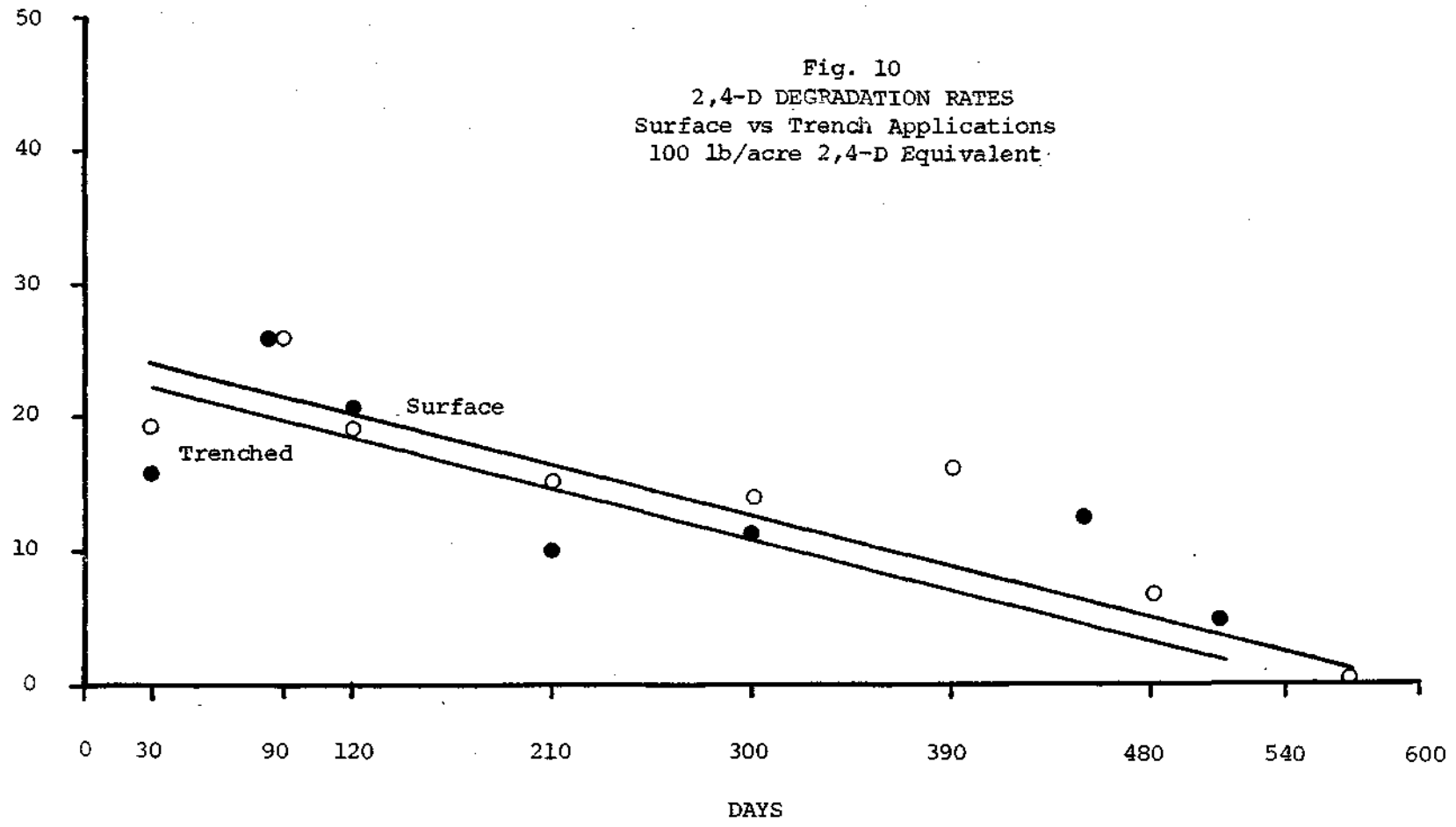
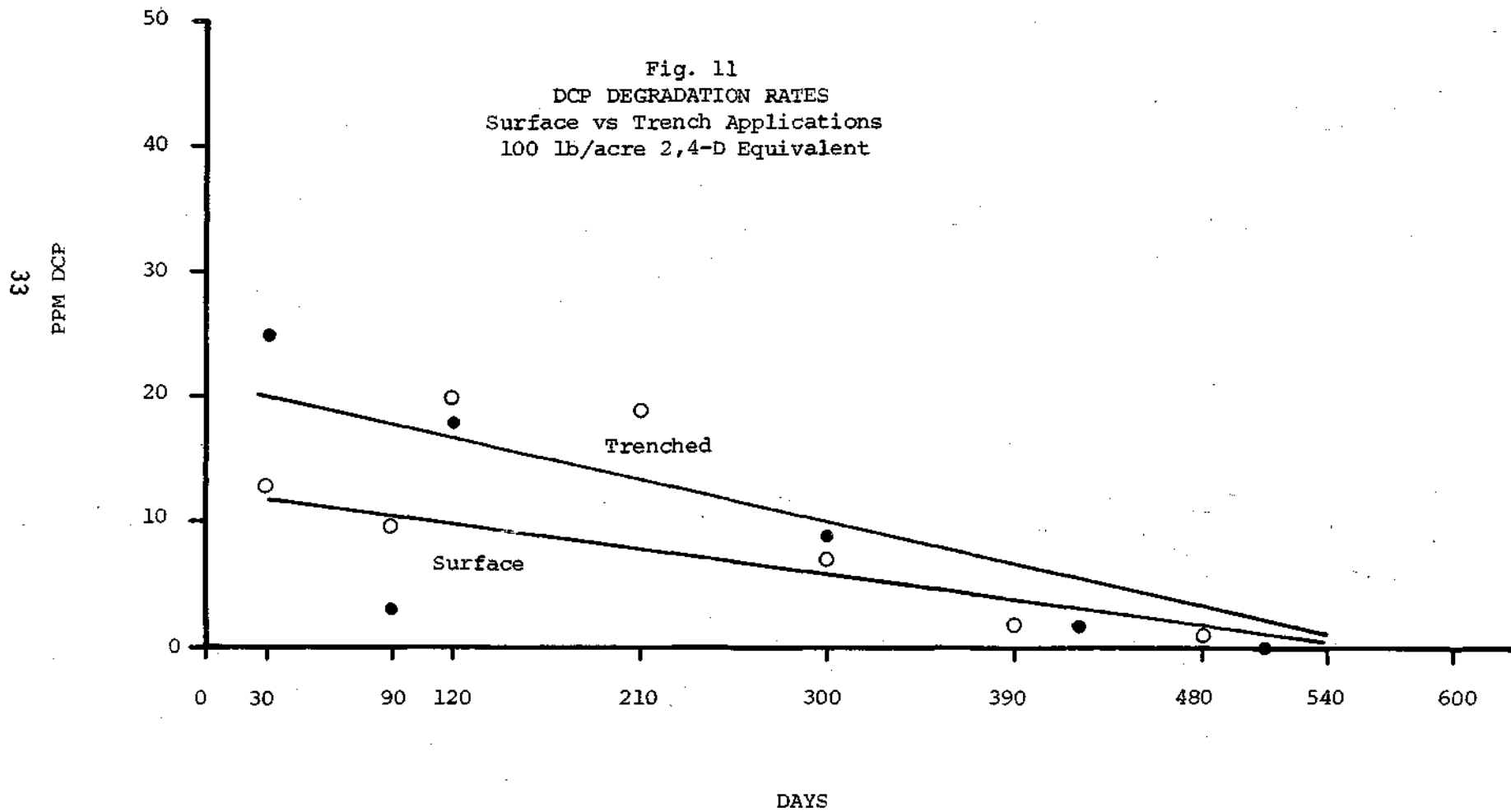


Fig. 11  
DCP DEGRADATION RATES  
Surface vs Trench Applications  
100 lb/acre 2,4-D Equivalent



● 297

Fig. 12  
2,4-D DEGRADATION RATES  
Surface vs Trench Applications  
500 lb/acre 2,4-D Equivalent

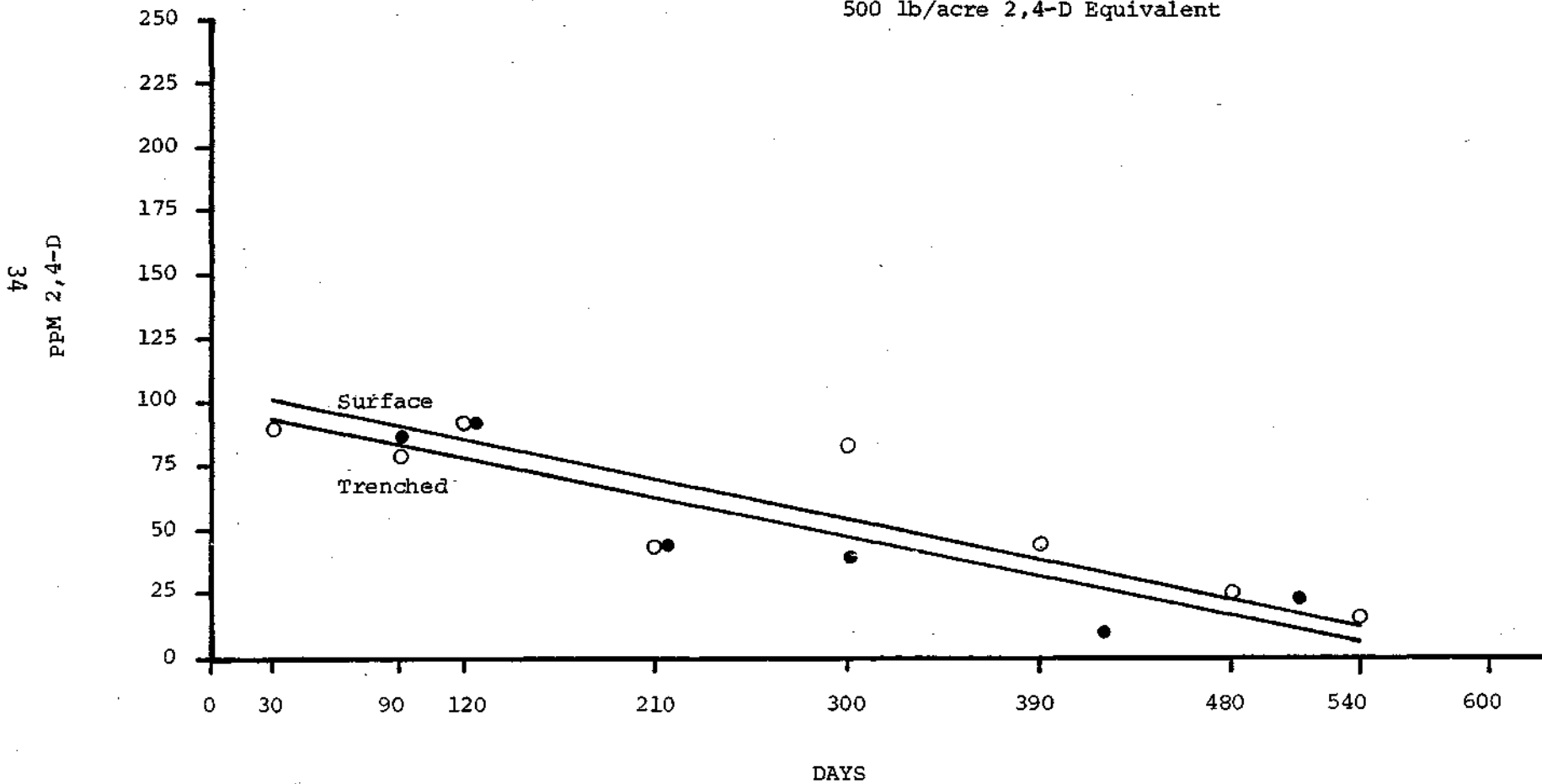
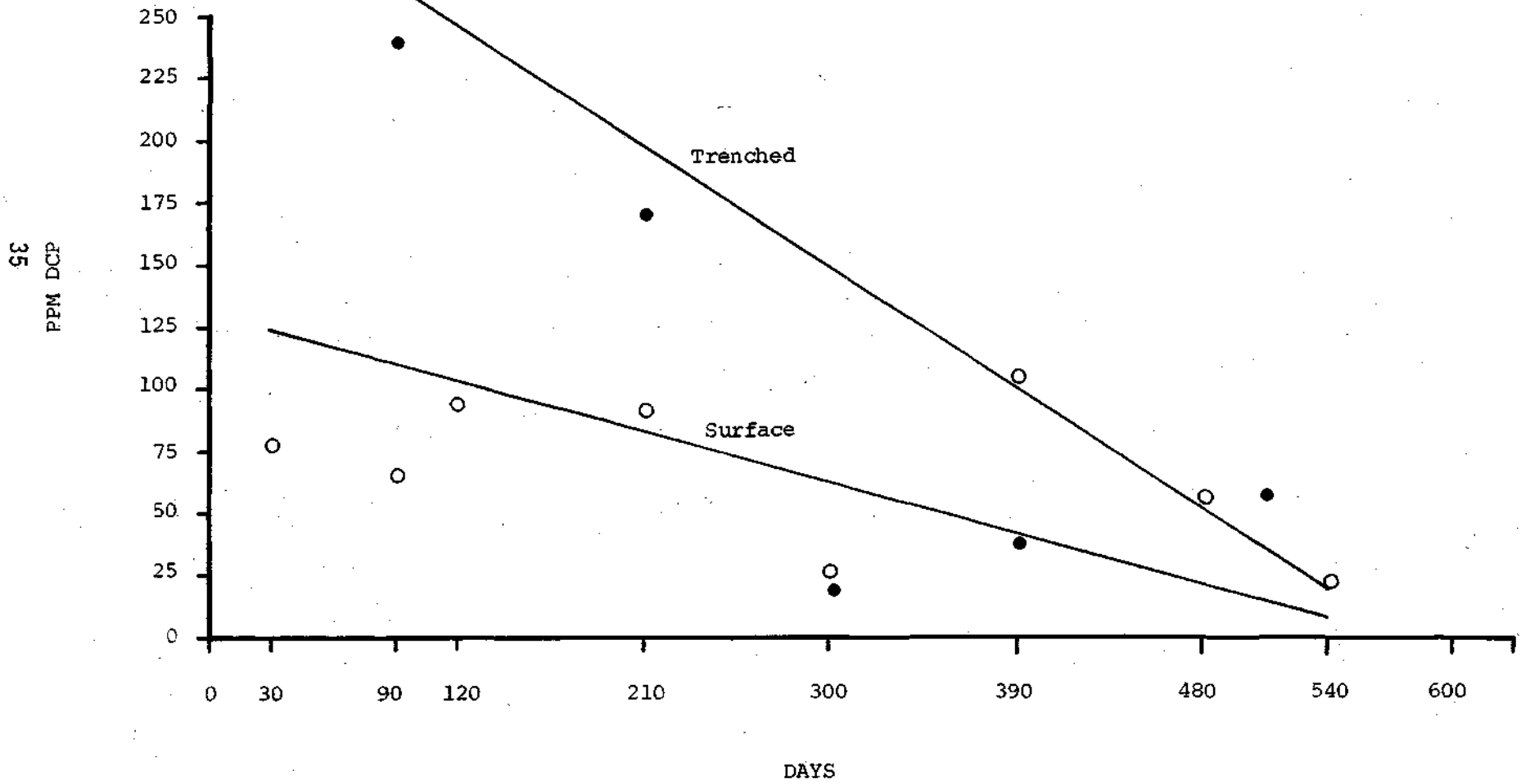


Fig. 13  
DCP DEGRADATION RATES  
Surface vs Trench Applications  
500 lb/acre 2,4-D Equivalent





will occur at the original point of the deposit of the waste material as exemplified in Table 1.

The hypothetical degradation curve referred to in a previous section of this report, is represented in Figure 3. Its principal features are an initial lag period representing an interval of microbiological adjustment followed by relatively precipitous decline in concentration of the chemical. As concentrations of the chemical diminish, the rate of degradation attenuates as the biological activity again readjusts to reduced concentrations of the agent. The lag period is not clearly evident in the data developed in the small plot studies; however, there does appear to be a well defined decline. Seasonal variation in soil characteristics affecting the soil sampling program and uneven distribution of the chemical have contributed to a good deal of scatter in the analytical values resulting from these tests.

Results of surface applications of the waste material at rates varying from 100-500 lbs/acre 2,4-D equivalent are illustrated in Figures 4 and 5. These data indicate a clearly apparent degradation of the 2,4-D and dichlorophenol fractions over an interval of more than 600 days. Scatter in the DCP data at the 500 lb. dosage was extreme and, although an attempt was made to fit a line, it is of doubtful validity. The best that can be said of this data is that there is an apparent decline. Other than this discrepancy, all dosages and both fractions indicate a rather clear degradation which is apparently dosage independent within the dosage ranges employed. Similar observations have been reported in agricultural usages of herbicides where, of course, dosages were much lower. It would appear likely that within some as yet unattained dosage threshold, once microbiological activity has become adjusted for presence of the waste, that rate of degradation approximates first-order kinetics and, thus, is independent of the concentration of material present.

Because of concern for the possibility of removal of the waste material on windblown particles, small plot experiments were set up to determine the effects of covering the surface of the soil with black plastic. Results of these experiments are illustrated in Figures 6 through 9, where waste was applied at the rate of 100 and 500 lbs/acre 2,4-D equivalent, and immediately covered with a black polyethylene film. Throughout the more than 600 day interval of observation, it was noted that not only did the plastic prevent particulate removal, but also that the volatile component so readily detectable on the 500 lb/acre plots not covered, was not detectable as an odor above these

plastic covered plots. Additionally, the plastic served as an effective moisture barrier so that the soil surface remained relatively moist throughout the interval of exposure in contrast to the very dry state of the soil during the hot, arid portions of the year in the surrounding terrain. Although the plastic was beneficial in terms of acceleration in rate of degradation. This approach may also be valuable as a means of preventing surface run-off during intervals of high rainfall and might be considered as an option in planning other chemical waste biodegradation projects where higher rainfall may be an important consideration.

As a more practical and less expensive alternative to the plastic cover in controlling airborne transport of waste material, studies were initiated on the effects of application of the waste in trenches approximately 10" below the ground and set on two-foot intervals. The results of this series of experiments are summarized in Figures 10 through 13. It was considered that these trenched plots would essentially simulate subsurface injection of material as a practical scale operation. The net effect of the application differs from surface applications in that the material is concentrated in bands approximately 5" wide, instead of being more or less uniformly distributed across the surface of the plot. Thus, where applications of 100 and 500 lbs/acre 2,4-D equivalent were made in 5" bands on two-foot centers, the actual concentration of material within these bands was approximately five times that of the surface application. Samples taken between trenches and in soil profile segments from the surface down through the point of application, indicate minimal vertical and horizontal movement of the agent from the site of initial deposition.

Under these conditions, with a relatively high concentration at a depth of about 10" beneath the surface of the soil, it was encouraging to note relatively little differences in the rates of degradation in the trenched plots and the surface applications. In Figure 13, the DCP degradation rates at 500 lbs/acre 2,4-D equivalent are badly scattered for both the trenched and the surface applications. Apparently, however, the averaging effect of determining concentration in terms of ppm per unit inch of soil profile still reflects a very high concentration of DCP at the 6-12" segment of the soil profile. The rather sizable variability in analytical data preclude a more detailed analysis of this difference. In any case, values beyond 300 days

indicate that there was marked diminution in dichlorophenol in samples drawn within the trenches.

In addition to analyzing the soil samples for concentration of 2,4-D and chlorophenol, a microbiological examination of these same samples from small plots was also conducted. Cultures were made on media at both pH7 and pH10, and in addition to plate counts, notation was also made of the relative numbers of bacteria, actinomycetes, nocardial organisms and fungi. Plate counts at both pH7 and pH10 indicated both seasonal effects and possibly an effect of the waste material on numbers of organisms. Relative quantities of the groups of microorganisms did not vary enough to indicate any major qualitative shifts in the population following introduction of the waste chemical.

#### SUBSURFACE INJECTION

A series of tests were established of 1/8 acre pilot scale subsurface injection plots. Two plots were applied by means of tractor-drawn equipment utilizing a conventional agricultural subsoiler consisting of a vertical blade on which a chisel, or foot, was mounted at an angle of approximately  $15^{\circ}$  from horizontal. A piece of metal tubing was attached to the blade which terminated at the base of the chisel in such a manner that a piece of hose from the injection pump could be inserted to permit deposition of the pesticide immediately behind the chisel. The equipment, with two injectors, was calibrated and application at 250 lbs/acre equivalent of 2,4-D was made on one-foot and on two-foot centers in the two plots.

During the process of application the overlying vegetative structure of greasewood was to all intents and purposes destroyed. The soil structure itself, to a depth of approximately 12", was drastically altered; particularly on the plot having one-foot centers. Roughness of terrain tended to cause considerable variation in the depths at which the waste chemical was injected, and in a few instances, material appeared on the surface.

Data derived from samples taken from these plots are summarized in Figures 14 and 15. Because of the extent by which the soil was broken up, waste distribution and sample variation was very large and the analytical data exhibit considerable scatter. There is, however, strong evidence of a decline in concentrations within the 480 day period under report for both the plots.

Fig. 14  
SUBSURFACE INJECTION  
250 lb/acre 2,4-D Equivalent  
2,4-D Fraction

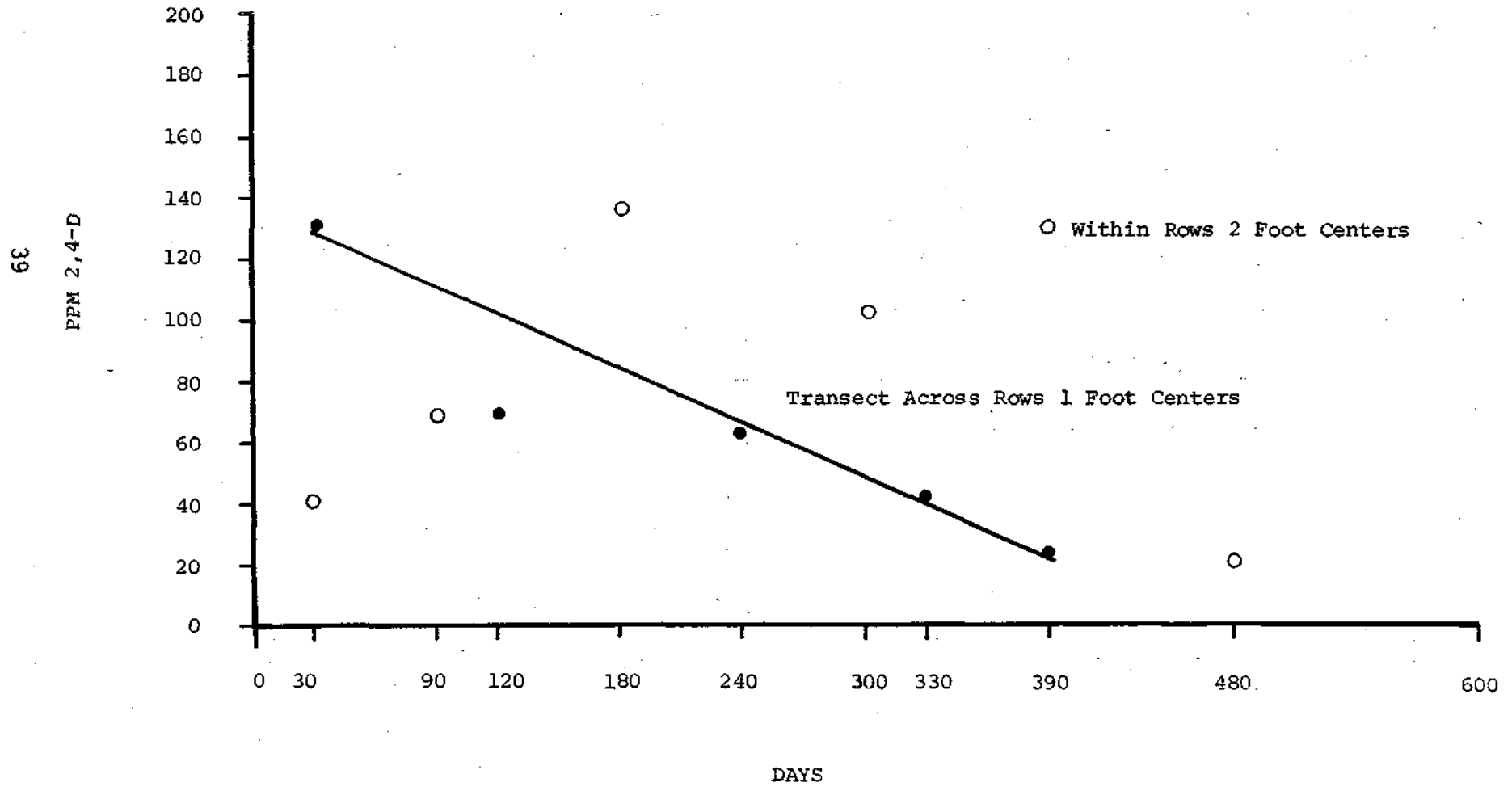
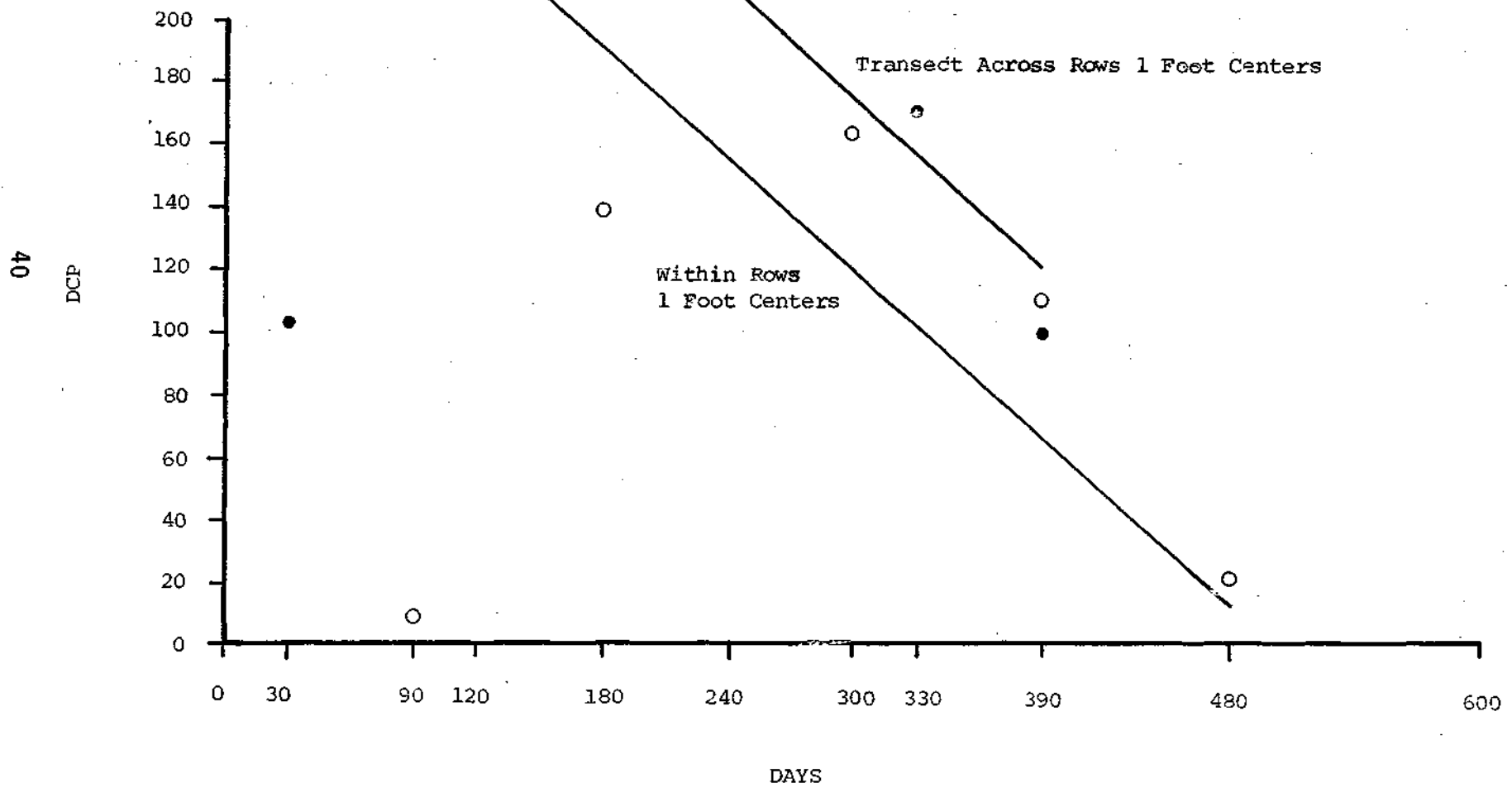


Fig. 15  
SUBSURFACE INJECTION  
250 lb/acre 2,4-D Equivalent  
DCP Fraction



These applications were made in the late summer, and during the fall and winter the odor of phenolic volatiles was not readily detected. It was apparent, however, the following year that during the high temperature extremes, that the broken soil structure was permitting escape of some of the volatile phenolic components. Removal of the vegetative structure during the process of application created concern as to possibility of wind erosion. However, during the summer and fall following treatment, effects of erosion were not observed in any appreciable degree. Broken remnants of the greasewood shrubs which remained imbedded at the soil surface may have contributed to this. Observations continue on these subsurface injection plots as well as other, more extensive treatments which have been conducted during the fall of 1971.

#### Pilot Subsurface Injection Study

Beginning 8 October, 1971, subsurface injection of the 2,4-D waste liquor was initiated on a 10 acre plot. This was an upland area southwest of the Alkali Lake playa having a silty soil of pH  $\pm$  8.5. Vegetation was predominantly moderate to sparse greasewood.

A batch plant was improvised to facilitate removal of the liquid and solid components of the waste from 55-gallon drums. It was necessary to split open the drum heads and use a jet of brine pumped from the pool lying about 14 feet below ground surface at the batch plant site. A 500-gallon mixing vat with a paddle wheel agitator was fed by overflow from a catch basin under a grill on which drums were placed, opened and jetted. The waste plus rinse water moved by gravity from the mixer to a 4,000-gallon holding tank from which it was loaded into the injection rig.

Injection was accomplished by means of a Ford 4000 series diesel tractor and a John Deere subsoiler consisting of two chisels spaced two feet apart and attached to the hydraulic three point hitch of the tractor. The tractor

also pulled a 1000-gallon nurse tank mounting a chemical diaphragm pump which delivered the waste mixture to the heel of each chisel.

The data relating to this treatment are as follows:

Plot size	10 acres
Waste liquor consumed	335 drums
"    "    "	16,500 gal.
Rinse water	4,000 gal.
Total volume	20,500 gal.
Volume per acre	2,050 gal.
Mean cons. 2,4-D--all batches	2.57%
2,4-D/acre	432 lbs.
Combined out put at both chisels	50 gpm
Depth of chisels	10 <sup>+</sup> in.
Tractor speed	0.32 mph
Volume per trip	900 gal
Estimated time per round trip	45-50 min.
Estimated time per acre	115 min.

No real difficulty was experienced with the application itself. At this time the soil was very dry and offered minimal resistance to the subsoiler. Had higher moisture been present, problems would have developed since the Ford 4000 tractor appeared marginally powered for this loading. A more powerful wheeled machine appears advisable. This would also result in considerably economy in equipment time per acre since greater speed would be available. Speeds of two to three mph on this relatively flat terrain appear to be practical under dry soil conditions.

Although an application rate of more than 400 pounds of 2,4-D was estimated, injection behind the chisels resulted in concentrated 6-10" diameter bands on two foot centers which were obviously wet with the waste liquor. This suggests that a plane or Noble blade type of subsoiler would provide more uniform distribution and more effective utilization of the acreage available.

In the course of the application the rather fragile vegetative structure was demolished. The debris, however, remained on or beneath the soil surface and no problem with wind erosion was observed in the following months. Slow recovery of shrubs has been observed, principally between injection points.

This may be a factor favoring band rather than sheet injection.

Soil samples have been taken at irregular intervals on this plot since treatment. Fifty-seven days after treatment, two transects across injection points were run with four samples taken into the bands and four between bands on each transect. Each sample consisted of a 3" core extending from 0-16" below the surface and well through the band of waste where this occurred. Samples were blended and analyzed for 2,4-D and dichlorophenol as in the studies previously covered. Averages for these samples and subsequent samplings are as follows:

Post Treatment Soil Samples			
<u>Site</u>	<u>DCP</u>	<u>2,4-D</u>	<u>Days after Treatment</u>
Bands	550 ppm	145 ppm	57
Between Bands	0	0	
Bands only	1087 ppm	223 ppm	120
Bands only	320 ppm	78 ppm	230
	0 = < 5 ppm		

Grant support terminated shortly after the 120 day sample and appreciable amounts of additional work was not possible. These data are not sufficient to evaluate rates of decline in 2,4-D-DCP concentrations. There is, however, no reason to expect that effects similar to those demonstrated on the small 10' X 10' plots and the smaller subsurface plots will not occur.

Marked disturbance of the soil structure was noted. No attempt was made to compact the soil other than by passage of the injection rig. The net result was that about 1/3 of the injection bands were significantly compacted. During the winter and spring following the October injection, when most of the 9-12" of precipitation occurs, some odor of phenols could be detected where soil was loose or where voids still occurred at the surface. By the second winter and spring, the soil surface had settled and few voids were observed. A few red-brown stains, typical of the coloration imparted soil by the waste, appeared in surface depressions in the non-compacted areas or where ground irregularity brought an injection band close to the surface. The odor of phenol on the plot was more marked than during the first winter.

These observations further support the need of thorough compaction of the soil and restoration of the soil structure. Leveling of the soil surface



to reduce puddling during precipitation intervals might further reduce the problem of surface migration. This advantage needs, however, to be weighed against the probability of removal, or windrowing, of vegetative debris and rooted remnants through leveling.

### Operations Projection

Experience gained in this study has provided us with a reasonable estimate of the resources required for the injection phase of the program. It became very apparent, however, that the principal technical problem, and the most expensive operation, would be the de-barrelling and blending system. The 55-gallon reused, light drums contained from 10% to 100% highly alkaline compacted solids, the average compaction being about 30% of total volume. The high velocity jet in most cases was insufficient and solids had to be broken up manually by means of a rod. Final jetting removed virtually all solid residues. The drums were crushed and buried on site.

Total removal of the drum head appears necessary and removal of the bottom may also accelerate the de-barrelling process. It has also been suggested that drums and their solids might better be split longitudinally by means of a hydraulically activated thrust splitter. Modifications of a fence post splitter may be all that would be required.

A mobile de-barrelling and batch plant moving in the drum storage does appear superior to a fixed plant requiring movement of the drums.

Projection of resources required for de-barrelling, blending and injection of the wastes are made on the following assumptions.

1. Approximately 25,000 drums of waste must be processed.
2. In so far as this store of drums and this site is concerned the operation will be terminal.

## Resource Requirements

1. Land (500 lb 2,4-D/acre)	950 acres
2. Operating rate--100 drum/day =	250 work days
3. Labor--foreman, equipment operator, 3 laborers, cook-housekeeper (7) = \$250/day =	\$62,500
4. Supervision & Administration	8,000
5. Transportation - personnel	2,500
6. Equipment*	
Utility truck	3,600
Wheel tractor with fork life	8,000
Wheel tractor and applicator	15,000
Mobile de-barrelling-mixer plant	20,000
Tanker truck - 6,000 gal used	6,000
Hand tools & equipment	2,000
7. Personnel - food & lodging	12,500
8. Safety equipment & garments	1,800
9. Site maintenance & utilities	<u>1,200</u>
	\$153,100
20% contingency	<u>30,620</u>
	\$183,720
Salvage or equipment	<u>&lt;13,650&gt;</u>
	\$170,170

\*Based upon probable new, used, or construction costs, and operating costs.

These estimates are recognized to be a broad extrapolation from our on-site experience. The operating rate is considered very conservative to allow for de-barrelling problems as well as down time. This is likely to be faster than estimated which will result in savings at the rate of about \$680 for every day gained. No figures are included for the value of the land and improvements or their amortization, in this cost estimate. Depending upon the appraisal base, this value could be in excess of \$50,000. Presumably, this work would be performed by a private contractor whose bid would include a profit margin of at least 20% above their estimated costs.

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES  
1069 State Office Building  
Portland Oregon - 97201

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OPEN FILE REPORT  
July 1, 1971

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GEOLOGIC EVALUATION  
  
OF THE  
  
ALKALI LAKE DISPOSAL SITE

BY

V. C. Newton, Jr.    Geologist - Petroleum Engineer  
Donald Baggs        Field Assistant

Governing Board

Fayette I. Bristol, Chairman  
R. W. deWeese  
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Raymond E. Corcoran  
State Geologist

NOTE: None of the appended  
field data accompanying the  
Open File Report are included  
in this copy.

## GEOLOGIC EVALUATION OF THE ALKALI LAKE DISPOSAL SITE

The State Department of Geology and Mineral Industries began studies on a proposed chemical disposal site at Alkali Lake in June 1969. The work was carried out in cooperation with the Oregon State University Department of Environmental Science, which is conducting research under a federal grant. The Lake County Planning Commission, Governor's Advisory Committee on Synthetic Chemicals in the Environment and several other state agencies are interested because of the storage of toxic chemical residues at the lake by Chem Wastes, Inc. The state is also involved to the extent that legislature agreed to accept responsibility for storage of the chemicals at Alkali Lake.

The object of this investigation was to determine if geologic conditions at Alkali Lake were suitable for disposal of toxic chemicals. Geologic structure, relationships of rock formations, chemistry of playa sediments and associated brine pool, surface drainage, underground aquifers and soil permeability, all are relevant to the proposed disposal project. A secondary objective of this study was to estimate reserves of sodium carbonate in the brine pool and playa crust to see if mining would be feasible with low cost backhaul from the disposal operation.

The first phase of geological investigations was to sample foundation material in the vicinity of experimental test plots where various applications of chemicals were to be observed. Apparent permeability was checked and depth to the water table measured. Analyses were made of the brine beneath the test plots. The auger drilling in the summer of 1969 showed that test plots should be located at the south end of the lake where permeability of sediments was low and the water saline. More drilling was done in 1970 for determining the limits of the brine pool as well as sampling the lake beds to a depth of 50 feet. A total of 16 auger holes were drilled in the summer of 1969 and 1970 (see figure 1). Lake sediments above the water table were analyzed for salt content by the State Department of Geology and Mineral Industries. Reconnaissance geologic mapping was done to verify published data and a study made of aerial photographs of the lake to locate faults and evaluate geomorphic features. Prevailing wind direction could be learned by examining the dune structures on the aerial photographs.

Results of this study indicate the lake playa and bordering area to be useable for disposal purposes as far as geological features are concerned. The possibility of chemical liquids or residues reaching useable water supplies by surface drainage or underground seepage appears remote. Low cost backhaul should make the deposits at Alkali Lake economic; however, the mining would be on a small scale because of limited reserves of sodium carbonate. No major problems are evident in connection with disposal of wastes at Alkali Lake.

### History and prior investigations

Mining claims were first filed on Alkali Lake in the latter part of the 1800's by a Portland firm which was interested in the boron prospects (later tests showed little boron at Alkali Lake). Prior to World War I the Pearson Engineering Corp., London, England, took an option on the claims along with options at Searles Lake, California, because these dry lakes appeared to them as good mining prospects for soda ash. The outbreak of war terminated

this project. Some sodium carbonate was mined from Alkali Lake in the 1920's and sold in Portland as washing soda (Stott, 1952). Eyde Nitrogen Company, Norway, became interested in the property in the 1920's for manufacturing sodium nitrate. Although the process appeared to be commercial, nothing came of the Eyde inquiry.

M.F. Gouge of the Ottawa Department of Mines, Canada, visited Alkali Lake in 1924 to study the potholes and determine how they formed. O.F. Stafford, a mining consultant, was hired by the Oregon Department of Geology and Mineral Industries in 1939 to explore the commercial possibilities of dry lakes in eastern Oregon. The importance of sodium salts for many chemical processes led to a study of the evaporite deposits at Alkali Lake, Summer Lake, and Lake Abert by Allison and Mason in 1947. Later, in 1952, Bonneville Power Administration funded a study by W. J. Stott, Professor of Chemistry at Portland University, to explore for evaporite layers at depths below the playa surface. This study also included other dry lakes in eastern Oregon. Chem Wastes, Inc., Portland, purchased the Alkali Lake patent in 1967 for the purpose of storing and treating chemical wastes. The company also planned to re-examine the commercial value of salts in the playa sediments and in solution in the brine pool and thus take advantage of the low cost backhaul of evaporite to Portland.

Geologic mapping has been done in northern Lake County by the U.S. Geological Survey and the Department of Geology and Mineral Industries. N.L. Mundorff did geologic mapping at Alkali Lake in 1947 for a thesis project at Oregon State College. Some mapping was done during the present project to supplement the earlier work.

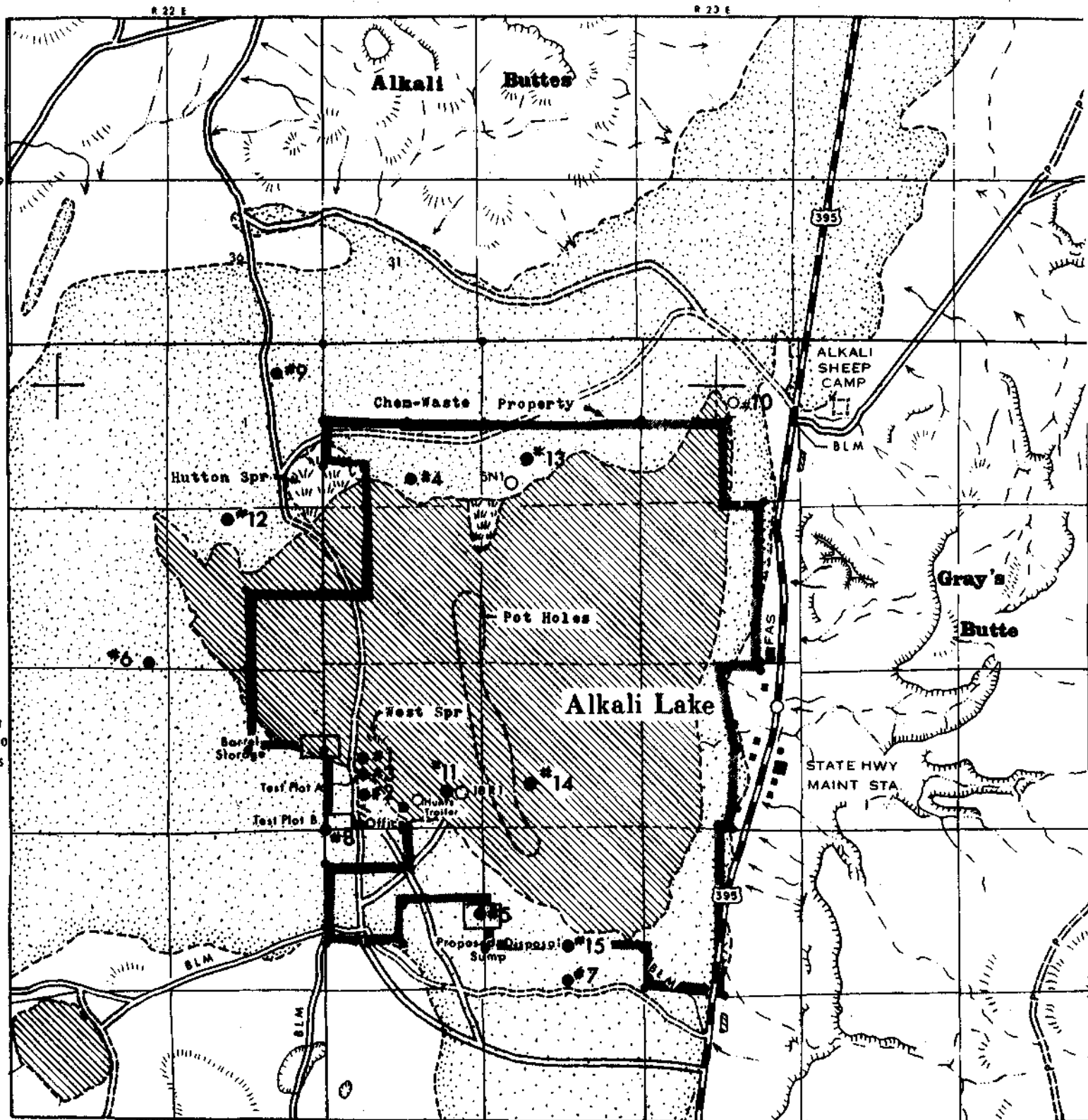
### Geography and physiography

Alkali Lake is located in northeastern Lake County about 60 miles north of the city of Lakeview and 15 miles north of Lake Abert in Lake County. The dry lake is approximately 8 miles long by 5 or 6 miles wide. It is separated from North Alkali Lake by small volcanic cones named Alkali Buttes and the highlands between Alkali Lake and Lake Abert are also eruptive volcanic features. The northern extension of Abert Rim borders the east side of Alkali Lake rising 1200 feet above the valley floor. Highway 395 traverses the valley along the base of the Abert fault scarp in a north-south direction roughly parallel to the scarp. Elevation at the lake is 4244 feet. Mean annual temperature is 50°F, rainfall 10 to 16 inches, and evaporation approximately 55 inches per year.

Settlement around Alkali Lake consists of a highway maintenance station, service station, restaurant, and one or two ranches; the remainder of the property is Federal Range Land. In contrast to the desert appearance of the area, fresh water is available 50 to 200 feet below the ground surface. Vegetation is typical of the Oregon High Desert, consisting of sage, greasewood, rabbit brush, and range grasses. The alkali flat is barren of growth except for green patches around springs which flow year around.

Alkali Lake lies within a broad lowland forty miles wide stretching from Summer Lake on the west to Lake Abert and Alkali Lake on the east. This broad depression is bounded by the Winter Ridge fault scarp at Summer Lake and the Abert fault scarp on the east side.

# ALKALI LAKE AND VICINITY



Base by Oreg. Highway Dept  
1959



Cartography by S.R. Renoud

STATE OF OREGON  
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

Figure 1

Several levels of ancient lake terraces are evident on the slopes of buttes and high areas testifying to the existence of a large fresh-water lake during the ice age at a time when the climate was more humid than the present. Drainage in the broad lowland is controlled by cross faults, one set trending northwest and the other northeast. Structural features in the vicinity of Alkali Lake can be seen on aerial photographs.

A north-south lineation in the west half of the playa appears to be a surface drainage course and not a fault trace. Just west of this linear groove is a high area where springs seep out at the surface, and the accompanying growth has prevented erosion of sediments by wind.

The arrangement of sand dunes around the perimeter of the playa shows that winds prevail from the southwest and northeast. This probably has been the case for several hundred years. The dunes at the north end of the playa show the work of varying wind currents as well as the prevailing winds. The varied direction of winds here are caused by Alkali Buttes. Auger drilling disclosed that there is 20 to 30 feet of aeolian deposits at the north and south ends of the lake (see descriptions of auger borings in appendix). Erosional remnants of lake beds are evident along the west sides of the lake and to some extent on the east shore. Mundorff (1947) concluded from his studies that the lake basin is a deflation basin from which 20 or 30 feet of sediment has been stripped by the wind.

### Stratigraphy

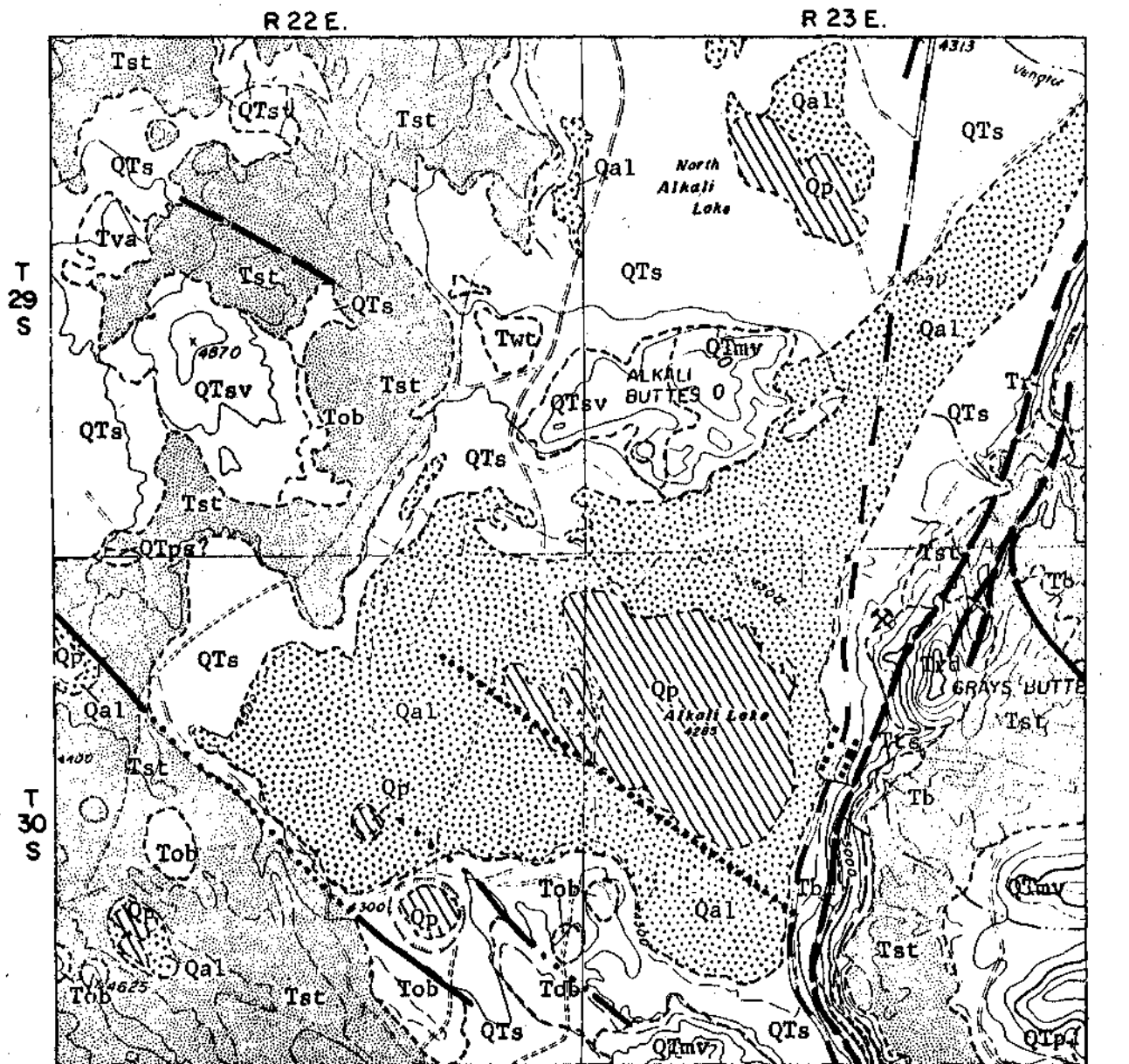
The oldest rocks in the vicinity of Alkali Lake are tuffaceous sediments and tuffs exposed along the Abert scarp south of Gray's Butte. This rock unit (Tson geologic map, Fig. 2) is approximately 1300 feet thick (Walker and Repenning, 1965). Several hundred feet of Miocene-Pliocene andesite and basalt flows overlie the oldest rocks. Younger lavas and lacustrine beds of Pliocene age approximately 300 to 400 feet thick rest on the andesite and basalt flows. Pliocene-Pleistocene pyroclastics, basalt and interbedded lake sediments overlie the Pliocene rocks. This upper unit is 150 to 300 feet thick where exposed west and east of the lake playa (Walker, 1963). Cinder cones and volcanic vents were also formed during Pliocene-Pleistocene time. Alluvium, lake sediments, wind deposits, and capping flows of basalt represent deposition during Pleistocene and Holocene time. Allison (1945) found that pumice and ash falls were deposited with the youngest sediments in northern Lake County. Test wells 18 R-1 and 5 N-1 encountered Pliocene volcanics at 170' and 130 feet respectively after drilling through Holocene-Pleistocene and Pleistocene-Pliocene sediments. No prominent unconformities have been recognized in northern Lake County in the mapping done thus far (Walker, 1963).

Rhyolite plugs, (Gray's Butte) dikes, and domes intruded existing rocks some time between the end of Pliocene time and early Pleistocene time. These intrusions appear to occur along faults.

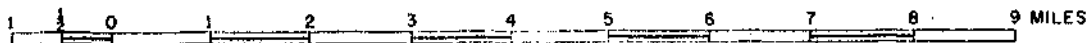
### Geologic structure

Southeastern Oregon from Crater Lake to the Idaho border lies within the Basin and Range geomorphic province and between these two locations there are several large north-south trending tectonic depressions bounded by high scarps of uplifted intervening fault blocks (Fuller and Waters, 1929). Alkali Lake and Lake Abert are situated on the east margin

# GEOLOGY OF ALKALI LAKE AND VICINITY



Scale 1:125,000



CONTOUR INTERVAL 200 FEET

WITH SUPPLEMENTARY CONTOURS AT 100 FOOT INTERVALS

Figure 2.

1970 MAGNETIC  
DECLINATION



EXPLANATION

MAP UNITS

HOLOCENE	<span style="border: 1px solid black; padding: 2px;">Qp</span>	Playa deposits Clay, silt, sand, and some evaporites.
HOLO-PLEISTOCENE	<span style="border: 1px solid black; padding: 2px;">Qal</span>	Alluvium Unconsolidated fluvialite gravel, sand, and silt. Large areas of windblown sand designated by stipple pattern.
PLEISTO-PLIOCENE	<span style="border: 1px solid black; padding: 2px;">QTs</span>	Sedimentary deposits Lacustrine, fluvialite, and aeolian sedimentary rocks.
PLIOCENE	<span style="border: 1px solid black; padding: 2px;">Tba</span>	Tba, basaltic and andesitic flows, interbedded sandstone, siltstone, and tuff.
	<span style="border: 1px solid black; padding: 2px;">Tob</span>	Tob, vesicular basalt flows, gray and reddish-gray.
	<span style="border: 1px solid black; padding: 2px;">Tst</span>	Tst, semi-consolidated lacustrine tuffaceous sandstone and siltstone, ash and ashy diatomite, tuff, lapilli tuff, and tuff breccia.
PLIO-MIOCENE	<span style="border: 1px solid black; padding: 2px;">Tb</span>	Basalt Basalt flows, generally dipping 5 to 10 degrees. Many major topographic rims capped by these flows.
MIOCENE	<span style="border: 1px solid black; padding: 2px;">Tts</span>	Tuffaceous sedimentary rocks Mostly fine-grained, poorly to moderately well-bedded tuffaceous sedimentary rocks and some ashy tuffs representing flood plain or shallow lake deposits.

VOLCANIC ROCKS - STRATIGRAPHIC RELATIONS UNCERTAIN

<span style="border: 1px solid black; padding: 2px;">Trd</span>	Intrusive rhyolite and dacite Plugs, dikes, small endogenous domes.
	Pyroclastic rocks of basaltic cinder cones
<span style="border: 1px solid black; padding: 2px;">QTp</span>	QTp, subareal deposits of unconsolidated, reddish, fine to coarse scoriaceous basaltic ejecta. Age, Miocene(?), Pliocene, and Pleistocene or Recent.
<span style="border: 1px solid black; padding: 2px;">QTps</span>	QTps, subaqueous deposits of partly consolidated yellowish-brown palagonitized basaltic ejecta.
	Rocks of silicic vents
<span style="border: 1px solid black; padding: 2px;">QTsv</span>	Dikes, plugs, and complex exogenous domes, including related flows and flow breccias, of dacitic to rhyolitic composition. Age, Pliocene and Pleistocene (?).
	Rocks of mafic vents
<span style="border: 1px solid black; padding: 2px;">QTmv</span>	Basaltic and andesitic agglomerate, breccia, scoria, cinders, flows, and intrusive masses forming constructional volcanic landforms. Age, Pliocene, Pleistocene, and Recent (?).
<span style="border: 1px solid black; padding: 2px;">Tva</span>	Andesite flows

Figure 3.

of one of these large depressions; Summer Lake, Silver Lake and Chewaucan Marsh are on the west side. This broad basin is a composite graben consisting of numerous small fault block units resulting from criss-crossing faults. The upthrown fault blocks dip to the east and west away from the main graben basin. Also, smaller fault blocks within the graben, tilt away from the center suggesting that the gross structure is a broad faulted anticline with the crest down-dropped. The greatest displacements occur at the margins of the graben and decrease toward the center (Donath, 1958).

The main fault system, which developed in Pliocene time, divides the region into large blocks separated by N 35° W and N 20° E trending fractures. The northwest-trending faults die out northward, becoming hinge-type faults. Displacement along the northeast-trending Abert fault also decreases to the north. Later faulting on a grand scale superimposed north-south trending fractures over the earlier main fault pattern and produced the characteristic Basin and Range structure. The "Range Faults" (Larson, 1965) are believed to have been initiated in early Pleistocene time (Peterson and McIntyre, 1969). Subordinate faulting adds to the complexity of the structure. The structural evolution of the region relates to tensional stresses and adjustments to igneous activity in the crustal rocks (Ikeagwauni, 1965).

Seismic profiles by Donath (1958) disclose that faults buried under quaternary sediments in the Summer Lake area conform to surface trends and that dips of the faults are nearly vertical.

Folding of crustal rocks in Lake County is believed to have taken place both concurrently and following Pliocene faulting. Deformation appears to have occurred after most eruptive centers had been formed. The entire area was folded into low broad anticlines and synclines with northwest or northeast axial trends (Peterson and McIntyre, 1969).

#### Correlation of deep wells

Two deep test wells were drilled at Alkali Lake by Portland University in 1952. (see figure 2). The well at the south end of the playa in sec. 18 is referred to as well 18R-1 and the well at the north end of the playa in sec. 5 is referred to as 5N-1. Drilling was halted in the test wells when it seemed apparent that no more saline waters would be encountered. Sands at the top of both wells probably are Holocene aeolian deposits. Directly beneath the aeolian sediments are Pliocene-Pleistocene lake beds (Qts, Walker, 1963). Both wells probably penetrated Pliocene volcanics (Tba and Tob, Walker, 1963) which contained fresh water. Analyses of water from the wells correspond quite closely (see appendix). Based upon stratigraphic relationships described by Walker (1963) Miocene volcanics should be found below the lake playa at a depth of 400 or 500 feet. Older lake beds should underlie the volcanics and may possibly contain brackish or saline water. Saline water was found at 1200 feet in a well on the ZX Ranch south of Summer Lake and when the well was plugged back to 400 feet it produced fresh water (Stott, 1952).

#### Correlation of auger holes

A total of 15 auger holes were drilled around the periphery of Alkali Lake by the Oregon Department of Geology and Mineral Industries in the summer of 1969 and 1970 to obtain data on the brine pool and to define stratigraphy of lake beds to a depth of 50 feet. Generally speaking, the holes on the outer margin of the playa encountered a covering of aeolian deposits to depths of 10 to 30 feet and beneath these sediments, lake beds were found. (See figure 5). There were

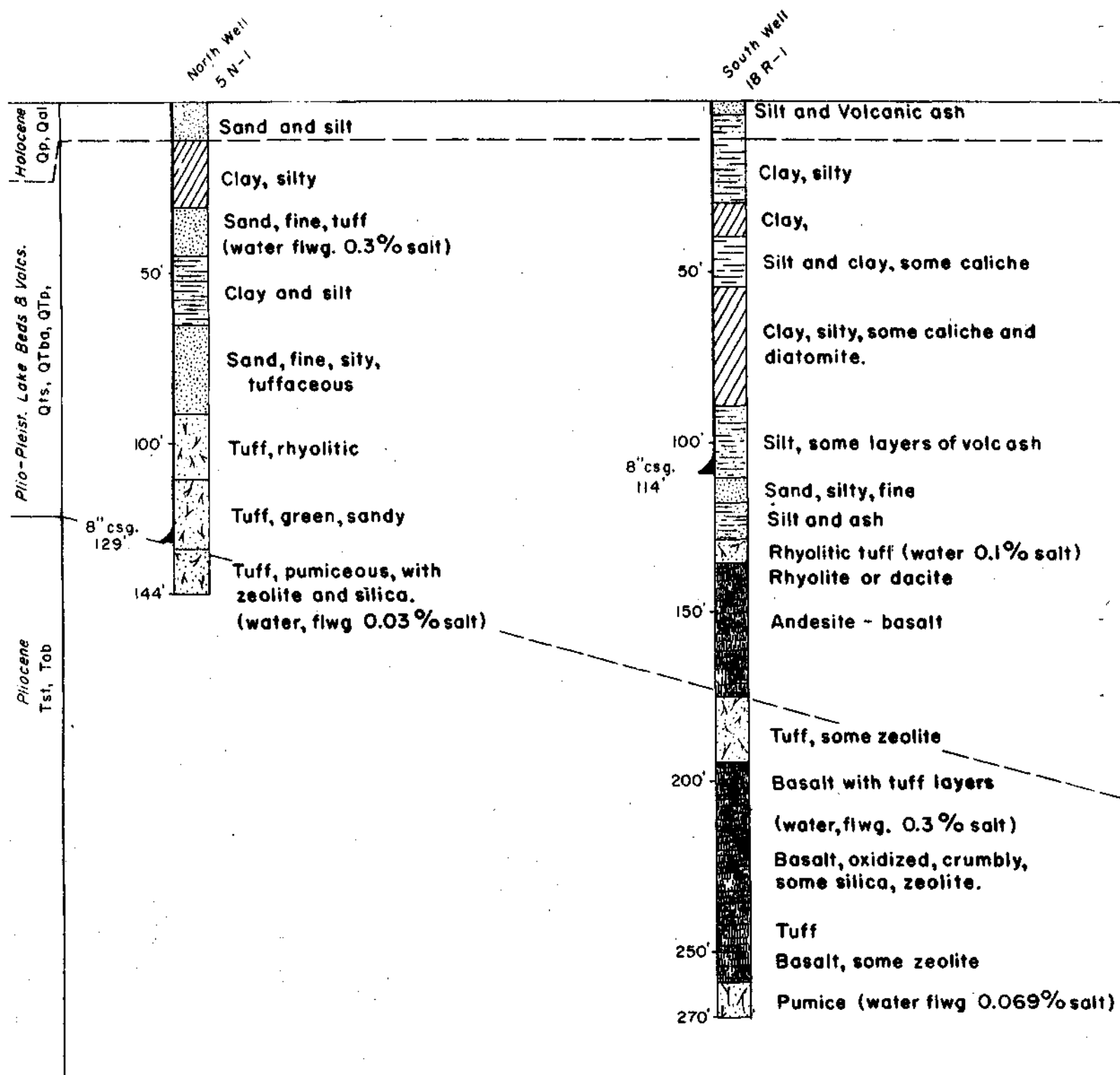


Figure 4 Correlation of wells 5N-1 and 18R-1

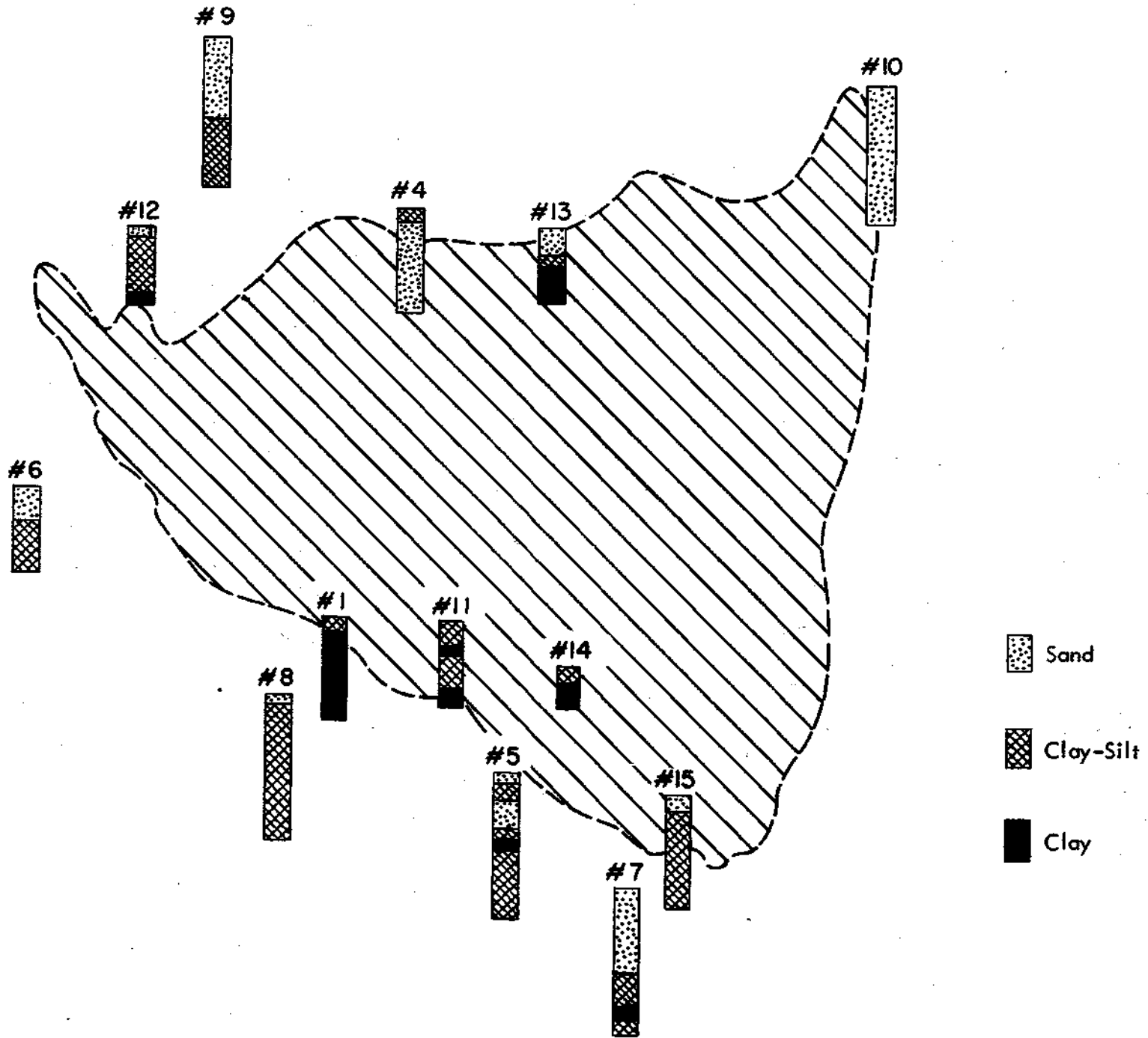


Figure 5 Alkali Lake auger holes

some fine silty sands in the lake beds but silts and clays predominated. Scattered diatoms were noted in auger samples but no diatomite layers were found. Thin beds of peat were drilled in the lower portion of a few holes and thin hard layers of siliceous material were common. Silicified ash beds caused holes No. 10 and 14 to be abandoned prematurely. Most of the samples of lake sediments were intermixed with volcanic debris. Dunes contain a post-lacustrine pumice mixed with aeolian sediments derived from lake beds (Allison, 1945).

### Water characteristics

Analysis of water from springs, water wells, and auger holes (see appendix) were made to assist with geologic interpretation and to determine limits of the shallow brine pool. Three main features can be seen from these analyses: 1) the brine pool is situated adjacent to a north-west-trending fault barrier at the south end of the playa (see isogram in appendix); 2) the spring water and deep fresh water aquifers show a common source; and 3) water supply to the basin from the surface and from below is relatively fresh. Evidently the playa salts and brine pool result from evaporation of these relatively fresh waters (a conclusion suggested by Allison and Mason, 1947). Presence of arsenic in the deep water and concentration of arsenic in the brine pool confirm this conclusion. The arsenic may in some way be related to mineralization along the barrier fault at the south end of the lake. Metals found in the water sample from auger hole No. 6 could also be associated with this postulated fault. It has been suggested, however, that these metallic constituents could have come from corrosion of shells and cartridge brackets left on the Air Corps firing range. Hole No. 6 is situated on the approach to the old target area.

Analyses made by Portland University in 1952 (see appendix) show a marked decrease in salinity in formation water below a depth of 40 feet in well 18R-1. Water sampled in well 5N-1 was fairly fresh even at the top. Evidently only the top 20 or 30 feet of water contained in the lake sediments is saline; below this depth the salinity decreases.

### Soda ash reserves

Several estimates of evaporite reserves have been made in past investigations of Alkali Lake. Most investigators agreed that sodium carbonate was the chief prospect for mining and that Alkali Lake seemed to hold the largest deposit of this salt of any of the dry lakes in eastern Oregon (Stott, 1952). Sodium carbonate is a relatively rare occurrence in nature, being formed from certain spring and alkali lake brines. Most sodium carbonate used today is made artificially by the ammonia-soda process (Solvay Process) for use in organic and inorganic chemicals. Sodium carbonate has been mined at Alkali Lake and sold for washing soda. One problem not mentioned in prior studies is the presence of arsenic in the evaporite and the brine. Can it be easily separated from the sodium carbonate?

The principal salts at Alkali Lake are: sodium carbonate, sodium chloride, and sodium sulfate. There are also smaller amounts of potassium sulfate, phosphate, boron, arsenic, silica, iodine, and fluoride intermixed with the soda. The greatest concentration of salts at Alkali Lake occurs in the pot hole area (see figure 1). Allison and Mason (1947) sampled the potholes to a depth of 4 feet to check salt content of the evaporite lenses and underlying lake beds. They found the lenses to be 3 or 4 feet thick in the center of the "potholes" tapering to a few inches at the perimeter. The "potholes" range from 2 feet to 30 feet in diameter. The top portion of

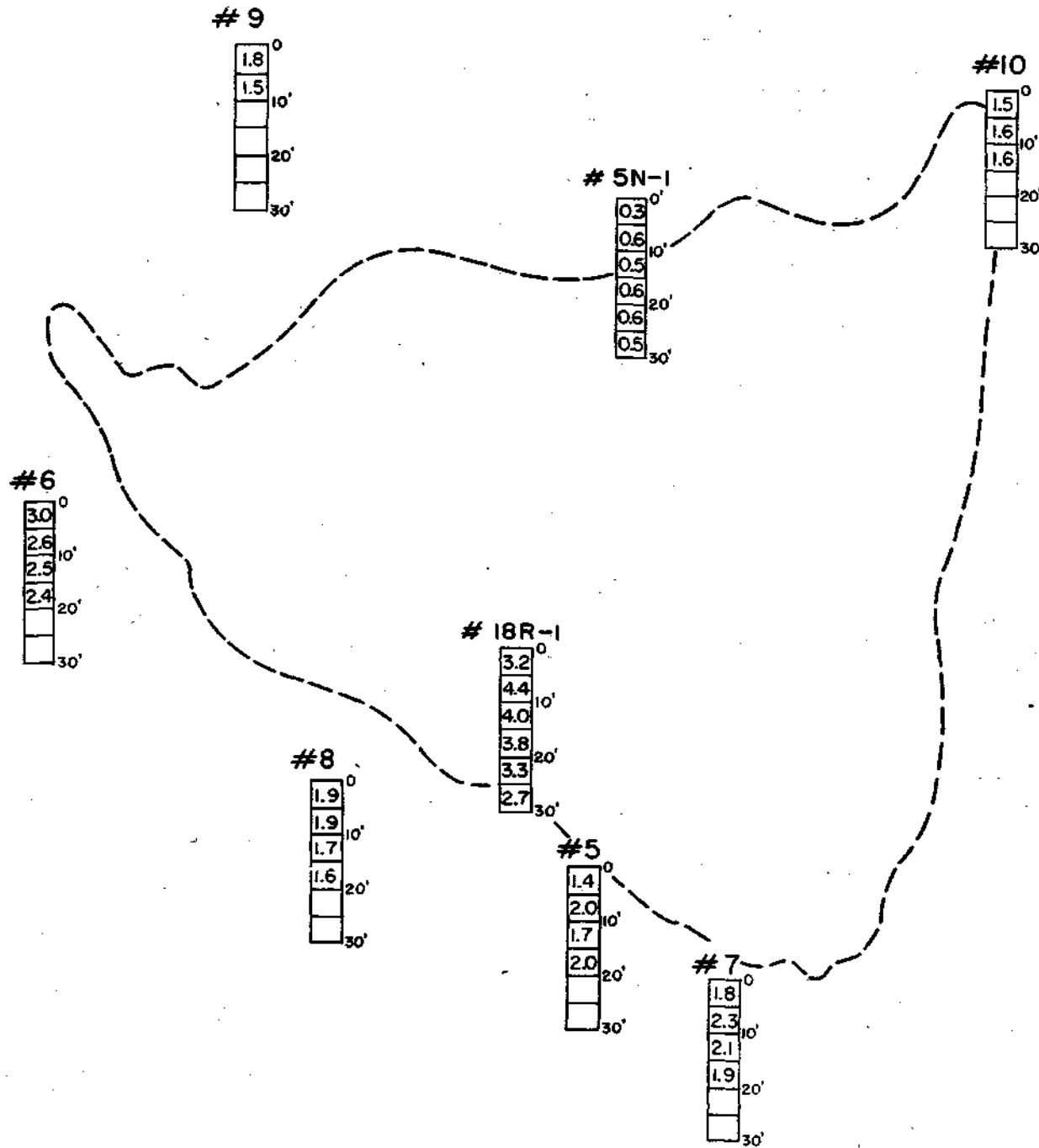


Figure 6. Percentage of salts in the playa sediments

the lens analyzed 40% sodium carbonate decreasing to 18% at 42 inches. Tests on well 18R-1 show that sodium carbonate diminishes to 1% at a depth of 20 feet; it is reasonable to expect a similar decline beneath the potholes.

The surface crust on the playa yielded 7% sodium carbonate (see figure 4) in tests made by Allison and Mason (1947). Replacement of evaporite was checked at one pothole during the 1947 project. After one year a 13-inch layer of new crystals formed in a pothole that had been cleaned of evaporite. The potholes are thought to originate from seepage of fresh water from the deep aquifer upward to the playa. Evaporation and concentration of salts occurs near the surface of the potholes and crystals form when saturation is reached. Surface crusts at Summer Lake yielded 5 tons of salt per acre (Allison and Mason, 1947), 3.5 tons of which are sodium carbonate.

Sodium carbonate concentrated enough to extract commercially at Alkali Lake is limited to the upper 20 or 30 feet of the brine pool. Limits of the producible brine are assumed to fall above the 20,000 mc mho line (see figure 7). Studies of auger samples indicate that the lake beds have low permeability and porosity but no laboratory tests were made in this investigation. Effective porosity is assumed to be 10% and concentration of sodium carbonate approximately 8% in the brine. Total recoverable reserves of sodium carbonate at Alkali Lake appear to be:

Brine Pool	200,000 tons
Potholes	100,000 tons
Surface Crust	<u>10,000 tons</u>
Total	310,000 tons

Inasmuch as the average annual evaporation rate in Lake County is 55 inches (Waring, 1908), some replacement of sodium carbonate can be expected annually. However, mining operations depending on solar evaporation in the playas of southeastern California have failed even though the water source contained a much larger dissolved content than source waters at Alkali Lake (Stott, 1952).

### Summary and conclusions

All the geologic evidence suggests that Alkali Lake is a closed drainage basin. Surface water appears to drain from all directions to the lake flat. Geologic structure indicates that regional drainage is south to southeast in the Summer Lake-Lake Abert graben. Artesian flows in wells 18R-1 and 5N-1 establish that the deep fresh-water aquifer is separated from shallower water zones by confining layers of sedimentary rock. The occurrence of several large fresh-water springs and artesian wells in the vicinity of the lake playa show that ground water is moving into the basin; thus, liquids placed on the ground surface are not likely to escape the lake basin. Permeability of lake beds is generally low as seen from the auger samples; therefore, movement of fluids through them should be slowed considerably. Where wind-deposited sand occurs around

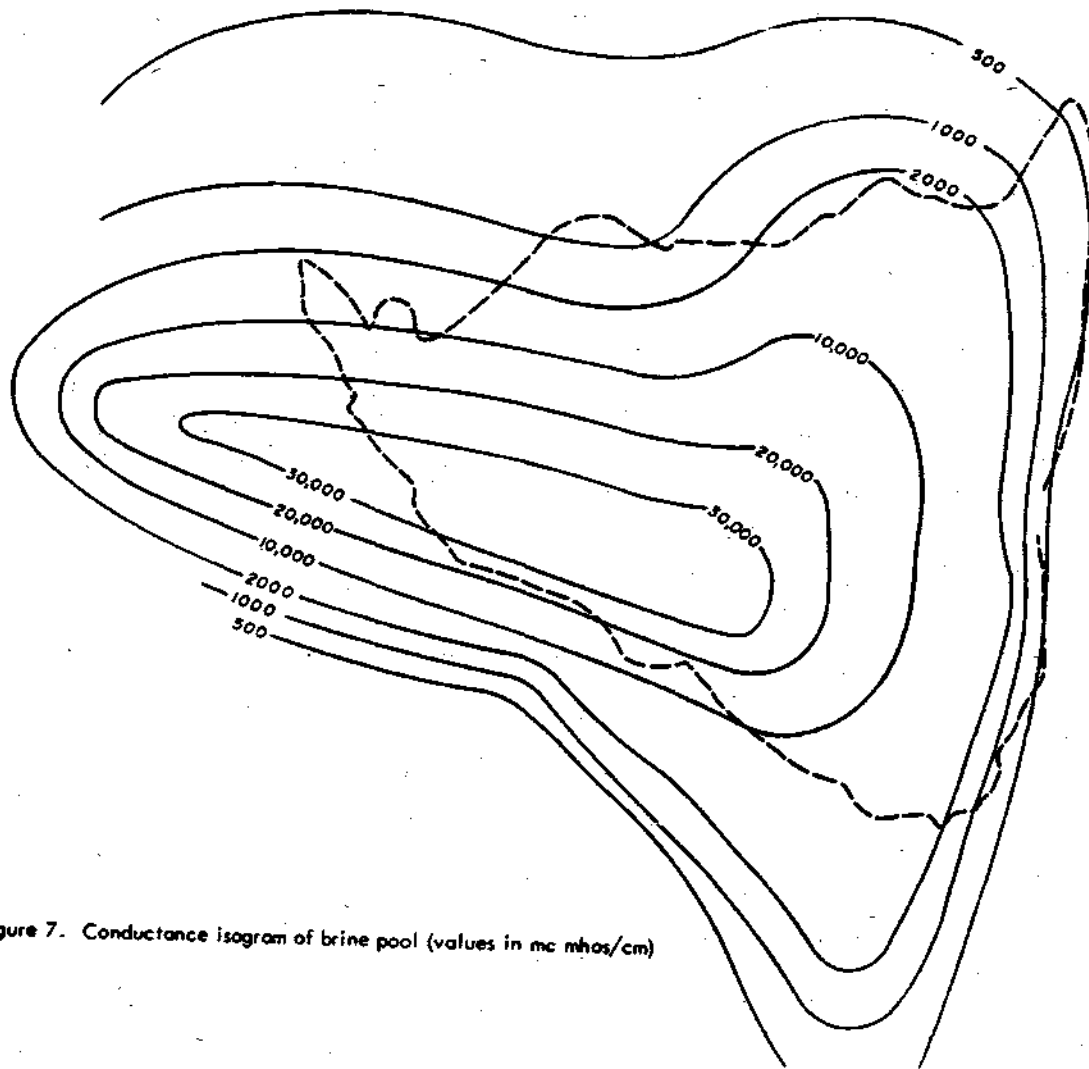


Figure 7. Conductance isogram of brine pool (values in mc mhos/cm)



the playa margins, seepage of surface-applied liquid would be rapid until lake beds were encountered. Some of the lake bed silt layers transmit fluid fairly well as seen in the 15-foot hole near the Chem Waste office. This hole can be pumped at approximately 6 gpm of alkali water without going dry, but the underlying clayey layers would retard vertical movement of fluids. Lateral seepage would be toward the brine pool.

Geology of the Alkali Lake playa has been covered in prior projects so the present investigation offers only a few additions to geologic interpretations, mainly to describe the lake sediments to a depth of 50 feet and establish limits of the brine pool. Previous mapping is used here to relate geology to proposed disposal operations. A fault along the south lake margin is indicated by the salinity isogram as well as a lineament on the aerial photograph of the playa. Springs occur in the west half of the playa but no surface expression of structure can be identified; perhaps some north-south trending structure influences upward seepage.

The possibility of economic mining of sodium carbonate depends upon low cost transportation to markets. Reserves of this salt are relatively small and would support only a small venture. Source of the brine appears to be in the deep fresh-water zone which evaporates after reaching the surface; thus, renewal of salt supply will be quite slow. The brine is confined to the upper 30 feet of the lake beds and below that depth salinity decreases rapidly. The presence of arsenic in the evaporites may interfere with processing the soda ash.

Use of the lake playa for disposal of chemical wastes has merit as there is little danger of polluting usable water supplies. The location is remote and land-use potential low. Methods of disposing of toxic chemical wastes being tested at Alkali Lake by Oregon State University Department of Environmental Science include degradation by soil bacteria, degradation by photosynthesis, surface spreading dilution in conjunction with bacterial degradation, and range brush control. Some other methods which reportedly hold promise for use at Alkali Lake are dehydration, high temperature incineration, and chemical neutralization utilizing alkaline salts contained in the brine pool. Chem Waste, Inc. also may utilize the property for storage of chemical residues for recycling to secondary uses.

Wind erosion will be a problem if the lake site is used for disposal of solid waste residues. Sand dunes around the perimeter of the playa testify to the erosive force of the wind. Prevailing wind direction is from the southwest and northeast but cross currents also occur because of topographic obstacles. A diversity of dune alignments is evident at the north end of the playa on aerial photographs. Relative to the wind, odors from spread wastes will be noticeable for some distance unless methods can be devised to screen them. Another detrimental character of the site is the alkaline soil which will likely retard bacterial activity. Results of test plot studies will undoubtedly determine to what extent this is true.

The State Department of Environmental Quality is the licensing agency for disposal facilities and may place restrictions on the proposed operations or require certain monitoring stations. The State Engineer may, in conjunction with the Department of Environmental Quality, request test drilling and monitoring wells. Recommendations for additional work by the Oregon Department of Geology and Mineral Industries include a cored hole to 50 feet to better define the lake beds and measurements for permeability or percolation tests on fluid seepage in the lake beds. Seismic profiles may be helpful in the interpretation of subsurface geology but they are not essential, especially if another deep test hole is drilled.

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THE PESTICIDE AND PESTICIDE  
CONTAINER MANAGEMENT PROGRAM IN  
KLAMATH COUNTY, OREGON

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August, 1973

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The Pesticide Management Program in  
Klamath County, Oregon

Warren S. Staton\*

INTRODUCTION

Pesticidal and herbicidal chemicals are and will continue to be widely used and accepted as an integral part of this nation's food and fibre production complex. It has been estimated that nationally about a billion pounds of pesticide active ingredients were sold in 1970 resulting in the use of about 240 million containers. Because of the construction of the openings in many of these containers, it is physically impossible to completely empty the contents without a thorough rinse at the time of product use. Significant quantities of concentrate are left behind in the containers after use. These containers, varying in size from 1 gallon to 55 gallon capacity are now buried, crushed or discarded in a variety of hazardous and unsatisfactory ways. This practice constitutes a double loss, for not only is the steel or other material of which the container is composed (weighing 4 to 35 pounds) lost to reuse, but the contents are free to leach into and contaminate irreparably the groundwater at innumerable unsupervised disposal sites, one of which is shown as Plate A.

The Merrill, Oregon Management Facility

Through the action of the Agricultural Chemicals Committee of Klamath County, a cooperative effort to collect and manage these containers was initiated involving Klamath County and Oregon State University's Environmental Health Sciences Center, and the Pesticide Management Facility at Merrill, Oregon was brought into existence.

The immediate objective of this Facility was to provide for secure storage of pesticide materials and containers and to determine processing requirements necessary to prepare containers for recycling for reuse as containers or scrap or for disposal by other acceptable means. Figure 1 shows a general layout of the facility, with the container storage area, service buildings, and concrete processing area slab all located within a climb-proof fence. A detail of the container stacking mode used is also shown, while a picture of a portion of the storage area is shown as Plate B. Figure 2 shows a larger-scale detail of the processing area arrangement. Figures 3 and 4 show construction details as well as a more detailed plan of the processing area while estimated development costs are shown on page 66.

\*Principal Investigator, E.H.S.C. and Associate Professor, Dept. of Civil Engineering, Oregon State University.



Plate A. The Problem: One of the innumerable uncontrolled dump sites used for spent pesticide containers.

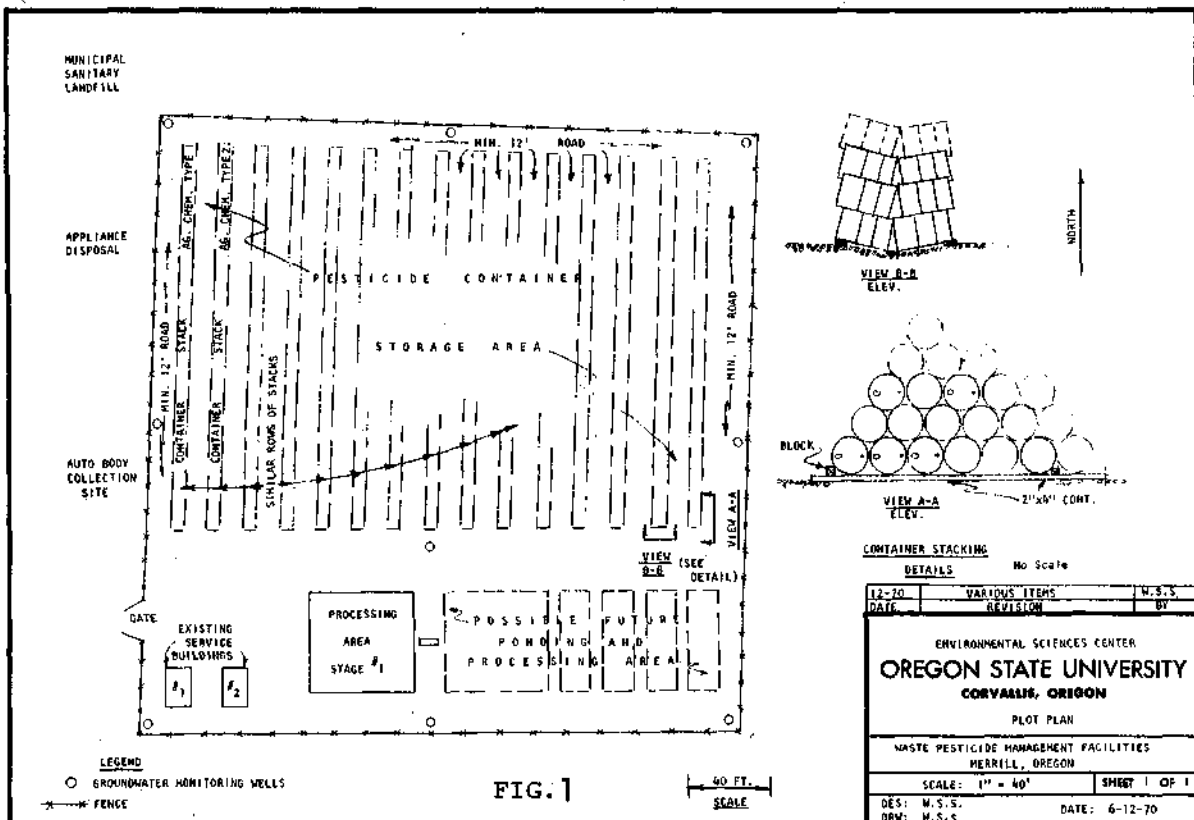


FIG. 1

CONTAINER STACKING DETAILS No Scale

12-70 DATE	VARIOUS ITEMS REVISION	M.S.S. BY
ENVIRONMENTAL SCIENCES CENTER <b>OREGON STATE UNIVERSITY</b> CORVALLIS, OREGON PLOT PLAN		
WASTE PESTICIDE MANAGEMENT FACILITIES MERRILL, OREGON		
SCALE: 1" = 40'		SHEET 1 OF 1
DES: M.S.S. DRW: M.S.S.		DATE: 6-12-70

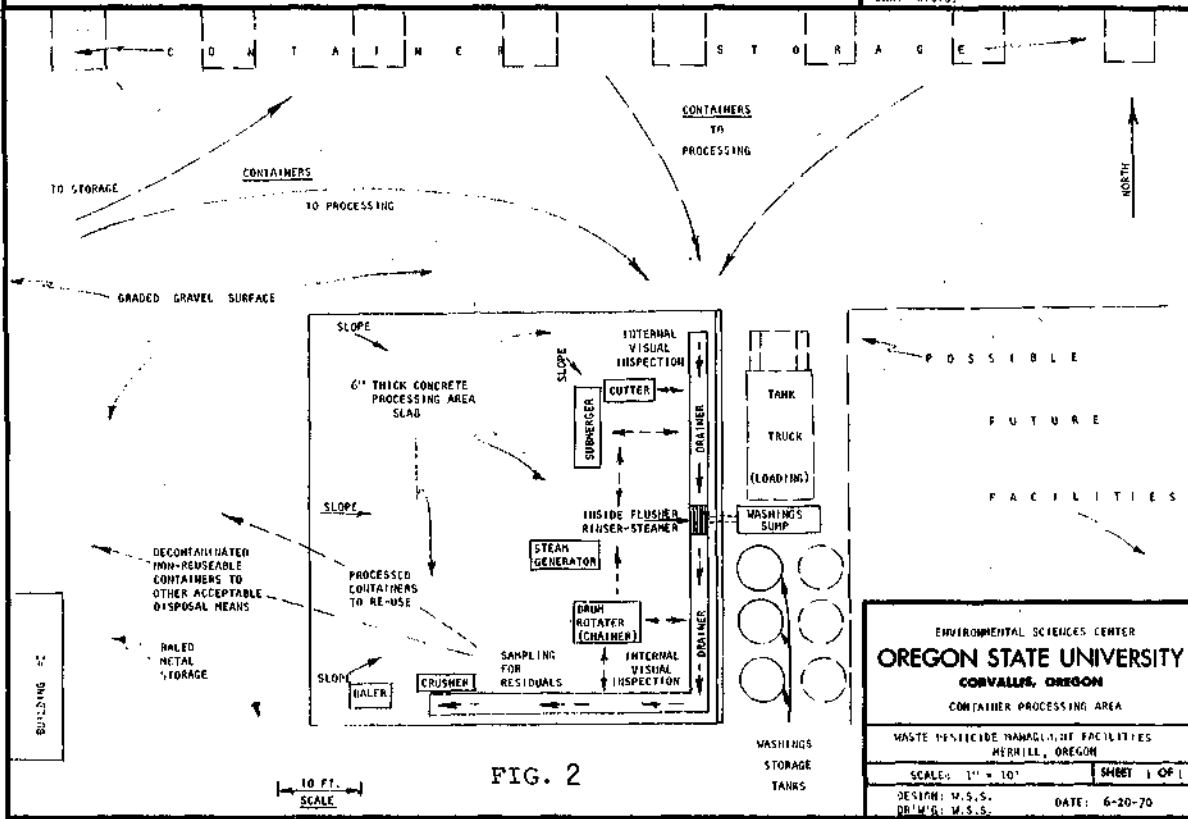
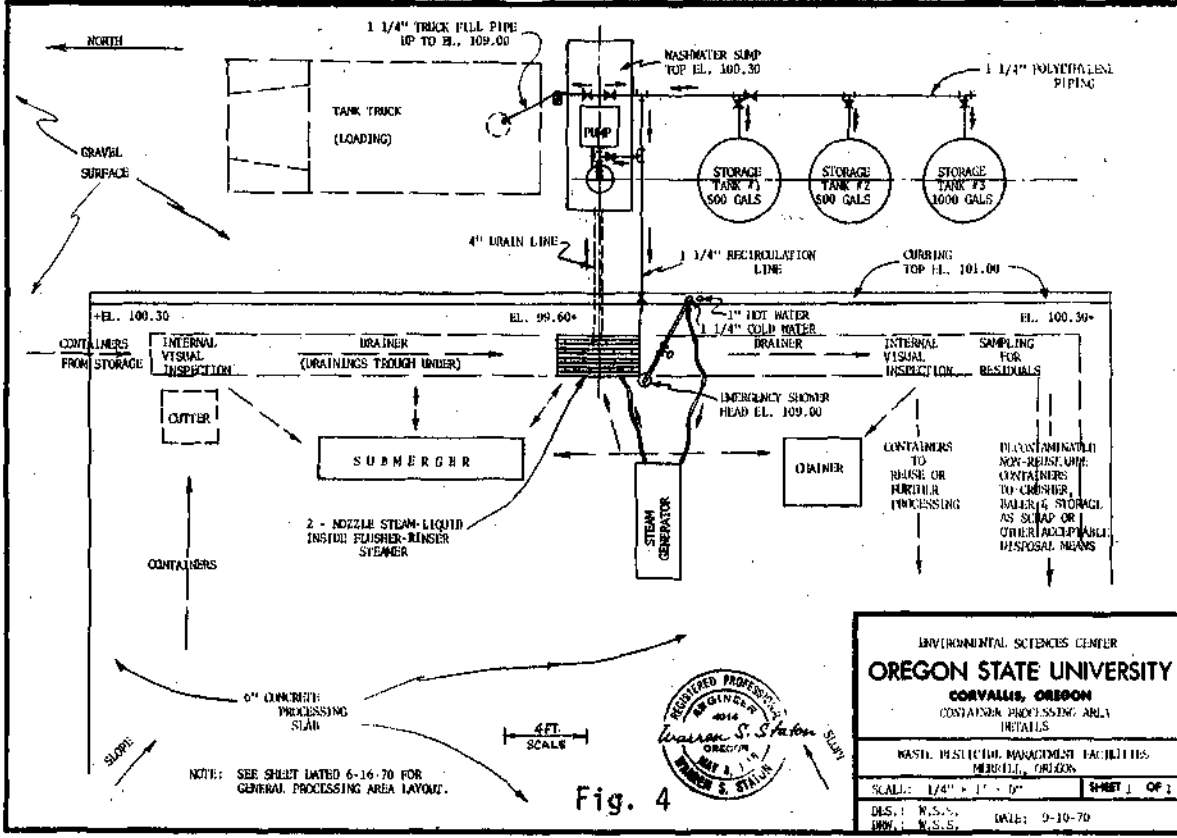
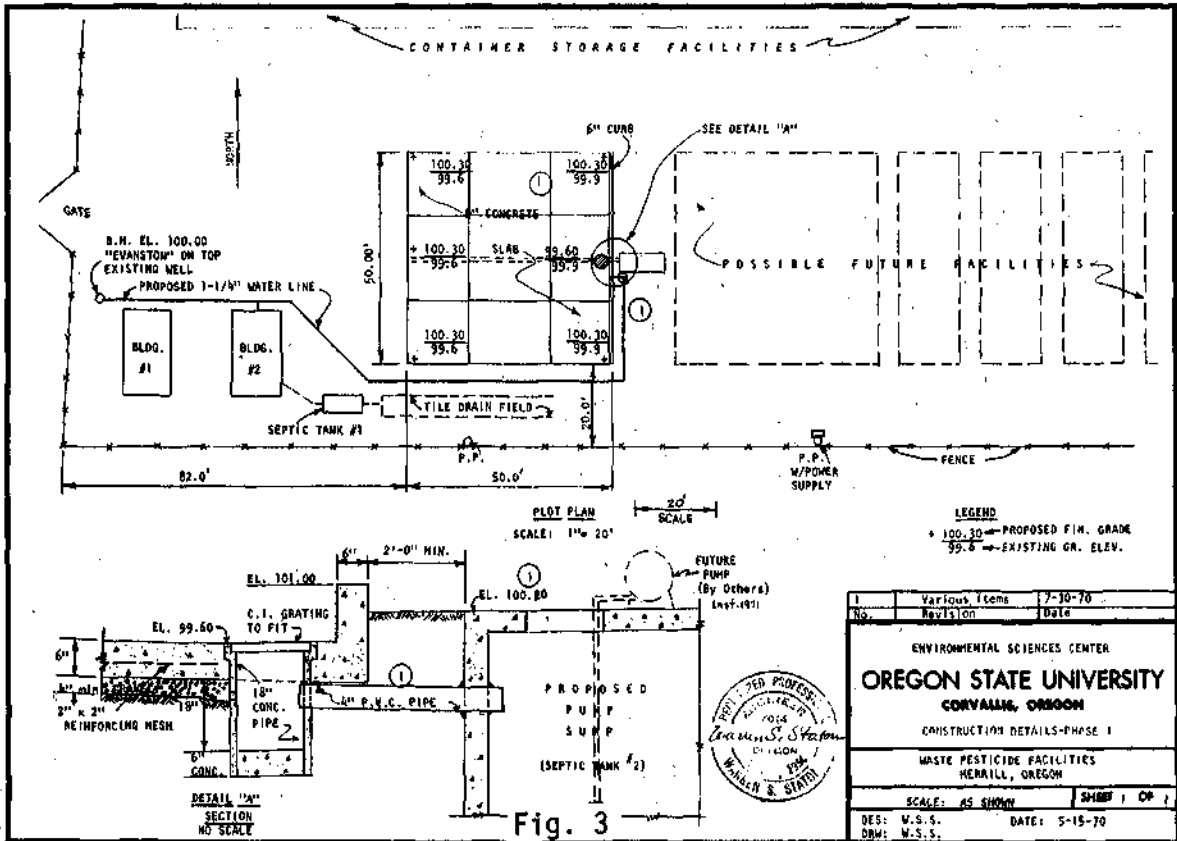


FIG. 2

ENVIRONMENTAL SCIENCES CENTER  
**OREGON STATE UNIVERSITY**  
 CORVALLIS, OREGON  
 CONTAINER PROCESSING AREA

12-70 DATE	VARIOUS ITEMS REVISION	M.S.S. BY
WASTE PESTICIDE MANAGEMENT FACILITIES MERRILL, OREGON		
SCALE: 1" = 10'		SHEET 1 OF 1
DESIGN: M.S.S. DRW: M.S.S.		DATE: 6-20-70



Following is an estimate of cost to develop a management facility such as that at Merrill, Oregon:

ESTIMATED COSTS FOR DEVELOPING TYPICAL 2-ACRE IMPROVED\*  
CONTAINER MANAGEMENT FACILITY

1. Site clearing and grading with slope for drainage, lump sum	\$1,000	
2. 4" Pit-run gravel surfacing	1,500	
3. Fencing, lump sum	<u>3,000</u>	
Items 1-3, sub-total		\$5,500
4. Operations building, lump sum	1,000	
5. Water supply well and pump, lump sum	3,000	
6. Shower, toilet, sink, plumbing, septic tank, tile drain field, installed	2,500	
7. Concrete slab (reinforced) 50' x 50', 6" thick, with drain, pump sump and piping	<u>3,000</u>	
Items 4-7, sub-total		<u>9,500</u>
	Sub-total	\$15,000
8. Installed equipment ( <u>Variable, depending upon level of processing to be performed</u> ): minimum \$500 for pump and cleaning nozzles to \$60,000-\$75,000 or more for nearly complete processing equipment: (Submerger, inside jet rinse, chainer, steamer, chime straightener, conveying equipment, leak tester, etc. at \$9,000 to \$15,000 each, all of commercial manufacture)		<u>75,000</u>
	Total =	\$90,000**

---

\* Depending upon level of use to be made of the management site, development costs could vary from \$3,000 for fencing a stable, bare, well-drained area to approximately \$90,000 to develop site and install adequate equipment for nearly complete processing as shown under Item 8 above.

\*\* No allowance for land acquisition included





Plate B. Container Storage Area.

#### Air and Ground Water Monitoring

Monitoring of air and ground water was and is considered essential to insure security of ground water and to detect the presence of pesticide fractions in the air.

To establish background information on pesticide content of the ground water at the Management Facility and to provide continuous monitoring of this parameter, 3-inch diameter test holes were augered and cased at locations shown on the Plot Plan of Figure 1. Base level data were obtained, and ground water samples were taken on a regular basis as a check on integrity of the site.

Samples were taken prior to any container treatment activity at the site as a means of providing an indication of background levels of pesticide content in the ground water under the site. Results of this background level survey indicated a pesticide concentration of zero directly under the center of the storage area ranging to 0.038 ppm 2,4-D at the south and southwest test wells and to a maximum of 0.053 ppm 2,4-D at the northwest test well.

It may be significant that the highest indicated concentrations occurred immediately adjacent to the Klamath County dump where solid waste has been buried for a number of years. However, these concentrations were so very small that the reliability of the results as indicators of 2,4-D content of the ground water, from whatever source, is questioned, since it is possible that such minute concentrations could result from equipment contamination from other work in progress. Ground water samples were taken on a regular

basis over the life of the project with the most recent sampling taken on October 2, 1972. Analysis of these samples indicated no residual present in ground water at the site.

Air sampling was initiated to monitor possible airborne pesticide materials by mounting a 24" x 24" x 1" glasswool filter on the fence on each of the four sides of the site and one control collector approximately ½ mile from the site. Removal and laboratory testing of the filter materials for volatiles and other pesticide fractions was conducted on a regular basis with the last analysis being performed on September 13, 1972. All tests for pesticide materials in air filters have been negative.

It is concluded, therefore, that no contamination of air, adjacent lands, surface or ground water has taken place as a result of air or water transport of pesticide materials from the container management site. It is concluded also that the specific stacking mode utilized at the site and as shown on Figure 1 has been responsible in large measure for reduction of air and ground water contamination from impounded containers.

#### Alternatives in Container Management

Some alternatives considered for the operation of a pesticide container management facility such as the one at Merrill were to provide for:

- (1) Complete processing at each management facility.
- (2) Preprocessing to a safe level at the facility with subsequent movement of the containers to a central, perhaps regional, facility for further processing to a level necessary for reuse or safe disposal through more conventional channels.
- (3) A mobile container-processing unit, moving from management facility to management facility with specialized equipment mounted on a trailer or trailers, which would have the capability of cleaning containers to residual levels necessary for reuse, reprocessing or safe disposal.

#### Container Processing

Because of the large investment necessary for commercial reconditioning and cleaning equipment and the intermittent nature of the operation contemplated at typical management facilities of this type, it was decided in this stage of operation, to hold major equipment purchases to a minimum, acquiring

or building needed equipment as determined by initial operations and deferring use of commercial equipment until a later phase.

The general categories of operations performed at the facility were:

Mechanical - Including abrading of residuals from interior surfaces by means of a drum rotater in combination with chains introduced through the bung holes.

Chemical - Including submergence in solutions at ambient and elevated temperature, stripping of residual contents by caustic and other chemical solutions, and other means.

Mechanical-Chemical Combinations - Including hot steam-chemical solutions introduced by jet action into the interior, agitation while submerged, and combinations with operations of the preceding categories.

In order to design a process line which would be capable of performing all of the functions necessary to render containers reusable as containers or scrap, or at least permit their release from the Management Facility as non-hazardous solid waste, a survey was made of various barrel and drum reconditioning equipment, and several commercial reconditioning facilities were visited.

Unit processes utilized by the barrel and drum reconditioning industry were modified and incorporated into a pilot process line which was used to clean containers. As will be shown later, processing at a management facility such as that at Merrill will adequately prepare many of the 5-, 30- and 55-gallon size drums for recycling to the original use or to non-food container reuse either as tight-head or open-head drums depending upon other conditions.

Reduction of residuals in containers by various process combinations were performed without opening the containers. Cleaning operations by mechanical and chemical means were performed through the existing bungs in the same manner that the container reconditioning industry performs these operations. Until optimum cleaning processes have been developed, however, it has been necessary to sample processed containers so that cleaning effectiveness of various combinations of agents could be accurately evaluated.

Attempts were made to clean non-metal containers of pesticide residual to a level at which they could be incorporated in a suitable landfill. It is anticipated that containers of plastic, glass and other materials may eventually have some recyclable economic value and could easily be reduced in volume by crushing and stockpiling until demand increases. It was also

found that the economic value of agricultural chemical material remaining in discarded containers often amounted to \$5.00 or more. Quantifying the magnitude of this loss to applicators led to issuance of a Cooperative Extension publication on proper container rinsing at point of use as well as strong recommendations to the packaging industry for container opening redesign.

Pilot process line sequences contained combinations of unit operations which are defined as follows and included in Work Plans of Appendix A:

- (1) Submerge - Place containers in submerger containing water or solutions at ambient or elevated temperatures for varying lengths of time required to clean with varying types and concentrations of solutions.
- (2) Chainer - Introduce chains through bung hold and rotate containers on chainer device for physical abrading and removal of internal deposits.
- (3) Internal Flush, Rinse, Steam - Subject interior surfaces to high pressure flushing with various combinations of water, steam, and solutions at both ambient and elevated temperatures.
- (4) Internal Spray Rinse - Place container bung hole over single high pressure nozzle and impinge spray on all surfaces.
- (5) Internal Visual Inspection - Determine amount of contents and condition of internal container surfaces, using quantitative as well as qualitative evaluation techniques both before and after processing.
- (6) Drain - Empty existing contents or those remaining after submergence.
- (7) Open Containers - Expose interior surfaces for careful evaluation of condition both before and after processing.
- (8) Sampling for Residuals - This operation included sampling of surfaces for exhaustive laboratory examination as an evaluation of process effectiveness.

Location of these unit operations in relation to one another in the processing area are shown on Figures 2 and 4.

Off-site completion of "open-ended" processes:

- (9) Transport to further processing or reuse as containers.
- (10) Recycle as scrap.
- (11) Incorporate into sanitary landfill.

Sequence combinations were called for as a process required for a certain type and condition of container as follows:

Sequence A: 6,8.

Sequence B: 1,6,2,3,6,8.



Plate C: Process Line showing sump, washings storage and Internal Spray rinse.



Plate D: Drum Rotator (chainer) and Submerger.



Plate E. Steamer, drain racks  
and solution storage tanks.

The sequences of unit operations were developed by project chemists working with consulting cleaning specialists to devise the most effective combination of chemicals, solutions and temperatures for each type of container and group of pesticides. Adjustments were made after field testing. Operations within sequences were sufficiently flexible as to care for variation in condition from container to container at the discretion of the operator.

A series of small scale pilot tests designed to evaluate relative cleaning effectiveness of cleaning solutions were completed on a number of standard-sized representative pieces cut from tops and bottoms of containers spiked in a uniform manner. Agricultural chemical materials used were 2,4-D ester, Guthion and Endrin, chosen as representative of the classes of chemicals to be expected at any container cleaning project. Solutions of 5% heavy duty detergent, 5% tri-sodium phosphate, 1% caustic soda and recommended Oakite<sup>R</sup> concentrations were used on samples both at ambient temperature of about 20°C and at 82°C, a recommended temperature for use of commercial container-cleaning products.

As expected, pesticide residuals found in samples treated at ambient temperature were found to be three to ten times as high as when treated at elevated temperature.

The cleaning effectiveness of the various solutions was not found to vary greatly from one solution to another even at elevated temperature except that the residual in samples treated with detergent was about two to three times that remaining after treatment with the other three solutions.

Extrapolating this information to the quantities expected to remain in a representative 5-gallon container (weighing from 4 to 5 lbs) after treatment with cleaning solutions only produces a quantity of about 0.5 gram per container.

A second series of pilot tests designed to analyze only the relative cleaning effectiveness of individual mechanical and other than cleaning solution type effects on reduction of pesticide residual was run and results obtained. In this series only 2,4-D ester was used as the test pesticide contaminant. Various combinations of a number of standard unit operations mentioned previously were tried.

#### Sampling and Testing Procedures

It was presumed that residual pesticide in containers would be approximately proportional to the interior surface area of the container. It was decided to take standard sample wedges which would include representative portions of tops, bottoms, sides and chimes (seams) of containers and would be simple to duplicate. A separate analysis of separated portions indicated no bias was introduced by the selected sample form. A set of arbitrary, easily repeatable sample dimensions were selected which resulted in a surface area of about 5.7 square inches. A picture of a sample taken from a container is shown as Plate F. Sets of 6 each of these wedges were considered a sample for analysis purposes and an average area obtained at 34.40 square inches which represents approximately 5.2% or  $\frac{1}{19.10}$  of the 5-gallon container surface area.

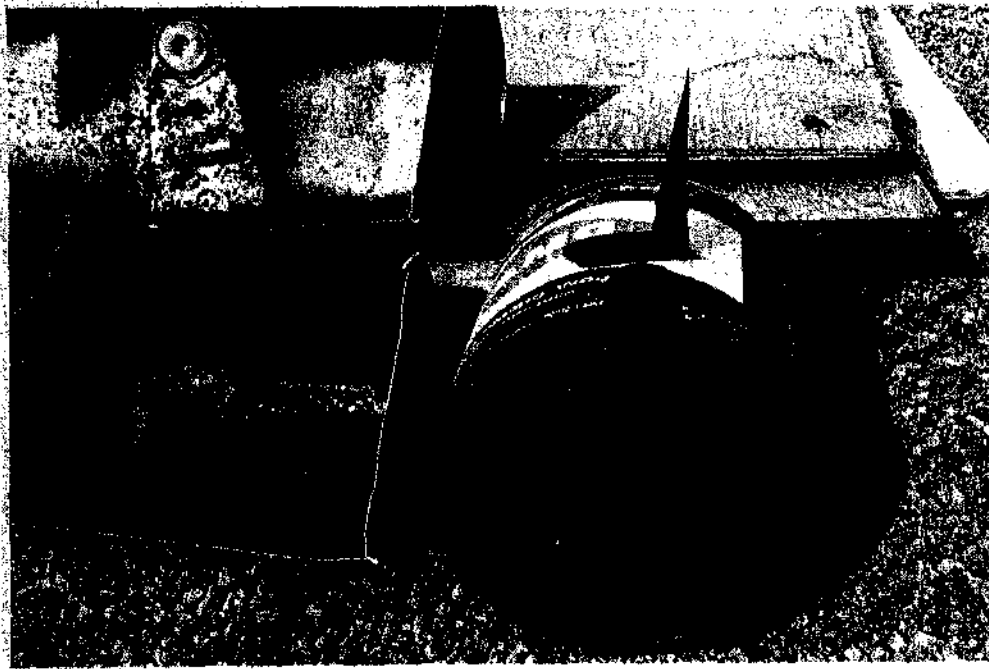


Plate F. Standard sample wedge cut from processed container and opened container used in evaluating cleaning effectiveness

Samples were removed from the body of the container with an impact tool, packaged in plastic bags and sent to the laboratory for analysis.

In order to establish a valid basis for comparison, a number of "raw" (unmodified) containers were analyzed to indicate a common residual expected in all unprocessed containers which produced an average of 507 mgs (0.507 gms) 2,4-D per sample set or 9700 mgs (9.70 gms) per container. Each container was "spiked" with a measured amount of pesticide material in accordance with the "Definition of Unit Operations" shown in Appendix A. The average amount of "spike" remaining after spiking operations was 3 ounces (85,000 mgs or 8.50 gms) which, when added to the "raw" container content, produced an average total content of 94,700 mgs (94.7 gms) of agricultural chemical per container or 4950. mgs (4.95 gms) per wedge set sample.

Approximately 300 sets of samples were taken from containers treated by various sequences of unit processes and sets of samples were selected at random for analysis.

### Results

A tabulation of the results of treatment by various sequences of unit operations is shown in Table A.



Table A  
Summary: Cleaning Effect of Unit Operations in Experimental Sequences

Unit Operation	Sequence of Unit Operations Performed								
	A	B	C	D	E	F	G	H	I
Raw Can	X	X	X	X	X	X	X	X	X
Drain	X	X	X	X	X	X	X	X	X
Spike		X	X	X	X	X	X	X	X
Rinse		X	X	X	X	X	X	X	X
Drain		X	X	X	X	X	X	X	X
Submerge			X			X		X*	X*
Drain			X			X			
Steam				X		X	X		
Chain					X	X			
Jet Rinse						X	X	X	X**
Drain	X	X	X	X	X	X	X	X	X
Sample	X	X	X	X	X	X	X	X	X
	A	B	C	D	E	F	G	H	I
mg 2,4-D	722	737	134	142	31	29	132	42	
Residual	207	393	454	380	75	34	32	680	
Per can	145	863	186	95	47	45	134	249	1300
Sample	120	2190	445	26	395	274	18	418	90
(6 pieces)	472	827	54	37	122	415	53	63	
	246	462	149	1099	1035	19	5	145	180
	307	1010	1415	28	30	29	59	100	320
	325	116	652	172	37	138	227	51	
	55	951	331	369	76	143	21	1408	
	178	129	76	222	232	843	38	57	400
	1415	55			219	26	113	670	50
	1200				20	49	8	556	
	1015				59	63		78	
								68	
								311	
$\bar{X}$ , mgs	507 (4950 spiked)	654	476	257	183	162	70	326	390

\*Sequence H:

- 1st 5 containers submerged in 5 lb/100 gal detergent solution.
- 2nd 5 " " " 10 lb/100 gal sal soda solution.
- 3rd 5 " " " 1 lb/100 gal caustic soda solution.

\*Sequence I;

- 1st 2 " " " 5 lb/100 gal detergent solution.
- 2nd 2 " " " 10 lb/100 gal sal soda solution.
- 3rd 2 " " " 1 lb/100 gal caustic soda solution.

\*\*Internal jet rinse using 5 lb/100 gal detergent solution.

Solution temperatures varied between 15°C to 19°C (59°F to 71°F).

## Discussion

Following is a tabulation by sequence of unit operations of resulting reduction in residual 2,4-D content.

Table B.

<u>Sequence of Unit Operations</u>	<u>Unit Operations Included (Unique operation underlined)</u>	<u>% Reduction in 2,4-D Residual</u>
B	Rinse Drain <u>Submerge</u> Drain	87.0
C	Rinse Drain <u>Chain</u> Drain	90.5
D	Rinse Drain <u>Steam</u> Drain	95.0
E	Rinse Drain <u>Jet Rinse</u> Drain	96.4
F	Rinse Drain <u>All Treatments</u> Drain	96.8
G	Rinse Drain <u>Steam-Jet</u> Drain	98.7

Sequences H and I, utilizing submergence in and/or jet rinse with detergent or chemical solutions, were more effective (93.7% and 92.2% reduction respectively) than submergence in plain water and more effective than Sequence C utilizing chaining. This would indicate that a saving of labor could be effected by utilizing chemical or detergent solutions as a substitute for more labor-intensive operations. The fact that Sequence F, utilizing all unit processes is lower in reduction of residual than others may be due to the fact that a few high residual values appear while others are consistently much below the average.

It was found that Sequence G, while being the most effective in terms of reduction of residual (98.7%), was also quite low in dwell time for effective steaming and internal jet rinse (1 minute each). The chainer was found to be the most time-consuming operation of all (35 minutes per 4-container cycle) mainly because of the nature of the equipment used. This operation would not be used for all containers, however, in actual production.

If it is assumed that spike material is completely eliminated by rinse of Sequence B, then it appears that the following portions of the "pre-spike" content have been removed:

Table C

<u>Sequence of Unit Operations</u>	<u>Average residual content per container, gms.</u>	<u>% Reduction in 2,4-D from original "pre-spike" content</u>
A (unmodified can)	9.7 ( $\pm$ 9.8 gms=1 S.D.)	--
B	12.5 ( $\pm$ 11 gms=1 S.D.)	+29
C	9.1 ( $\pm$ 8 gms=1 S.D.)	6
D	4.9	47
E	3.5	64
F	3.1	68
G	1.3	87

The figure of 1.3 grams per container shown above for Sequence G using an unmodified container is equivalent to a pesticide residual concentration of 637. ppm of container material (steel) as compared to an original concentration of 4750. ppm.

The foregoing indicates a reasonable expectation of residual of 1 to 2 grams of pesticide per five gallon container using combinations of mechanical and other than chemical agents in the cleaning process.

#### Time and Motion Studies

Time and motion studies were performed on certain of the sequences in order to evaluate throughput capabilities of these sequences. In general, rate of processing containers is a function of dwell times in the unit processes plus a small amount of transfer time depending upon physical distance between the process units as well as number of workers used. The unmechanized submerger with a required dwell time of 1 hour and a capacity of 12 containers would then have a throughput of about 90 containers per 8 hour day, but with a dwell time of 30 minutes, this unit could keep pace with other unit operations in the process line if less time were found to be effective in removing residuals.

Throughput capacity utilizing all unit operations but with limited chainer use was estimated at from 20 to 30 5-gallon container per hour, based upon an actual 3-hour operation by a 2-man crew attempting to simulate actual operation conditions. Costs of cleaning at an operation such as that at Merrill, Oregon, are estimated to be \$0.64 per container as detailed below:

ESTIMATED COSTS FOR PROCESSING CONTAINERS AT A MANAGEMENT FACILITY  
SUCH AS THAT AT MERRILL, OREGON\*

Operation: 250 days/year, 8 hours/day (No operation Saturdays, Sundays, or holidays)

Production: (20 containers/hour)(8hours/day) = 160 containers/day  
(250 days/year)(160 containers/day) = 40,000 containers/year

Costs:

Labor: 1 lead operator @ \$6.00/hour  
1 operator @ \$5.00/hour  
\$11.00/hour  
(8 hours/day)(\$11.00/hour) = \$88.00/day  
(250 days/year)(\$88.00/day) = \$22,000.00

Amortization of site development costs:

Amort.time: 7 years (See Site Development Cost Estimate p. 66)  
Cost/year =  $\frac{\$15,000 + \$3,000 \text{ equip.}}{7 \text{ years}}$  = \$2,600.00

Miscellaneous costs: cleaning materials,  
power, maintenance, etc. 1,000.00  
Total cost/year \$25,600.00  
Cost/container =  $\frac{\$25,600}{40,000}$  = \$0.64/container

\*No allowance for land acquisition included.

Washwater Collection and Disposal

Separate collection and storage of washwaters from use with each operation was on the basis of compatibility of characteristics and ultimate disposal requirements. Adequate valving is available to enable pumping from the washwater collection sump to tanktrucks, to tank storage or to lagoon storage, depending upon quantity of liquid and disposal requirements.

Disposal of washwaters resulting from pesticide container cleaning operations is of prime concern as one of the important elements in pesticide and hazardous materials management. Several alternatives are presently available such as beneficial use as originally or otherwise intended, storage, incineration and others. Most of these either involve high cost, insult to the environ-

ment or postponement of problem solution as in the case of storage, burial or similar means of removal from sight.

As a matter of additional pilot study for this project in the area of washwater treatment a number of recirculated filtration runs were made utilizing filter materials known to have adsorption and absorption properties.

Some very encouraging results were obtained but to reach definite conclusions would require further improvement of equipment and technique.

### Recycling Potentials

A pesticide management facility located adjacent to other waste management facilities such as that at Merrill can be expected to take advantage of this proximity. The Merrill scrap auto body collection site receives approximately 600 car bodies during an average year of operation. Stripped of motors, wheels, glass, upholstery, wood and plastics, the weight of steel might be expected to average approximately 2500 pounds per auto body. Study has shown that steel containers, not reusable as containers and cleaned to a level shown possible in pilot studies at Merrill, could be combined with these car bodies as a means of providing a "dilution factor" for the residual pesticide in the scrap mixture. The resulting scrap mixture, using a ratio of 20 5-gallon containers, or its equivalent, per car body, would have a residual pesticide concentration of about 28 parts per million or 0.06 pounds per ton of scrap. At this rate of combination, it is estimated that the scrap auto collection facility at Merrill could absorb over 20,000 5-gallon containers annually, which is more than the expected annual container use rate for the county.

The scrap-to-steel ratio at point of reuse would further reduce the pesticide concentration such that stack emissions of pesticide residuals would be a small part of the scrap contaminants and would be scrubbed out with other stack materials. Study of this aspect of the reuse stream will continue, making use of studies now in progress at Mississippi State on pyrolysis of pesticide materials.

The recycle possibilities for containers without treatment of any kind has not been studied in detail. Without inspection and treatment to some degree, however, the hazard to personnel who may come in contact with the containers or the resulting contaminated scrap still remains in addition to the possible higher pesticide content in stack emissions at point of scrap use.

Contact has been made with the scrap metal firm which regularly bales and removes scrap metal from the Klamath County-operated auto and scrap metal storage facility adjacent to the Pesticide Management Facility. The firm has offered to enter the Pesticide Management Facility and bale and remove acceptably decontaminated containers or accept such containers as a part of the miscellaneous metal scrap which they periodically remove.

It is contemplated that open, plastic-lined lagoons may be constructed both to concentrate liquids to less volume and to observe the effect of sunlight and air on pesticide washwaters.

It is also expected that practical uses will be found for these washwaters in limited modifications of the originally intended uses such as for fly control at landfill sites and control of vegetation in non-critical areas.

Investigation of other aspects of the waste pesticide container problem including economics have been studied. For example, a promising concept under study is the feasibility, design and cost of a mobile unit on which specialized equipment could be mounted for the purpose of moving from collection site to collection site for container processing should impoundment facilities such as those at Merrill be developed on a county or regional basis. A paper attached to this report as Appendix B entitled: "A Statewide Hazardous Residuals Management System" discusses the management of hazardous residuals on a regional basis together with the concept of the mobile container processing unit. Estimated capital and operating costs for such a unit are set forth in Appendices C and D.

#### Recommendations for Further Study

It is recommended that the following studies be undertaken as a logical extension of the present study.

1. Study and report upon the operation of hazardous residuals management sites in the context of the eventual statewide or regional "closed-end", all-inclusive residuals management system. Establish by such a study the optimum level of site development and equipment required at management sites.

2. Utilizing full-sized commercial reconditioning equipment in the plant of an existing container reconditioner, establish the optimum combination of unit processes required for processing hazardous residuals containers of several major types of agricultural chemicals to residual levels which would permit reuse of the container and possible beneficial use of washwaters.

3. Study feasibility and costs of separating hazardous materials and their containers from the solid waste stream or moving them in to central

locations if not included, classifying materials according to type and/or processing requirements, and separately impounding these materials adjacent to an actual solid waste disposal site.

4. Study feasibility and costs of pre-processing hazardous material containers at widely dispersed sites by use of a mobile processing unit as compared to costs of moving containers to fixed treatment facilities for processing.

5. Study feasibility, costs and overall operation of a solid-liquid-gas residuals management site by a cooperative effort with an existing disposal company and a secondary materials company in actual day-to-day operation.

6. Study application and effectiveness of additional treatment processes to washwaters resulting from pre-processing including:

- a. Chemical treatment
- b. Microbiological treatment
- c. Physical processes of filtration using various media etc.
- d. Effects of sun, wind and other agents.

7. Study feasibility and effectiveness of levying a container charge at some point in the sales chain as a means of providing:

- a. Incentive for return of containers to controlled recycling facilities.
- b. An amount to defray costs of container and washwater detoxification.

## APPENDICES

- Appendix A Definitions of Unit Operations and Example Workplans
- Appendix B A Statewide Hazardous Residuals Management System
- Appendix C Estimated Capital Costs for a Mobile Container Cleaning Unit
- Appendix D Estimated Capacity and Processing Costs of a Mobile Container Cleaning Unit



## Appendix A

OREGON STATE UNIVERSITY

Environmental Health Sciences Center  
Pesticide Container Cleaning Project

Definitions of Unit Operations:

0. Spike & Pre-rinse - Add  $\frac{1}{2}$  gallon agricultural chemical to can. Rotate to cover all interior surfaces than pour back into measurer, draining as completely as possible. Record amount remaining in can. Make up material in measurer to  $\frac{1}{2}$  gallon and repeat on next can until all have been treated.

Rinse each can with 1 gallon of water two times. Discard rinse water each time into a selected storage drum. Rinse exterior with hose.

1. Submerger - Completely submerge all surfaces of can in plain water at ambient air temperature. Time: 1 hour.
2. Chainer - Rotate can on chainer with 5 ft. length of chain for 5-gallon drums. Time: 10 minutes each axis.
3. Steamer - Inject steam into can through bung hold attempting to reach all surfaces. Time: 1 minute.
4. Internal Spray Rinse - Place can bung hold over single nozzle and impinge spray on all surfaces. Time: 1 minute.
5. Internal Visual Inspection - Determine condition of in-erior surfaces.
6. Drain - Empty contents or that remaining after previous processing.
7. Open Container - Expose interior surfaces for evaluation of their condition.
8. Sample: Cut standard wedge from top and bottom edge of can.

MERRILL PESTICIDE MANAGEMENT PROJECT

WORK PLAN 10-25-71

1. Process 6 unmodified cans from stack each as follows:\*  
Sequence A: 6, 8
2. Process 3 cans each with following sequences:  
Sequence B: 0, 1, 6, 8  
Sequence C: 0, 2, 6, 8  
Sequence D: 0, 3, 6, 8  
Sequence E: 0, 4, 6, 8
3. Process 5 cans each with following sequences:  
Sequence F: 0, 1, 2, 3, 4, 6, 8  
Sequence G: 0, 3, 4, 6, 8
4. Identify and retain cans for further use.

\*Use 2,4-D cans

MERRILL PESTICIDE MANAGEMENT PROJECT  
WORK PLAN 5-15-72

References:

Definitions of Unit Operations.  
Work Plan 10-25-71

1. Using 5 unmodified cans from 2,4-D stack for each sequence redo mechanical operations as follows:
  - Sequence A: 6, 8
  - Sequence B: 0, 1, 6, 8
  - \*Sequence C: 0, 2, 1, 6, 8
  - Sequence D: 0, 3, 6, 8
  - Sequence E: 0, 4, 6, 8
  - Sequence F: 0, 1, 2, 3, 4, 6, 8
  - Sequence G: 0, 3, 4, 6, 8
  
2. Using 5 unmodified cans from 2,4-D stack for each sequence do full-scale chemical effects tests using solutions noted:
  - Sequence H: 0, 1\*\*, 4 plus external rinse (plain water), 6, 8Use submerger for these sequences, thoroughly cleaning submerger and lining with two thicknesses of 4 mil plastic.  
  
Solutions to be syphoned out of lined submerger into sump and pumped to separate storage.

Notes:

- \* Unit Operation #1 has been added to this sequence.
- \*\* a. 5% detergent solution
- b.  $\frac{1}{2}$  10 pounds per 100 gallons Sal soda solution adjusted to pH 10-12.
- c. 1% caustic soda solution (1 pound per 100 gal.)
- \*\*\* Identify and retain cans for further use, protecting from weather.

## Appendix B

## Appendix B

### A STATEWIDE HAZARDOUS RESIDUALS MANAGEMENT SYSTEM

Warren S. Staton\*

Environmental Health Sciences Center  
Oregon State University

At the present time, land disposal is the principal method of solid waste disposal in most areas of the United States. Daily per capita rates of solid waste generation have grown steadily over the years reaching an amount of over 5 pounds in 1970. Projecting this trend into the future, it appears probable that a daily solid waste generation rate of at least 8 pounds per capita may be reasonably expected by the year 1980.

In addition to the increase in the solid waste generation rate, it is anticipated that as more stringent air and water quality standards are enforced, wastes previously burned or disposed into ground or surface waters will become solid (or liquid) waste disposal problems adding to the already huge amount of residuals being generated. It is estimated that, in Oregon's Willamette Valley alone, an additional 13,000 acres of land will be required for solid waste disposal by the year 2000. It can be readily seen that any improvement in separating out and reusing valuable components of the residuals stream with a consequent reduction in waste volume can result directly in a saving of our valuable land resource in addition to the value of recovered materials. An important component of solid waste not now included in either recycling or disposal because of the nature of the materials and their containers are the pesticides, herbicides and other environmentally hazardous materials generated and used by the technology of our increasingly complex society.

Pesticides, herbicides and other similar hazardous materials are necessary for the efficient production of food and fiber and unless a major breakthrough occurs in pest and weed control, these materials must continue to be used in agricultural applications. On the basis of manufacturers' sales, use of these agricultural chemical materials has risen by 10 to 15% per year since 1966, resulting in a 1970 total of 500,000 tons packaged in about 240 million containers of all sizes. In addition, an unknown tonnage of pesticides and their containers is used by industrial, governmental and urban users.

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\*Principal Investigator, E.H.S.C. and Associate Professor, Dept. of Civil Engineering, Oregon State University.

A recent Mississippi survey reveals that only about 7% of the containers used for agricultural chemicals are returned to dealers. The remainder are crushed, buried, burned, discarded to farm trash piles or otherwise disposed of in a variety of ways which are hazardous to humans and animals, contaminate soil and ground water or remain a visual blot on the landscape.

When the tremendous volumes of unwanted pesticide materials and their containers are considered, it is easily recognized that a major problem associated with pesticide disposal may be one of materials handling.

As with many other residuals, collection, storage, processing and ultimate disposal appear to be the main aspects of the problem of these materials and their containers. Following is a discussion of these considerations with salvage and recycle of valuable materials a guiding principle.

### 1. Collection

Present restrictions have operated to place these materials and their containers in a type of limbo in which they may not be reused nor be committed to sanitary landfill or be otherwise disposed and so are allowed to accumulate at the site of use; an unsightly, wasteful, and often potentially dangerous practice.

A pilot collection program to collect containers into impoundment facilities was recently successful in generating almost 4000 containers in Klamath County on a one-time, intensive effort campaign. This "assembly" program was on a voluntary basis without compensation for the container. The annual container use and the number still remaining in the County, however, is estimated to be several times the above figure while information obtained on the number of containers used annually in other agricultural regions of the State appears to indicate a large but as yet undetermined figure.

That container impoundment facilities are necessary is borne out by the numerous requests which have been directed to operating personnel and others connected with the Klamath County project for permission to bring containers in to the impoundment facility.

### 2. Storage

If movement of these containers to secure storage should be permitted and encouraged, some amount of unwanted, unused toxic materials would be included as residual materials brought in to every disposal site in the State. These hazardous materials must be impounded in properly located and supervised sites, separate from harmless residual

materials, be properly stored and classified according to type. Since at present most containers are metal, container impoundments should be located adjacent to auto body and general metal scrap salvage locations for ease of combination with these materials after a proper level of detoxification has been achieved.

It would be feasible to designate regional impoundment facilities adjacent to long range solid waste management sites such as would serve an area having a radius of approximately 25 miles. An area such as the Willamette Valley would then be served by approximately three or four such facilities to which hazardous materials and their containers could be brought. A limited number of impoundments could be appropriately located as required to serve other areas of the State.

Because of the possibility of spills and consequent air, soil and surface or ground water impairment, sites would need to be carefully selected, as well as managed and monitored on a continuous basis.

Weather conditions in some parts of the State may dictate that minimal covered storage may be required to prevent flushing of some materials from containers. However, an appropriate stacking mode will eliminate all but minor "washoff" from exterior surfaces. Longer term storage, such as would be required for "problem" residuals, could be provided in areas of low rainfall and on lands of lower potential for other uses as shown on the accompanying Residuals Management System map. Through sound engineering and design, leachate production and movement may be prevented or minimized to the extent that it will not cause a water pollution problem.

### 3. Processing

In order to render containers reusable as containers or scrap and to insure safety to personnel, detoxification facilities would need to be provided. Results from pilot plant process testing at Merrill, Oregon, indicate reduction in residuals may be obtained in approximate proportion to the cleaning effort expended but may be expected to reduce residuals beyond the point at which they are dangerous to humans who might handle the containers.

Two materials handling alternatives are available for container treatment.

1. Containers may be moved from points of use to stationary, centrally-located facilities for the detoxification treatment process



of cleaning, incineration or other types of treatments to be performed; or

2. The treatment, detoxification or cleaning equipment could be mounted on a mobile unit to be transported to sizeable but widely separated container collection points to perform detoxification operations.

Because of high cost involved for treatment or other process components, few stationary installations would be built with the necessity to move containers comparatively long distances in unmodified form. The small weight per unit volume of the container and consequent low value as scrap: (\$0.02 for a 5-gallon can and \$0.10 for a 55-gallon drum with scrap at \$7.00 per ton) operates against the economics of its being moved any great distance before being incorporated into the metal, fiber or plastic scrap stream. It appears that the second alternative of moving treatment facilities to the widely separated concentrations of containers offers promise of a feasible and practical solution to the logistics of processing containers to whatever degree would be required to permit their reuse as containers or scrap. A mobile unit, fitted with equipment necessary to open and clean containers could be provided to visit impoundment sites and process containers on a regularly scheduled basis proceeding from facility to facility along the Mobile Unit Route shown on the accompanying Residuals Management System map. Hazardous materials and washwaters would be carried with the mobile unit to be deposited at a central location or locations for further beneficial use or neutralization. Safely decontaminated containers would then be classified as non-hazardous. They could then be recycled to local secondary materials dealers, be incorporated in the general scrap being salvaged at the site, or be shipped to container reconditioning units if economically feasible. A survey of reconditioners and scrap processors and dealers indicates willingness to accept properly decontaminated containers for reconditioning and reuse or for inclusion in scrap.

#### 4. Ultimate Disposal

Barrel and drum reconditioners have been encouraging users of 55-gallon drums to utilize the recycleable 18-gage drum costing about \$7.00-\$8.00 and good for approximately 10-15 "round trips" as opposed to the light, throwaway "single trip" containers costing about \$6.00.

Conservative estimates also indicate that some 5-gallon containers have a useful life of 15-20 trips. At the end of the useful life of such containers the materials of which they are composed may be recycled as scrap.

The economic value of the container as scrap is so low that financing of facilities required to render containers harmless and reusable by a charge levied by the State at the wholesale level in an amount sufficient to cover both a refundable deposit and a cleaning charge should be considered. A charge of \$2.00 on a 5-gallon container would provide a \$1.00 refundable deposit plus \$1.00 for cleaning and managing. A \$5.00 container charge would provide a \$2.50 refundable deposit and \$2.50 for cleaning and managing a 55-gallon drum. If concentrated contents are worth \$15.00 per gallon at retail (a not unlikely figure) the container cleaning charge would be a very small (about 1% or less) percentage of the value of the contents.

Container charges would not necessarily be related to value of the container but rather to reduction of its considerable negative aspects:

- a. Relieve chemical user of his disposal problem
- b. Not occupy space in landfill
- c. Not deface the landscape with unsightly litter
- d. Not endanger ground water and surface water supplies
- e. Eliminate hazardous, toxic or otherwise dangerous materials from human or animal contact
- f. Recycle a non-renewable resource
- g. Reduce cost of recycled containers by reducing cost per trip
- h. Make reconditioned containers competitive with new containers for reduction of overall costs

It can be seen that if a container of recycleable quality is used initially and is promptly returned for reconditioning by the incentives of a refundable deposit charge outlined here, a major portion of the container problem would be solved.

Recommended Action:

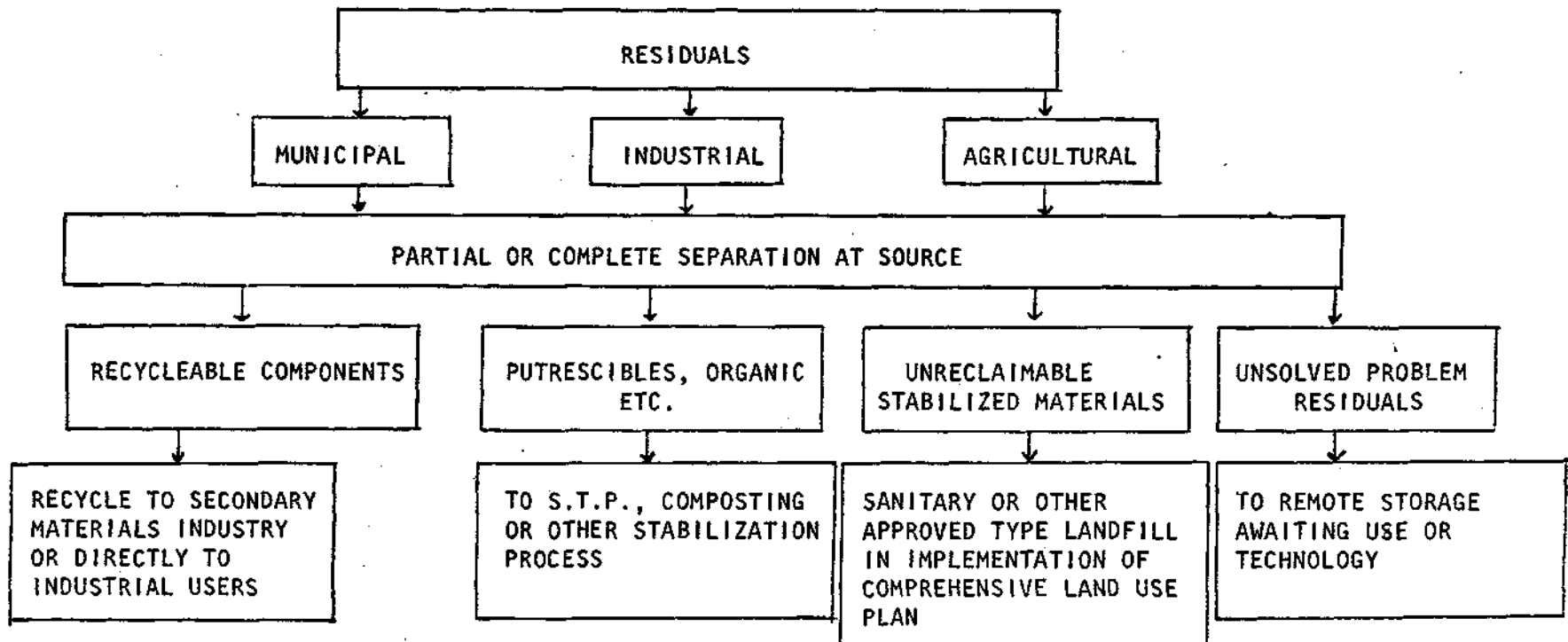
1. Consider hazardous residuals as a part of solid and liquid residuals to be dealt with on a regional, statewide and interstate basis as a closed-end system. Recognizing their special characteristics, study and designate

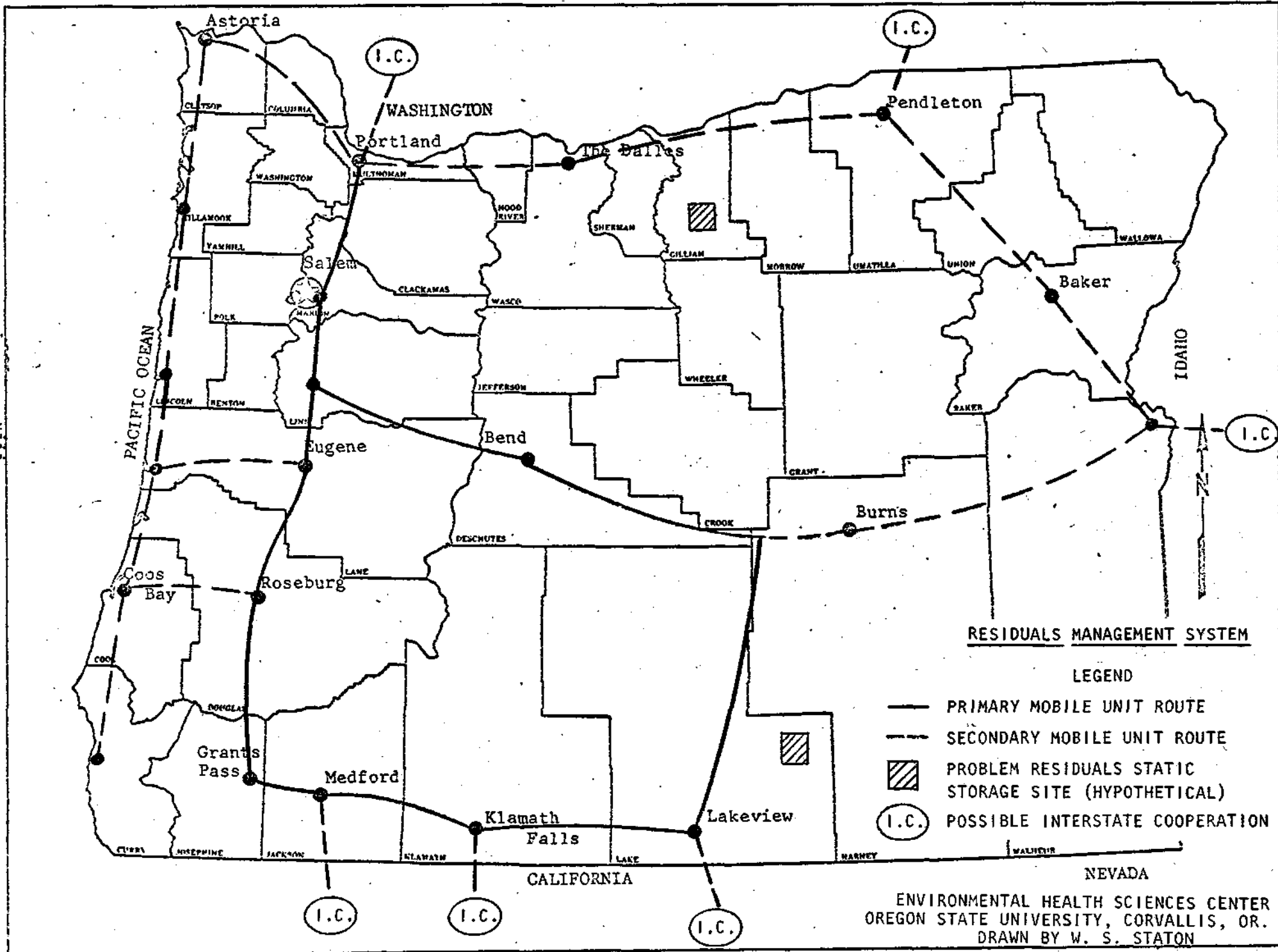
specific sites for impoundment purposes adjacent to regional solid waste facilities following special siting criteria.

2. Study logistics, feasibility and relative costs involved for mobile or static cleaning facilities for the specific sites which might be designated under Item 1 above.

3. Designate one of the sites selected under Item 1 above as a research facility which could be used in conjunction with further studies of the problems of hazardous materials storage and processing as well as the operation of the adjacent residuals management facility.

COMPREHENSIVE RESIDUALS MANAGEMENT SYSTEMS





**RESIDUALS MANAGEMENT SYSTEM**

**LEGEND**

- PRIMARY MOBILE UNIT ROUTE
- - - SECONDARY MOBILE UNIT ROUTE
- ▨ PROBLEM RESIDUALS STATIC STORAGE SITE (HYPOTHETICAL)
- (I.C.) POSSIBLE INTERSTATE COOPERATION

ENVIRONMENTAL HEALTH SCIENCES CENTER  
 OREGON STATE UNIVERSITY, CORVALLIS, OR.  
 DRAWN BY W. S. STATON

## Appendix C

## Appendix C

### ESTIMATED CAPITAL COSTS FOR A MOBILE CONTAINER CLEANING UNIT\*

Truck Tractor (Diesel)	\$ 23,000
Trailer Unit	10,000
Trailer Dolly Unit	3,000
Processing Equipment-Minimum	60,000 to 100,000**
Heating and Power Units	15,000
Conveyors and miscellaneous	<u>15,000</u>
Sub-total	166,000
Contingencies item	<u>9,000</u>
Total	\$175,000

\*Prepared with the assistance of Mr. Dean Reimann of Reimann and McKenny, Container Reconditioners, Portland, Oregon.

\*\*Including commercially manufactured items of equipment such as submerger, inside jet rinser, chainer, steamer, deheader, upender, conveyers, solution tanks, etc. at up to \$15,000 per unit.

## Appendix D



Appendix D

ESTIMATED CAPACITY AND PROCESSING COSTS OF MOBILE CONTAINER CLEANING UNIT\*  
(Based upon 55-gallon containers)

Cleaning capacity = 300 containers per day at 40 hours/week

Load Factors = 250 working days per year at 1 shift/day

Annual Production = (300) (250) = 75,000 containers/year

Capital Investment = \$175,000 (See Appendix C)

Amortization at 7 years:

	<u>Yearly costs</u>
Cost/year = $\frac{\$175,000}{7 \text{ yrs.}}$ = \$25,000/year	\$ 25,000

Labor:

Lead operator	\$20,000/year	
2 additional operators	<u>26,000/year</u>	
	\$46,000	46,000

Per diem costs away from home:

3 men (\$15/day man)(240 days/year) = \$11,000	11,000
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Transportation of unit:

10,000 miles @ \$0.50/mile = \$5,000	5,000
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Solutions and Power Generation Charges	<u>3,000</u>
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Sub-total	90,000
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Contingencies 10%	<u>9,000</u>
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Total	\$ 99,000
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Processing Cost =  $\frac{\$99,000}{75,000 \text{ containers.}}$  = \$1.32 per container

\*Prepared with the assistance of Mr. Dean Reimann of Reimann and McKenny, Container Reconditioners, Portland, Oregon.