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(2) Telephonic communications with G-3 or G-2, Detachment L.
엘. 파견대 작전처와 또는 정보처와의 유선 연락.

(3) Telephonic communications with Det L Avn, R-401 or the nearest airfield with a US Army Aviation Detachment.
엘. 파견대 항공과, 알-401 또는, 최기미 육군 비행대 주둔 비행장과의 유선 연락.

(4) AFKN news and weather broadcasts. AFKN should be monitored during the day for any changes in the earlier forecasts.
에이. 에프. 케이. 엔. 뉴스 및 기상예보. 기 예보된 기상과의 여하한 기상의 변동을 청취하기위해 24시간 계속 청취해야 한다.

c. To assure communication between KMAG representatives and application teams, FROKA will provide at least one English speaking person with each application team.
고문단 대표와 살초제 살포조 간의 의사소통을 보장하기 위해 1군은 각 작업조에 최소한 1명의 영어회화 가능한 통역을 배치한다.

Annex A (Format for Vegetation Control Operations Report) to Det L Vegetation Control SOP (U)

엘. 파견대 식물 통제 예규 (보) 부록 애이. (식물 통제 작전 보고 양식)

"LOCUST REPORT"

"메뚜기 보고"

ALPHA: (Date/time group - local time):____________________

알파: (일/시 - 현지 시간):

BRAVO: (Date/time group of defoliation operation): FROM________TO________

브라보: (살포 작전 일/시): 부터 까지

CHARLIE (Monuron):

챠아리 (머뉴론):

LINE 1: (Area of Application) FROM____________TO____________

라인. 원: (살포 지역) 부터 까지

LINE 2: (Amount of Agent Applied in Pounds):____________

라인. 투: (작용제 살포량 - 파운드 단위로):

LINE 3: (Size of Area in Hectares):____________

라인. 트리: (살포 면적 - 훽타. 단위로):

LINE 4: (Violation of Employment Restrictions):____________

라인. 포: (제한 사항에 대한 위반 사항):

DELTA (Agent ORANGE):

델타 (오랜지. 작용제):

LINE 1: (Area of Application) FROM____________TO____________

라인. 원: (살포 지역) 부터 까지

LINE 2: (Amount of Agent Applied in Gallons):____________

라인. 투: (작용제 살포량 - 개론. 단위로):

LINE 3: (Size of Area in Hectares):____________

라인. 투리: (살포 면적 - 훽타. 단위로):

LINE 4: (Violation of Employment Restrictions):____________

라인. 포: (제한 사항에 대한 위반 사항):

ECHO (Agent BLUE):

애커 (부루. 작용제):

LINE 1: (Area of Application) FROM____________TO____________

라인. 원: (살포 지역) 부터 까지

LINE 2: (Amount of Agent Applied in Gallons):____________

라인. 투: (작용제 살포량 - 가론. 단위로):

2002

Annex A (Format for Vegetation Control Operations Report) to Det L Vegetation Control SOP (U)

엘. 파견대 식물 통제 예규 (보) 부록 에이. (식물 통제 작전 보고 양식)

LINE 3: (Size of Area in Hectares):____

타인.투리: (살포 면적 - 헥타. 단위로):

LINE 4: (Violations of Employment Restrictions):_____________________________

타인.포: (제한 사항에 대한 위반 사항):

NOTE: This report format is classified CONFIDENTIAL and will not be

주 : 이 보고양식은 3급비밀이며 본 예규로부터 분리 시키거나

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복사 할수 없다. 평문 유선보고는 아래 명시된 발음상의 명칭만을

be submitted daily using phonetic line identifiers only as outlined below.

사용 일일 보고 한다.

a. Lines 1 through 4 under the phonetic identifiers will be

발음상 호칭 타인.원.에서 타인.포.까지는 아래와 같이

completed as follows:

작성 보고한다:

(1) LINE 1: This line normally consits of grid coordinates

타인.원: 여기에는 통상 살포지역을 선상으로 표시하는

identifying a linear area of application. When Priority 2 areas are being

좌표로 된다. 만일 우선 순위 2 지역이 작전중(살포중)에 있을때는

treated, this line will consist only of the CP or OP number and NO

검문소나 관측소 번호만을 보고하고 절대로 좌표를 보고해서는

coordinates will be given.

않된다.

(2) LINE 2: This line consits of the pounds or gallons of

타인.투: 여기에는 살포된 작용제의 양을 파운드.나 가론.

agent applied, and should not be confused with the total volume of diluted

단위로 보고하며, 이것을 용해한 총량과 혼동해서는 않된다. 따라서

agent. Pounds or gallons of <u>undiluted agent</u> will be reported.

용해하지 않은 작용제의 실량을 파운드.나 개론.단위로 보고해야한다.

Annex A (Format for Vegetation Control Operations Report) to Det L Vegetation Control SOP (U)
앨. 파견대 식물 통제 예규 (보) 부록 애이. (식물 통제 작전보고 양식)

(3) LINE 3: The estimated size of the treated area in hectares
라인.투리: 작용제 살포 지역의 예상 면적을 헥타.단위로
will be reported on this line. One hectare is a 100 meters square, i.e. a
보고 한다. 일 (1) 헥타.는 가로 세로 각각 100미터 평방을 말한다. 즉,
piece of land 100 meters on each side or 10,000 square meters. For purposes
사방이 각각 100미터의 땅, 또는 만 미터. 평방을 말한다. 이를 대략
of mental reference two football fields laying side-byside is approximately
암산으로 계산하려면 1 헥타.는 축구장을 두개 붙여 놓은것으로 상상하면
on hectare.
용이하다.

(4) LINE 4: The report on this line will be keyed to paragraph
라인.포: 이 라인.의 보고 요령은 본 예규 제4조에 준하며
4 of the basic SOP, additionally, the precautions and requirements listed
추가적으로 제7조에 명시된 예방책과 요망사항은 필요할때에 보고
in paragraph 7 will be reported when applicable. When reference to
한다. 그리고 각 조항의 번호 참조만으로는 설명이 불충분하다고
paragraph numbers is considered insufficient for explanation, the statement
생각할때는 "설명 추가" 란을 추가하고 안전한 통신 수단을 이용
"EXPLANATION FOLLOWS" will be added, and a complete second report will be
완전한 두번째 보고를 한다.
made by a secure communications system.

b. For example, a report involving application of 4 drums (50 lbs per
예를 들면, 머뉴론. 작용제 4드럼 (드럼당 50파운드) 살포시
drum) of Monuron in which there was a unexpected wind shift resulting in
예기치 못한 풍향의 전환으로 작용제가 비 무장지대내로 날아들어갈 우려가
possible drift of agent into the DMZ would be given as: "THIS IS MAJOR
있을때 하는 보고는 다음과 같이 한다: "보고자 도크스. 소령,
DOKES, DETACHMENT ZERO. LOCUST REPORT FOLLOWS. ALPHA - 071630 MAR 68;
제로. 파견대 소속. 메뚜기 보고임. 알파 - 68년 3월 7일 16시 30분,

Annex A (Format for Vegetation Control Operations Report) to Det L Vegetation Control SOP (U)

엘. 파견대 식물 통제 예규 (보) 부록 에이. (식물 통제 작전 보고양식)

BRAVO - FROM 070800 MAR TO 071700 MAR 68; CHARLIE LINE 1 - FROM CS076366

브라보 - 68년 3월 7일 0800시 부터 3월7일 1700시 까지, "차아리. 라인. 원. - 씨.

TO CS080300, CHARLIE LINE 2 - 200; CHARLIE LINE 3 - 10; CHARLIE LINE 4 -

애스.076366부터 씨. 애스.080300까지, 차아리. 라인. 투. - 200, 차아리. 라인. 투리. -

PARAGRAPH 4a (2) EXPLANATION FOLLOWS; END OF REPORT."

10, 차아리. 라인. 포. - 제4조 에이. (2)항 설명추가함. 보고 끝."

ANNEX K

CONFIDENTIAL

SUMMARY OF AREA COVERAGE (U)

1. (C) I US Corps (GP) Area (Includes 2nd US INF Div, 98th ROK RCT, and 5th ROKMC BDE)

Materiel	Allocation	Coverage Capability	Actual Area Coverage Reported
Monuron UROX 22	145,000 lb	580 acres	580 acres
Agent Orange	7,425 gal	2,475 acres	2,475 acres
Agent Blue	15,070 gal	5,023 acres	5,023 acres

2. (C) FROKA Area

Materiel	Allocation	Coverage Capability	Actual Area Coverage Reported
Monuron UROX 22	245,000 lb	980 acres	2,624 acres
Agent Orange	13,475 gal	4,491 acres	3,792 acres
Agent Blue	19,305 gal	6,435 acres	3,626 acres
	TOTAL	19,984 acres	18,120 acres

2006

ANNEX M: ESTIMATED COSTS OF VEGETATION CONTROL (U)

1. (C) General

a. Data presented in estimating cost of defoliation was developed from statistics sampled from V ROK Corps area where two main battle area divisions conducted defoliant operations.

b. Data presented in comparing the cost of defoliation to manual clearing was developed from statistics obtained from FROKA in manual clearing of large areas in 1967.

c. Defoliant applications were conducted in three phases as follows:

(1) Monuron application: 18 April through 25 April 1968 (7 days)

(2) Agent Orange application: 3 June through 15 June 1968 (12 days)

(3) Agent Blue application: 15 June through 9 July 1968 (25 days)

d. The quantities of defoliants and area coverage accomplished were as follows:

(1) Monuron: 43,000 lb, 172 acres

(2) Agent Orange: 1,760 gallons, 586 acres

(3) Agent Blue: 2,695 gallons, 900 acres

e. 3,345 ROKA personnel were detached to assist in defoliant application. These figures include not only personnel utilized in actual operations, but also those involved in mixing and transporting material and gainfully engaged in direct support of the operation.

2. (C) Cost Estimation:

(C)

a. Manpower:

During the 44 day period ROKA personnel were applying defoliants, a total of 1,177,440 man hours were expended. Assuming that the daily average cost of ROKA labor is $1.50 per day, then 3,345 X 44 X $1.50 = $220,770 for total cost of labor.

b. Cost of Material:

(1) Agent Orange: 3 gal/acre x $7 per gal + 50 gal diesel x .11 per gal = $26.50 per acre. 586 acres x $26 per acre = $13,771

(2) Monuron UROX 22: 250 lbs/acre x .60 per lb = $150 per acre. 172 acres x $150 per acre = $25,800

(3) Agent Blue: 3 gal/acre x $5 per gal = $15 per acre. 900 acres x $15 per acre = $13,500

(4) Total area coverage: 1,658 acres
Total cost of Material: $53,071

c. Total costs (Funded and unfunded):

(1) Cost of Manpower:
3,345 man x 44 days x $1.50 per day = $220,770

(2) Cost of Material:
13,771 + $25,800 + $13,500 = $53,071

(3) Total Cost Manpower and Material = $273,841

(4) Cost per acre: $273,841 ÷ 1,658 acres = $165.16 per acre

d. If costs are estimated only on the basic costs of material considering that manpower is available at unfunded costs, then the cost of defoliant operations can be computed as follows:

(1) Average cost of defoliants per acre:
$150 + $26.50 + $15 ÷ 3 = $63 per acre

(C)

2008

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Location	Dates	Agents	Project Description	DoD Involvement
Fort Chaffee, AR	5/16/1967-5/18/1967, 7/22/1967-7/23/1967, 8/23/1967 - 8/24/1967	basic, in-house, improved desiccants and Orange, Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Derrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI.	Yes
Pinal Mountains near Globe, AZ	1965, 1966, 1968, and 1969	2,4-D isooctyl-ester, 2,4,5-t isooctyl-ester, silvex, propyleneglycolbutylether ester, 2,4,5-T butyl ester, 2,4,5-T 2-e-h e	In 1965, the USFS began a land improvement program in the Pinal Mountains. The program called for spraying an area of chaparral with herbicides to accomplish the objectives of multiple land use.	No
Brawley, CA	1950-51	2,4-D	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.Here, irrigation water studies were done with the agent. H.F. Arle worked here.	Undetermined
Orlando, FL at Army Grove Air Force's Tactical Center	3/14/1944, 4/12/1944	ammonium thiocynate, zinc chloride, sodium nitrate, sodium arsenate, sodium fluoride	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.	Yes
Marathon, FL	3/21/1944-3/23/1944	zinc chloride, ammonium sulphamate, ammonium thiocynate	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Spraying was done here.	Yes
Near Lake George, FL	Spring 1944	zinc chloride	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Spraying here.	Yes
Orlando, FL, Cocoa, FL	1944	ammonium thiocyanate and zinc chloride	Tests were conducted in 1944 by the Army in Orlando and Cocoa areas of Florida to determine the value of ammonium thiocyanate and chloride as marking and defoliation agents.. They were conducted initially at ground level and later from aircraft.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Bushnell Army Air Field, FL	2/1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was aerial spray experiments on potted plants	Yes
Bushnell Army Air Field, Bushnell, FL	2/1945-4/1945	2,4-D and its ammonium salt	Trials, performed by C.W.S. personnel from Camp Detrick, MD tested the practicability of severely injuring or destroying crop plants sprayed from smoke tanks mounted on tactical aircraft.	Yes
Avon Air Force Base, FL	2/1951-4/1951	butyl 2,4 D	Trials were conducted at Avon Air Force Base, FL by Chemical Corps with personnel of the Air Force and Navy to determine the practical effectiveness of spraying pure anticrop agents from at low volume from aircraft. C-47 and Navy XBT2D-1 aircraft with various nozzles were used.	Yes
Englin Air Force Base, FL	11/1952-12/1952	2,4-D, 2,4,5-T: 143 and 974, respectively	Two trials: Chemical Corps- concerned with basic fundamental work, using 2,4-D, Air Force-concerned with evaluating prototype large capacity spray system for aircraft installation using 2,4,5-T, primarily. Used 3 atomizing nozzles: Bete Fog Nozzles, Whirljet Spray Nozzles, and Fogjet 1.5F50	Yes
Avon Park Air Force Base, FL	Spring 1954	butyl 2,4-D, butyl 2,4,5-T, Isopropyl 2,4-D	Series of tests were conducted at Avon Park AFB during the spring of 1954 to study the behavior of chemical anticrop aerial sprays when released from high-speed jet aircraft. The Navy F3D jet fighter was used with Aero 14A Airborne Spray Tanks to disperse the anticrop agents.	Yes
Jacksonville,FL	7/18/1962-7/21/1962	Purple, Fuel Oil, Mix	The HIDAL was used successfully on an H-34 helicopter to spray herbicidal materials. Therefore, it had not been calibrated previously. Spray tests were performed to do so. This was done under order by OSD/ARPA.	Yes
Eglin AFB, FL, C-52A test area	1962-70	Orange (1962-68), Purple (1962-68), White (1967-70), Blue (1968-70)	CPT [redacted]iscussed vegetation changes and ecological studies of the 2 square mile test area which had been sprayed with herbicides over the period 1962-70.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Apalachicola National Forest near Sophoppy, FL	5/3/1967-5/8/1967	basic desiccants and Orange/Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
Eglin AFB, FL	6/11/1968-9/12/1968	orange, Bifluid #1, Bifluid#2, Stull Bifluid	A spread factor study was performed by the Army to correlate the spherical drop sizes of both Orange and Stull Bifluid defoliants. It involved development of new techniques to determine spread factors over an extended range of drop sizes. A spinning cup drop generator was used.	Yes
2 areas in FL, 2 areas in GA, and 1 in TN	1968	bromacil, Tandex, monuron, diuron, and fenuron	In 1968, emphasis was given to soil applied herbicides for grass control. Applications were made by a jeep-mounted sprayer on small plots or by helicopter on larger plots.	Undetermined
GA and TN	1964	diquat and Tordon 101, various	In 1964, helicopter spray tests were conducted on transmission line rights-of-way by the Georgia Power Company and Tennessee Valley Authority in collaboration with Fort Detrick to evaluate effectiveness of several commercially available herbicides.	Yes
Fort Gordon, GA	7/15/1967-7/17/1967	in-house desiccants mixtures and formulations, Orange and Blue	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
Kauai Branch Station near Kapaa, Kawai, HI	6/1967, 10/1967, 2/1968, 12/1967	Blue,diquat,paraquat, Orange, PCP, Picloram, White, HCA, 2,4,5-T, Endothall	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes
State Forest area, 3500 ft.elevation on slope of Mauna Loa, near Hilo, HI	12/2/1966, 12/4/1966, 1/12/1967	Orange, M-3140, TORDON ester, 2,4-D ester, 2,4,5-T ester	The purpose of this project was to evaluate iso-octyl ester of picloram (TORDON) in mixtures with ORANGE, as a candidate defoliant agent, using ORANGE as standard. There were personnel from Fort Detrick there.	Undetermined

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Hilo, HI	12/1966	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables. There were Fort Detrick personnel there.	Yes
Kauai,HI	1967	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
Vigo Plant CWS, Terre Haute, IN	5/1945-9/1945	LN (see attached) *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was aerial trials spraying field grown plants.	Yes
Jefferson Proving Grounds, Madison, IN	Summer 1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was dropping trials.	Yes
Hays, KS, Langdon, ND	1960	stem rust of wheat	Two studies on the stem rust of wheat were conducted during 1960 to obtain data on the establishment, development, and destructiveness of artificially induced stem rust epiphytotics.	Undetermined
Fort Knox, KY	1945	various	In 1945, a special project known as Sphinx was conducted jointly by CWS and the ARML to investigate the use of chemical agents for increasing the flammability of vegetation prior to flame attack.	Yes
Area B, Camp Detrick, MD	Spring/Summer 1953	3:1 mixture 2,4-D and 2,4,5-T	Personnel at Camp Detrick tested the feasibility of using an experimental spray tower for applying a mixture of chemical anticrop agents to broad-leaf crops.	Yes
Fort Ritchie, MD	1963	Tordon, 2,4-D, Orange, diquat, endothal, and combinations of each with Tordon	Various studies were done to explore the effectiveness of different herbicides. They were all field trials. These studies were done by personnel from the US Army Biological Laboratories.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Fort Meade, MD	1963	cacodylic acid, Dowco 173, butyediol	Various studies were done to explore the effectiveness of different herbicides. They were all field trials. These studies were done by personnel from the US Army Biological Laboratories.	Yes
Camp Detrick, MD-Fields A,B, and C	1946-1947	2,4,5-T, 2,4,5-T triethanolamine, tributylphosphate, ethyl 2,4-D, butyl 2,4,5-Ttriet 2,4-D,	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots.	Yes
Camp Detrick, MD- Fields C,D, and E	1948	2,4,5-T, isopropyl phenol carbamate, LN-2426, 2,4-D	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots.	Yes
Camp Detrick, MD-Fields C,D,E	1949	triethelyne. 2,4,5-T, carbamates	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. [redacted] and [redacted] b6	Yes
Camp Detrick, MD-Fields A,B,D,E	1950	2464, butyl 2,4-D, 974, butyl 2,4,5-T, q:q 143 and 974	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were done by [redacted] and [redacted] b6	Yes
Camp Detrick, MD-Field F	1950-51	2464, carbamate, butyl 2,4-D, 143 and 974 (orange?),2,4,5-T, 2,4-D, Orange	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were done by [redacted] and [redacted] b6	Yes
Fort Detrick, MD; Fort Ritchie, MD	1956-1957	various, 577 compounds	In 1956 And 1957, defoliation and desiccation were carried out at Fort Detrick and Fort Ritchie, Maryland by the Chemical Corps and Biological Warfare Research. These were bench tests.	Yes
Poole's Island, Aberdeen Proving Ground, MD	7/14/1969-	Orange, Orange plus foam, Orange plus foam Orange, Foam	During the week of 7/14/1969, personnel from Naval Applied Science Laboratory in conjunction with personnel from Limited War Laboratory conducted a defoliation test along the shoreline.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Fort Detrick, MD	8/1961-6/1963	1410 compounds	From 8/1961 to 6/1963, compounds were spray-tested in the greenhouse to evaluate them as effective defoliants, desiccants, and herbicides.	Yes
Near Wayside, Miss., Wilcox Road, Greenville, Miss.	9/19/1967	picloram, bromacil, pyriclor, and terbacil, Orange, cacodylic acid	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Fulcher Ranch, Greenville, Mississippi	4/15/1968	picloram and bromicil	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Gulfport, Miss.	1968-1970	Orange	While discussing the mandatory disposal of Orange, it was mentioned that 15,161 drums were being stored at Gulfport, Mississippi.	Yes
Galatin Valley near Bozeman, Montana	7/3/1953, 7/6/1953, 7/14/1953	4- fluorophenoxy-acetic acid and 2 of its esters, 3:1 butyl 2,4-D and butyl 2,4,5-T	A preliminary series of field evaluations of chemical agents for attacking wheat using a miniature spraying system mounted on light aircraft were performed by USDA.	No
Fort Drum, NY	1959	Orange	The Commanding General, 1st US Army, requested that Ft Detrick assist with defoliation efforts at Ft Drum. Thirteen drums were sprayed there on 4 square miles from a helicopter spray device.	Yes
Stone Valley Experimental Forest in Huntington County and near State College in Centre County, PA	3/1969-10/1970	bromacil, diuron, tandex, fenuron, picloram	Soil- applied herbicides were studied by the U of Pa with Ft Detrick for 18 months for their effectiveness, rapidity of action, and duration of response in native stands of central PA grasses, broadleaf weeds and woody plants. These herbicides were spread or sprayed.	Undetermined
Kingston, RI	7/26/1949, 1950-51	trieth.2,4,5-T, butyl 2,4,5-T,974	The experiments were directed mainly towards the investigation of plant inhibitors applied as sprays or to the soil in the solid form to be taken up by the roots. Experiments were carried out under supervisi [redacted] f RI State College. [redacted] was also there.	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Beaumont, TX	6/1944	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, they were testing on rice crops.	No
Marinette, WI, Weslaco, TX	5/1967-1/1969	arsenic compounds, Orange, cacodylic acid, sodium cacodylate	71 new arsenic compounds were tested in primary screening against 6 plant species in greenhouse tests. Then, 5 of the most active compounds were tested in field trials against Red Maple and compared to formulations of cacodylic acid and a 50:50 blend of orange and sodium cacodylate. The Ansul Co. for DoD.	Yes
Beaumont, TX	1950-51	2,4-D	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent. Here, irrigation water studies were done with the agent. [redacted] and [redacted] worked here. b6 b6	Undetermined
Granite Peak, UT	Summer 1945	LN *phenoxy	Small plot experiments were commenced to test the effectiveness of LN agents. Various trials were done under contract with the USDA, aided by personnel at Camp Detrick. Here, it was dropping trials.	Yes
Prosser,WA	1950-51	2,4-D b6	The purpose was to determine means of accomplishing defoliation of tropical forest vegetation by application of a chemical agent.Here, irrigation water studies were done with the agent. [redacted] worked here. b6	Undetermined
southeastern part of Kompong Cham Province and Dar and Prek Clong plantations, Cambodia	6/1969	Orange	In 6/1969, the US government received notice of charge by Cambodian government that major defoliation damage to the Cambodian rubber plantation near the RVN border had occurred as a result of US defoliation activity. This was confirmed by a team of experts.	Yes
Base Gagetown near Fredericton, New Brunswick, Canada	6/20/1967-6/24/1967	basic desiccants and Orange, Blue, various	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Kumbla, South India	1945-1946	LN compounds *phenoxy	The main objective of the experiments was to determine the feasibility of accomplishing severe injury or destruction of tropical food crops by the application of growth-inhibiting (LN*) compounds in static trials. Field plantings were treated with various agents at different rates in different forms.	Yes
Korea, third Brigade, 2nd Division area	7/23/1968-7/24/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Korea,2nd and 4th Brigades, 2nd Division area	8/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Korea, third Brigade, 2nd Division area	10/3/1968	Hyvar XWS, tandex, Urox B, Urox Oil concentrate (liquids) bromacil, tandex, Urox 22 (solids)	In 1968, chemicals were sent from the Plant Sciences Lab, Ft Detrick, MD, to the Republic of Korea for the purpose of testing their effectiveness in the control of vegetation.	Yes
Laos	12/1965- 1967	Orange	In December 1965, herbicide operations were begun in Laos, with sorties being flown from Tan Son Nhut and Da Nang. The purpose was the exposure of foot trails, dirt roads and other LOCs that crossed into SVN. This network leads from NVN, through the eastern panhandle, to Combodian border.	Yes
Las Marias, Puerto Rico	2/1967-12/1967	various, including Orange	During the period of 12/1966 - 10/1967, a comprehensive short-term evaluation was conducted by personnel from Fort Detrick's Plant Science Lab in coordination with contract research on formulations by chemical industry and field tests by USDA and U of HI	Yes

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Las Mesas Cerros, Mayaguez, Puerto Rico	5/24/1968, 5/26/1968, 5/27/1968	picloram, bromacil, pyriclor	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Las Mesas and La Jagua experimental areas at Mayaguez, Puerto Rico	2/1956-6/1956	2,4,5-T, 2,4-D, pentachlorophenol, ammate, weedazol, endothal Harvestaid, Butyne -1,4-diol	During February to June, 9 chemicals were evaluated in PR on 16 genera tropical woody plants. The chemicals were applied in highly concentrated solutions with a microsprayer to the leaves.	Yes
Guanica and Joyuda, Puerto Rico	6/1956-9/1956	2,4,5-T, potassium cyanate, amiendo, F-2, 6-Ca-4, Y-F Tree and Brush Kiler, ACP M-118, Shed A-Leaf	9 chemicals were evaluated on 16 genera of tropical woody between June and September. The chemicals were sprayed to duplicate small branches, using a microsprayer.	Yes
Las Mesas and La Jagua, Mayaguez, Joyuda at Cabo Rojo, and Guanica Insular Forest at Guanica, Puerto Rico	9/1956-12/1956	6-Ca-4,Liojn Oil,2,4,5-T, B-1613, B-1638, Ammate, V-C1-186, endothal, shed-a-leaf, M-118, Y-F,esteron 2,4-D,F3,F4,F5,F6	16 compounds with defoliating properties were evaluated using 28 different tropical woody plants, each representing a separate genus. The chemicals were applied to duplicate small branches with a microsprayer and to single larger branches or whole trees with a 2-gallon knapsack sprayer.	Yes
Las Mesas and La Jagua, Mayaguez, Guanica Beach, Puerto Rico	1/1957-3/1957	V-C 3-105, V-C 1-21, V-C 1-443, F-7, TBP, Phillips 713, V-C 3-173	7 compounds were evaluated on 29 different woody plants to determine their effectiveness as defoliants, desiccants, and as killing agents. They were applied with a microsprayer to the upper leaf surfaces of duplicate small branches.	Yes
Las Mesas and La Jagua, Mayaguez, Guanica Beach, Puerto Rico	4/1957-6/1957	B-1676, B-1638, NP 1098, SD 1369, Ammate, Shed-a-leaf	7 compounds were sprayed on 25 different plants in order to evaluate their effectiveness as defoliants, desiccants, and killing agents. The compounds were applied with a microsprayer to the upper and lower leaf surfaces of duplicate small branches.	Yes
Las Mesas and La Jagua, Mayaguez, Puerto Rico	7/1957-12/1957	MgClO3, Golden Harvest Defoliant, Dow-M562, F-8, F 9, F-10, F-11, F-12	8 different spray formulations were applied to 16 different tropical trees and shrubs in order to evaluate their effectiveness as defoliants, desiccants, and killing agents.	Yes

 2017

Information from Department of Defense (DoD) on Herbicide Tests and Storage outside of Vietnam

Near Rio Grande, on the northeast coast of Puerto Rico	8/23/1967, 10/18/1967, 12/21/1967-12/26/1967	picloram, bromacil, pyriclor, and terbacil	In 1967, the Dow Chemical Company was awarded a DoD research contract. The objective was to prepare as pellets mixtures of various herbicides and to test them on varying vegetation situations for the control of a range of plant species.	Undetermined
Loquillo, Puerto Rico	4/1966, 10/1966	Orange	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
At Sea	Summer 1977	Orange	In 1977, the USAF incinerated 2.22 million gallons of Herbicide Orange at sea in an operation entitled PACER HO. Extensive industrial hygiene sampling efforts supporting the transfer operations at Gulfport, MS and Johnston Island indicated all exposures were inconsequential (2-3 orders of magnitude below the TLVs for 2,4-D and 2,4,5-T).	Yes, Gulfport No, JI
Thailand	1964-1965	Purple, Orange, Others	Sponsored by ARPA; ARPA Order 423, Between the mentioned dates, there was a large-scale test program to determine effectiveness of mentioned agents in defoliation of upland forest or jungle vegetation representative of SEA.	Yes
Thailand	1964-65	Orange, Blue	Field tests of defoliants were designed to evaluate such variables as rates, volume of application, season, and vegetation. Data from aerial application tests at several CONUS and OCONUS locations are provided in tables.	Yes
Replacement raining Center of the Royal Thai Army near Pranburi, Thailand	1964 and 1965	Orange, Purple	An extensive series of tests were conducted by Fort Detrick during 1964 and 1965 in collaboration with the Military Research and Development Center of Thailand. The objective was to perform onsite evaluation of phytotoxic chemicals on vegetation in SE Asia.	Yes

2018

COPY # 2 OF 2 5756

5756

[redacted] b6

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[illegible] -5555--[illegible].

[illegible] VIETNAM

[illegible] VIETNAM

[redacted]

FSA 68BACC-01123

1. [illegible] BE RELEASED TO U.S. ARMY [illegible]

[illegible] 55 GAL DRUMS

[illegible] 350 EA 55 GAL DRUMS

[illegible] SUPPORT OF ARMY CINCOREP, TAB J. (PROJECT [illegible])

[illegible] TRANSPORTATION FOR PICK UP AT SAIGON FOR [illegible] KOREA NOT LATER THAN 20 MARCH 1968.

[illegible] TRANSPORTATION IS COL [redacted] C. O., [illegible] AGENCY, TACV, SAIGON [illegible] b6

[illegible] FOR TRANSFER TO ARMY IS 21-2020 03-5010 [illegible] REQUEST SAAA [illegible] REIMBURSEMENT TO [illegible] (GP-4)

Declassified
27 May 74

[redacted] b6

68BACC-01123

TRANS:
POE - POE
$10,373 per DR

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2019

SECURITY CLASSIFICATION: UNCLASSIFIED ~~SECRET~~

TYPE MSG: BOOK | MULTI x | SINGLE

PRECEDENCE: ACTION ~~ROUTINE~~ / INFO

RESERVED FOR COMMUNICATION CENTER 99495

Declassified 2 May 74

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[redacted]

DTG 27/2145Z FEB 68

FROM: SAAMA KELLY AFB TEX

TO: COMUSMACV COC7 AFG MSS TMA RVN

INFO: AFLC/MCSFF

CSAF/AFSSSEE

CG USARV LONG BINH VIETNAM

CG 1ST LOG CMD TAN SON NHUT VIETNAM

FSA

UNCLASSIFIED

~~SECRET~~ SAO

SPECIAL INSTRUCTIONS: Down-graded to Confidential 26 Feb 71

[redacted]

1. a. Reference CSAF/AFSSSEE 170112Z Feb 68.

b. Request 610 drums of Herbicide Blue and 350 drums Herbicide Orange, cited in reference a, be released to U S Army from Saigon RVN stocks. Army contact for transportation is Col Roscoe Goodell C. O. Traffic Management Agency, MACV, Saigon RVN.

2. Request this headquarters and info addressees be notified date product is released to the Army. GP-4.

O
OO [redacted]
OT [redacted]
OR [redacted] 27 Feb 68
OM [redacted]
OS [redacted]
OP
[redacted]

DATE 27 | TIME 1115
MONTH FEB | YEAR 1968
PAGE NO | NO. OF PAGES

DRAFTER — TYPED NAME AND TITLE: Mr. [redacted] IM Specialist [redacted] | PHONE 6119

RELEASER — SIGNATURE: signed

TYPED (or stamped) NAME AND TITLE: Acting Deputy Director of AF Aerospace Fuels

SECURITY CLASSIFICATION: ~~SECRET~~ UNCLASSIFIED

REGRADING INSTRUCTIONS: SAO-68-036

DD FORM 173 NOV 63 REPLACES EDITION OF 1 MAY 55 WHICH MAY BE USED

2020

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COPY # 1 OF 2

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A/am

12 MAR 68 07 06

68BACC-01493

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FM COMUSMACV
TO [illegible]/CG USAEIGHT SEOUL
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INFO [illegible]/DA
[illegible]/CSAF
[illegible]/SAAMA KELLY AFB TEXAS
[illegible]/CINCUSARPAC
[illegible]/CINCPAC
[illegible]/CG USARC
[illegible]/CO RED RIVER ARMY DEPOT TEXARKANA
[illegible]/CG USARV LBN RVN
[illegible]/CG 1ST LOG COMD LBN RVN
[illegible]/AFLC
I
[illegible] 07069 FROM MACT-A-CS AFLC FOR [illegible]
SUBJ: PROJECT [illegible] (U)
REF: A. CSAF DTG 170112Z FEB 68 (S) (NOTAL)
B. SAAMA KELLY AFB TEX DTG 272145Z FEB 68 (S) (NOTAL)
C. DA [illegible] DTG 021752Z MAR 68 (S) (NOTAL)

FSA

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Repro [illegible]

Downgraded to Confidential 12 Mar 71 (al)

Declassified 27 May [illegible]
[redacted]
66

PAGE 2 [illegible] 16600 S E C R E T
1. (S) REF A DIRECTED TRANSFER OF FOLLOWING HERBICIDES TO U.S. ARMY FROM SAIGON RVN STOCKS AND SUBSEQUENT MOVEMENT TO KOREA [illegible] [illegible] 20 MARCH 1968:
A. [illegible] DRUMS OF HERBICIDE, BLUE.
B. [illegible] DRUMS OF HERBICIDE, ORANGE.
2. (U) REF B REQUESTED DATE HERBICIDE RELEASED TO U.S. ARMY [illegible] REQUESTED LIFT INFORMATION ON SAME.
3. (U) HERBICIDE SPECIFIED ABOVE LOADED ABOARD SS [illegible] VICTORY AT SAIGON ON 9 MARCH 1968. TOTAL OF 960 DRUMS [illegible] [illegible] 5, UPPER TWEEN DECK.
4. (U) SS [illegible] VICTORY, VOYAGE NUMBER [illegible], ETD [illegible] 14 MARCH AND ETA INCHON, KOREA 20 MARCH 1968.
[illegible]

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ZNY EEEEE
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R 291019Z MAR 68
FM COMUSMACV
TO RUAMWC/CG USAEIGHT SEOUL
INFO RUAMAC/COMUSKOREA
RUEPDA/DA
RUEFHQA/CSAF
RUWTOUA/SAAMA KELLY AFB TEXAS
RUMMNOA/CINCUSARPAC
RUHHHQA/CINCPAC
RUCLPGA/CG USAMC
RUWTLUA/CG RED RIVER ARMY DEPOT TEXARKANA
ZEN/CGUSARV LBN RVN
ZEN/CG 1ST LOG COMD LBN RVN
RUEAPIA/AFLC MCSFF

FSA

UNCLAS E F T O 08861
SUBJ: PROJECT OBP
REF: COMUSMACV CITE 07267 DTG 140606Z MAR 68 (S) 68 RACC-0152T-0
REQUEST FURNISH INFO PARA TWO (2) REF MSG.
BT

[redacted] b6
Please run down msg cited and let me know what's going on — 929

ACTION To: OR ok
COPY To: O
SUSPENSE:
From: O [redacted]
AUTHORITY: [redacted] b6

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* UNCLASSIFIED E F T O *
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THIS MESSAGE IS SUSPECTED DUPLICATE. DETERMINE IF PREVIOUSLY RECEIVED PRIOR TO TAKING ACTION.

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ACTION OR
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14 MAR 58 1909

14 MAR 58 1933
BACC

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FSA

Downgraded to Conf 12 Mar 71
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[illegible] ... -ROUTDUA.
[illegible]
[illegible] ARMY DEPOT TEXARKANA
[illegible]
[illegible] (S)
[illegible] DEPARTED
[illegible] WITH PERSICION

[illegible] ADVISE ATA SS JOPLIN
[illegible]

Declassified 2 May 76
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~~CONFIDENTIAL~~

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2023

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EE RUAMWC 1674 1011345
ZNR UUUUU ZFD RUWTDSA
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FM CGUSAEIGHT
TO RUMSMA/COMUSMACV
INFO ZEN/COMUSKOREA
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RUWTWIA/SAMMA KELLY AFB TEXAS
RUHHRSA/CINCUSARPAC
RUHHHGA/CINCPAC
RUECDNA/CGUSAMC
RUWTLCA/CG RED RIVER ARMY DEPOT TEXAS
RUMSVA/CGUSARV LBN RVN
RUMSLC/CG 1ST LOG COMD LBN RVN
RUEDFIA/AFLC MCSFE

THIS MESSAGE IS SUSPECTED DUPLICATE. DETERMINE IF PREVIOUSLY RECEIVED PRIOR TO TAKING ACTION.

BT
5
UNCLAS EA 67250 GL-SMZ
SUBJECT: PROJECT ELF
R. Jeyonal O CCN 6236
1. REFERENCES:
A. COMUSMACV MSG 07267, DTG 140006Z MARCH 68.
B. COMUSMACV MSG 08860, DTG 291019Z MARCH 68.

PAGE 2 RUAMWC 1674 UNCLAS
2. INFORMATION REQUESTED PARA 2 REF ALPHA IS AS FOLLOWS:
ATA OF SS JOPLIN VICTORY WAS 1300 HRS 20 MARCH 1968 AND
POD SS JOPLIN VICTORY WAS INCHON
BT

FSA

106904

2024

Item ID Number 03787 ☐ **Not Scanned**

Author

Corporate Author

Report/Article Title Reports, Correspondence, Notes: Project Pacer HO, 1972-1982

Journal/Book Title

Year 0000

Month/Day

Color ☐

Number of Images 485

Descripton Notes Items were filed together in a container labeled, "Disposition of Herbicide Orange Project Pacer HO Reports Correspondence Meeting Briefs." Includes photographs of storage drums (not scanned) and the following reports: Aerial Measurements of Hydrogen Chloride of Incinerator Ship Vulcanus (December 1975); Land Based Environmental Monitoring at Johnston Island - Disposal of Herbicide Orange (September 1978); and Proposed Two-Step Procedure for Cleaning the Waste Tanks of the M/T Vulcanus Following Incineration of Orange Herbicide.

2025

AGENDA
SCIENTIFIC ADVISORY BOARD
REVIEW OF HERBICIDE ORANGE
12-13 DECEMBER 1972

12 DECEMBER 1972

0830-0900	ADMINISTRATIVE MATTERS, INTRODUCTION, GROUND RULES, ETC.	[redacted], M.D., DIRECTOR, BOCKUS RESEARCH INSTITUTE, UNIVERSITY OF PENNSYLVANIA b6 LT [redacted] b6 USAF SCIENTIFIC ADVISORY BOARD
0900-0930	INTRODUCTION TO ORANGE BACKGROUND SUMMARY OF ALTERNATIVES	[redacted] b6, AFLC/DS
0930-0950	NATIONAL ENVIRONMENTAL POLICY ACT AND ORANGE DISPOSAL	MAJOR [redacted] b6 HQ USAF/PREV
0950-1020	HERBICIDE ORANGE (INCLUDING DIOXIN) CHEMISTRY TOXICOLOGY HERBICIDAL ACTION	[redacted] b6 .D. (COLONEL, USA[redacted]AF ENVIRONMENTAL HEALTH LAB/CC, KELLY AFB
1020-1035	BREAK	
1035-1130	DISPOSAL BY USE BRAZIL FOREST SERVICE DEPARTMENT OF HIGHWAYS USAF RETURN TO ORIGINAL MANUFACTURERS	MR. [redacted] b6 SAF/IL MAJOR [redacted] b6
1130-1300	LUNCH	
1300-1350	DISPOSAL BY INCINERATION CONUS COMMERCIAL PLANT JOHNSTON ISLAND PLANT SUE BURNER	MR. [redacted] b6 SAAMA/SF

2026

1405-1455	DISPOSAL BY CHEMICAL CONVERSION FRACTIONATION CARBON TETRACHLORIDE	DR. [redacted], b6 ENVIRONMENTAL PROTECTION AGENCY, SOUTHEASTERN RESEARCH LABORATORY, ATHENS, GEORGIA
1455-1510	BREAK	
1510-1625	DISPOSAL BY BIODEGRADATION SOIL BIODEGRADATION MICROBIAL DEGRADATION SLUDGE BURIAL	CAPTAIN [redacted] b6 USAFA/DEPARTMENT OF LIFE AND BEHAVIORAL SCIENCES
1625-1640	DRUM DISPOSAL	MR. [redacted] b6 SAAMA/SF
1640-1700	SUMMARY/MATRIX REVIEW RECOMMENDATIONS	MR. [redacted] FLC/DS b6

2027

SECRETARY OF THE AIR FORCE

DR. [redacted] b6

SPECIAL ASSISTANT TO THE SECRETARY OF THE US AIR FORCE FOR ENVIRONMENTAL QUALITY

[redacted] b6

ASAF/IL, DEPUTY FOR SUPPLY & MAINTENANCE

[redacted] b6

ASAF/IL, ASSISTANT DEPUTY FOR SUPPLY & MAINTENANCE

HQ US AIR FORCE

H. E. GOLDSWORTHY, b6 LT GENERAL, USAF
HQ USAF/DEPUTY CHIEF OF STAFF, SYSTEMS & LOGISTICS

W. W. SNAVELY, b6 MAJOR GENERAL, USAF
ASSISTANT DEPUTY CHIEF OF STAFF, SYSTEMS & LOGISTICS

JONAS L. BLANK, b6 MAJOR GENERAL, USAF
DIRECTOR OF SUPPLY & SERVICES/DCS/SL

R. M. CLINKSCALE, b6 COLONEL, USAF
CHIEF, GENERAL SUPPORT & SERVICES DIVISION
DIRECTORATE OF SUPPLY & SERVICES, DCS/SL

[redacted] b6 LT COLONEL, USAF
CHIEF, FUELS BRANCH
GENERAL SUPPORT & SERVICES DIVISION
DIRECTORATE OF SUPPLY & SERVICES, DCS/SL

2029

HQ US AIR FORCE (CONT'D)

MR. [redacted] b6
FUELS BRANCH, GENERAL SUPPORT & SERVICES DIVISION
DIRECTORATE OF SUPPLY & SERVICES, DCS/SL

[redacted] b6 MAJOR, USAF
ENVIRONMENTAL PROTECTION GROUP
DIRECTORATE OF CIVIL ENGINEERING
DEPUTY CHIEF, OF STAFF, PROGRAMS & RESOURCES

[redacted] b6 MAJOR, USAF
DIRECTORATE OF PROFESSIONAL SERVICES
SURGEON GENERAL

HQ AIR FORCE LOGISTICS COMMAND

MR. [redacted]
ASSISTANT DEPUTY CHIEF OF STAFF/
DISTRIBUTION

[redacted]T COLONEL, USAF
DIRECTORATE OF PROFESSIONAL SERVICES
OFFICE OF THE SURGEON

MR. [redacted]
SPECIALIZED TRAFFIC BRANCH, TRAFFIC
DIVISION
DIRECTORATE OF TRANSPORTATION, DCS/
DISTRIBUTION

HQ US AIR FORCE ACADEMY

A. L. YOUNG, CAPTAIN, USAF
DEPARTMENT OF LIFE & BEHAVIORIAL
SCIENCES

HQ SAN ANTONIO AIR MATERIEL AREA/AFLC

R. R. MOULTON, b6 COLONEL, USAF
DIRECTOR OF AEROSPACE FUELS

MR. [redacted] b6
PRODUCT ENGINEERING BRANCH, QUALITY DIVISION
DIRECTORATE OF AEROSPACE FUELS

2032

US AIR FORCE ENVIRONMENTAL
HEALTH LABORATORY, KELLY AIR
FORCE BASE, TEXAS

WALTER W. MELVIN, b6 M.D. (COLONEL, USAF)
COMMANDER

MR. [redacted] b6
SUPERVISORY CHEMIST

US ENVIRONMENTAL PROTECTION
AGENCY

MR. [redacted] b6
INDUSTRIAL POLLUTION CONTROL
OFFICE OF RESEARCH & MONITORING
WASHINGTON, D.C.

DR. [redacted] b6
SOUTHEAST ENVIRONMENTAL RESEARCH
LABORATORY
ATHENS, GEORGIA

USE

	FEASIBILITY	CONFIDENCE LEVEL/RISK	EST. COST	START - COMPLETION	ENVIRONMENTAL AFFECT	BIO POLITICS	DRUM DISPOSITION	EST. USAF TRANSPORTATION COSTS	EST. USAF STORAGE COSTS
USAF	FAIR	SMALL		90 DAYS INDEF.	MINOR BUT BENEF.	HIGH INTEREST	USER	NORMAL	
REGISTER FOR PUBLIC USE	FAIR	SMALL		60 DAYS INDEF.	MINOR BUT BENEF.	HIGH INTEREST	USER	NORMAL	
FEDERAL LAND	FAIR	SMALL		90 DAYS INDEF.	MINOR BUT BENEF.	HIGH INTEREST	USER	NORMAL	
BRAZIL	GOOD	SMALL		90 DAYS 2 YEARS	MINOR BUT BENEF.	SOME INTEREST	USER	$1,075,006	
RETURN TO MANUFACTURERS	NO INTEREST EXPRESSED			30 DAYS		NONE	USER	$750,000	

2034

BIODEGRADATION

	FEASIBILITY	CONFIDENCE LEVEL (RISK)	EST. COST	START - COMPLETE	ENVIRONMENTAL AFFECTS	BIO POLITICS	DRUM DISPOSITION	USAF TRANSPORTATION COSTS	USAF STORAGE COSTS
SOIL	GOOD	SMALL	$300,000	60 DAYS / 180 DAYS	MINOR	HIGH INTEREST	CLEAN & SALVAGE / CRUSH & BURY	TO WENDOVER RANGE $1029393	
MICROBIAL	POOR	SMALL	$500,000 TO $1000000	90 DAYS / 1½ YEARS	MINOR	ASSUME HIGH INTEREST	SAME AS ABOVE		
SLUDGE	FAIR	SOME	$200,000 TO $800,000	90 DAYS / 5-10 YEARS	MINOR		INCLUDES DISPOSAL		

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INCINERATION

	FEASIBILITY	CONFIDENCE LEVEL (RISK)	COST	START - COMPLETION	ENVIRONMENTAL AFFECTS	POLITICS	DRUM DISPOSITION	USAF TRANSPORTATION COSTS	USAF STORAGE COSTS
CONUS	GOOD	SOME MINOR	$1,000,000	180 DAYS / 1½ YEARS	MINOR	HIGH INTEREST	CLEAN, SCRAP, OR REUSE	$643,000 HOUSTON TEX	
JOHNSTON ISLAND	POOR	SOME MINOR	$6,000,000	1 YEAR / 2½ YEARS	MINOR	LOW INTEREST	SAME	$300,000	$200,000 TO $400,000
SUE BURNER	GOOD	LOW			UNSURE	HIGH INTEREST	SAME	GENERAL AVERAGE $643,000	

CHEMICAL CONVERSION

	FEASIBILITY	CONFIDENCE LEVEL/RISK	EST. COST	START - COMPLETION	ENVIRONMENTAL AFFECT	BIO POLITICS	DRUM DISPOSITION	EST. USAF TRANSPORTATION COSTS	EST. USAF STORAGE COSTS
FRACTIONATION	DEMONSTRATED AS VOLUME REDUCTION OR AS A PRETREAT STEP ONLY	GOOD AS A PRETREAT	UNKNOWN	8 MONTHS TO INDEFINITE	SIGNIFICANT AS TO NEED TO DISPOSE OF 2,4,5-T DIOXIN CUT BOTTOMS	SIGNIFICANT	CLEAN SCRAP SALVAGE REUSE	$800,000	
CONVERSION TO CARBON TETRACHLORIDE	GOOD WITH OR WITHOUT FRACTIONATION PRETREAT	LITTLE RISK	4 TO 6 MILLION CAPITAL WITH PRODUCT CREDIT POTENTIAL OF 2 TO 6 MILLION	$1\frac{1}{2}$ YEARS TO 4 YEARS	NONE TO MINOR	MINOR	CLEAN SCRAP SALVAGE REUSE	$650,000 HOUSTON TEX	SOME POSSIBLE

2037

OVERALL COMPOSITE

	FEASIBILITY	CONFIDENCE LEVEL (RISK)	EST. COST	START - COMPLETION	ENVIRONMENTAL AFFECTS	BIO POLITICS	DRUM DISPOSITION	USAF TRANSPORTATION COST	USAF STORAGE COST
USE	FAIR	SOME	UNDER $800,000	30 DAYS TO 2 YEARS	SOME GOOD	HIGH INTEREST	BY USER	OFFSHORE $1075006	
BIODEGRADATION	GOOD	SMALL	$300,000 TO $1000000	90 DAYS TO 5-10 YEARS	MINOR	HIGH INTEREST	CLEAN, BURY, SCRAP, REUSE	WENDOVER $1,029,393	
INCINERATION	GOOD	SOME MINOR	$1000000 TO $6000000	1½ YEARS CONUS 2½ YEARS J.I.	MINOR	HIGH INTEREST	CLEAN, SCRAP, REUSE	$643,000	
CHEMICAL CONVERSION	GOOD	LITTLE RISK	$3000000 TO $5000000	1½ YEARS 4 YEARS	NONE TO MINOR	MINOR	CLEAN, SCRAP, REUSE	$650,000	

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USAF SCIENTIFIC ADVISORY BOARD
AD HOC COMMITTEE ON THE
DISPOSAL OF HERBICIDE ORANGE
12-13 December 1972

ATTENDANCE

Committee Members

[redacted] M.D. b6	Bockus Research Institute Univ of Pennsylvania
Dr. [redacted] b6	Oak Ridge National Lab
Dr. [redacted] b6	Univ of Minnesota
Dr. [redacted] b6	Dept of Agriculture
Dr. [redacted] b6	Duke University
Dr. [redacted] b6	Univ of Maryland
Mr. [redacted] b6	EPA Office of Solid Waste Management Programs
Dr. [redacted] b6	Univ of Washington
Dr. [redacted] b6	Univ of Iowa
Dr. [redacted] b6	General Electric Co
Prof [redacted] b6	Univ of Pennsylvania
Brig Gen [redacted] (GOP)	PACAF
Lt Col [redacted] b6	SAB Secretariat

Briefers/Observers

Lt Gen H. E. Goldsworthy b6	DCS/Systems & Logistics
Maj Gen Jonas L. Blank b6	Dir of Supply & Services AF/LGS

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Mr. [redacted] b6	Dep for Supply & Maint SAF/I&L
Dr. [redacted] b6	Asst for Environ. Quality SAF/I&L
Mr. [redacted] b6	Asst Dep for Supply & Maint SAF/I&L
Lt [redacted] b6	AF/LGSKE
Mr. [redacted] b6	AF/LGSKE
Maj [redacted] b6	AF/PREV
Maj [redacted] b6	AF/SGPP
Mr. [redacted] b6	Asst Dep Ch of Staff, Distribution (HQ AFLC)
Mr. [redacted] b6	HQ AFLC (DST)
Lt Col [redacted] b6	HQ AFLC (SGP)
Col Ralph Moulton b6	Dir Aerospace Fuels Hq San Antonio Materiel Area
Mr. [redacted] b6	Hq San Antonio Air Materiel Area (SFQT)
Col Walter W. Melvin b6	Commander, USAF Environ Health Lab
Mr. [redacted] b6	Staff Engineer Industrial Pollution Control, Office of Resch & Monitoring EPA
Dr. [redacted] b6	Southeastern Resch Lab EPA

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Capt [redacted] b6	Dept of Life & Behavioral Sciences, USAFA
Lt [redacted] b6	Hill AFB, Civil Engineering
Col Daniel W. Cheatham, Jr. b6	SAB Secretariat

USAF SCIENTIFIC ADVISORY BOARD
AD HOC COMMITTEE ON THE
DISPOSAL OF HERBICIDE ORANGE
The Pentagon, Room 5C1034
14 March 1974

AGENDA

0900 Administrative Details

0930 Introduction and Brief Overview of the Alternatives

-- What we propose--What we reject

0945 Brief Discussion of Weak Solutions that were Rejected and Why

1000 Expanded Discussion of Stronger Solutions that were Rejected

-- CONUS incineration--Biodegradation--Chloronolysis--Use

1130 Lunch

1230 Discussion of Proposed Solution(s)

-- Technique:

a. Shipboard Incineration

b. Johnston Island Incineration

-- Supporting Data:

a. Test Data

b. Environmental impact

c. Economics

26 February 1974

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1430	Summary
	-- Technical Feasibility
	-- Cost
	-- Environmental Impact
	-- Time
	-- Political Ramifications
1445	Discussion
1515	Executive Session
1700	Adjourn

SCIENTIFIC ADVISORY BOARD AGENDA

HERBICIDE ORANGE
14 MARCH 1974

0900-0930	Administrative Detail	Mr. [redacted] b6
0930-0945	Introduction to the Problem and Brief Overview of Alternatives	Mr. [redacted] b6
0945-1000	Alternatives Rejected Upon Minimal Evaluation	Col W.W. Melvin b6
1000-1130	Alternatives Rejected Upon Extensive Study Incineration in CONUS Biodegradation Use Chlorinolysis	Maj [redacted] b6 Capt [redacted] b6
1130-1230	Lunch	
1230-1300	Review of "Orange" Incineration Studies	Maj C. Williams
1300-1430	Incineration Options/Potential for Environmental Impact/Probable Impact Incineration at Sea Incineration at Johnston Island	Maj [redacted] b6 Capt [redacted] b6 Capt [redacted] b6
1430-1445	Summary Technical Feasibility Cost (Millions) Environmental Impact Duration (Time in months) Political Ramifications	Mr. [redacted] b6
1445-1515	Discussion	
1515-1700	Executive Session	
1700	Adjournment	

FEDERAL AGENCY BRIEFING

HERBICIDE ORANGE
15 MARCH 1974

0900-0910	General Introduction	Dr. [redacted] b6
0910-0930	Introduction to the Problem and Brief Overview of Alternatives	Mr. [redacted] b6
0930-0945	Alternatives Rejected Upon Minimal Evaluation	Col W.W. Melvin b6
0945-1015	Alternatives Rejected Upon Executive Study Incineration in CONUS Biodegradation Use Chlorinolysis	Maj [redacted] b6 Capt [redacted] b6
1015-1030	Break	
1030-1045	Review of "Orange" Incineration Studies	Maj [redacted]
1045-1130	Incineration Options/Potential for Environmental Impact/Probable Impact Incineration at Sea Incineration at Johnston Island	Maj [redacted] b6 Capt [redacted] b6 Capt [redacted] b6
1130-1200	Discussion	

2045

DEPARTMENT OF THE AIR FORCE
DEPARTMENT OF LIFE AND BEHAVIORAL SCIENCES
USAF ACADEMY, COLORADO 80840

14 March 1974

FIELD TESTS OF HERBICIDE ORANGE FOR BRUSHFIELD REHABILITATION AND CONIFER RELEASE

SUMMARY

A total of 358 acres of test plots in western Oregon were treated with Herbicide Orange on 10-11 May 1973. The plots on which Orange was applied were selected amoung sites available on the ownership of three industrial cooperators (Publishers Paper Company, Starker Forests, and Roseburg Lumber Company), all of whom had on-going chemical brush control programs. The cooperators provided the cost of application by helicopter and secured the application permits from the Oregon State Forestry Department. Tall brush plots were treated with 4.3 pounds per acre acid equivalent (one-half gallon Orange in 15 total gallons per acre), while low brush plots received 2.1 pounds per acre acid equivalent (one quart per acre in ten gallons total spray). Field observations and evaluations of the effectiveness of Orange were made by Oregon State University School of Forestry personnel.

Brush control with Herbicide Orange was excellent, with selectivity for conifers outstanding. On the basis of four months of observations, Orange was fully as effective for selective control of various woody brush and hardwood species in western Oregon as commercial brushkiller.

The test plots were treated under circumstances that would have shown up drift hazard to a maximum extent. That is, plots were applied at the very end of the dormant season, with maximum temperatures prevailing, and also a small amount of air movement. A small amount of leaf deformation outside of each plot was, in fact, observed. In no case, however, was this observable more than 200 yards beyond the boundary, which is no different from the pattern expected with commercial brushkillers of low-volatile formulation. It would appear that the activity outside the boundaries may have been attributable to fine droplet movement, a factor which is independent of volatility. Moreover, the degree of deformation was limited to minor curling of sensitive species. The plot boundaries were generally clearly defined and not characterized by irregularities typical of mass vapor movements. In summary, volatility is clearly a manageable problem, and need not restrict the use of Orange for dormant spraying for conifer release. In western Oregon Orange should <u>not</u> be sprayed when temperatures are above 60°F at the time of application, nor later than 15 May so as to insure avoidance of sensitive crops.

FOR OFFICIAL USE ONLY.

Project F882 A.

Title:

Field Tests of Herbicide Orange for Brushfield Rehabilitation and Conifer Release

Objectives:

1) To evaluate the impact of a high-volatile brushkiller on brush-dominated forest ecosystems.

2) To determine whether Orange can be used effectively in the re-establishment of conifers in western Oregon brushfields.

3) To evaluate the difficulties of using a technical grade ester without adjuvants for field use.

4) To obtain a crude estimate of whether drift problems from the high-volati butyl/ester are manageable.

Personnel:

[redacted], Project Leader
b6

Cooperators:

b6 b6 b6

Capt. [redacted], U.S. Air Force; [redacted] and [redacted] Starker Forests; [redacted] Publishers Paper Co. and [redacted], b6 of Roseburg Lumber Co.

Background:

Recent forest survey data indicate that there are some 4.7 million acres of commercial forest land in western Oregon and Washington that are either non-stocked or poorly stocked with conifers. Virtually all such land is occupied by vegetation whose presence precludes reestablishment of conifers. Much of the area is in the highest productivity class for growth of forest products (Gratkowsk et al., 1973). The productive potential of this area exceeds present levels of timber exports to Japan.

Concepts of selective brush control have been developed for reforestation with the aid of commercial formulations of 2,4-D and 2,4,5-T. There are presently some 100,000 acres being treated each year with various formulations of these materials, all as the low-volatile esters. Success has been good, especial in release operations, and on the slower-growing brush species (Lauterbach, 196 Theisen, 1967).

There are three general approaches to the use of phenoxy brushkillers in reforestation, with the differences tied to season of application. Dormant sprays

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Background (cont.)

are applied in spring, between the onset of plant growth activity in early spring and conifer bud bursting. Dormant sprays are applied in pure oil, with emphasis on penetration of bark of species not controlled effectively by foliage spraying. Dormant sprays are effective in reaching understory species, but are limited in effectiveness on species such as bigleaf maple, which are highly resistant at that time (Newton, 1961). Dormant sprays have maximum selectivity in favor of Douglas-fir, but are damaging, in general, to elongating pines (Newton, 1963). Because esters are compatible with oil, dormant sprays require no formulation adjuvants. This type of treatment is widely applicable in Oregon.

Summer and fall foliage sprays are used where brush species are typically resistant to dormant treatment and where costs are lower for comparable effect. Summer treatments are the least selective in Douglas-fir, but tend to have the greatest systemic activity on sensitive species. They are low in cost because of the use of water as a carrier, but they are relatively high in public relations hazard because of crop sensitivity at that time, and because of brown-out. They also occur when summer flows are low in streams and contamination problems are apt to be most severe. If drift is likely to be a problem, it will be least manageable in the summer season. Coastal fogs often prohibit their use in the Coast Ranges.

Fall foliage sprays are used primarily where selectivity is desired on pines. Shrubs tend to be somewhat less sensitive in fall than at other times, but the sensitivity of pines before midsummer precludes the use of phenoxy herbicides selectively. There is thus incentive for investigating dormant season applications.

The Air Force is storing some 2.3 million gallons of Herbicide Orange. This formulation contains 8.6 pounds per gallon of 2,4-D and 2,4,5-T, as the butyl esters. It contains no other formulation adjuvants. The Air Force has been charged with responsibility for getting rid of the chemical by an environmentally acceptable means.

Orange varies in its dioxin content from less than 0.05 parts dioxin per million parts 2,4,5-T to 14 ppm. The Air Force is able to identify a substantial quantity of low-dioxin material. Dr. [redacted] of the Air Force, has indicated that some 575,000 gallons are below the EPA dioxin standard for production of new 2,4,5-T, and can be readily identified by lot. Since the Orange appears to meet dioxin standards, and to be unconfounded by formulation additives, there appear to be no undue hazards in attempting to evaluate its use for dormant brush control in reforestation. The existence of large areas in a poor condition of reforestation, and the continuation of the trend toward an increase in brush domination, are the incentives for making every possible tool available for reforestation, consistent with public safety. These tests are directed toward evaluating Orange as a reforestation aid, with reference to solving a public problem that extends to both forestry and military affairs.

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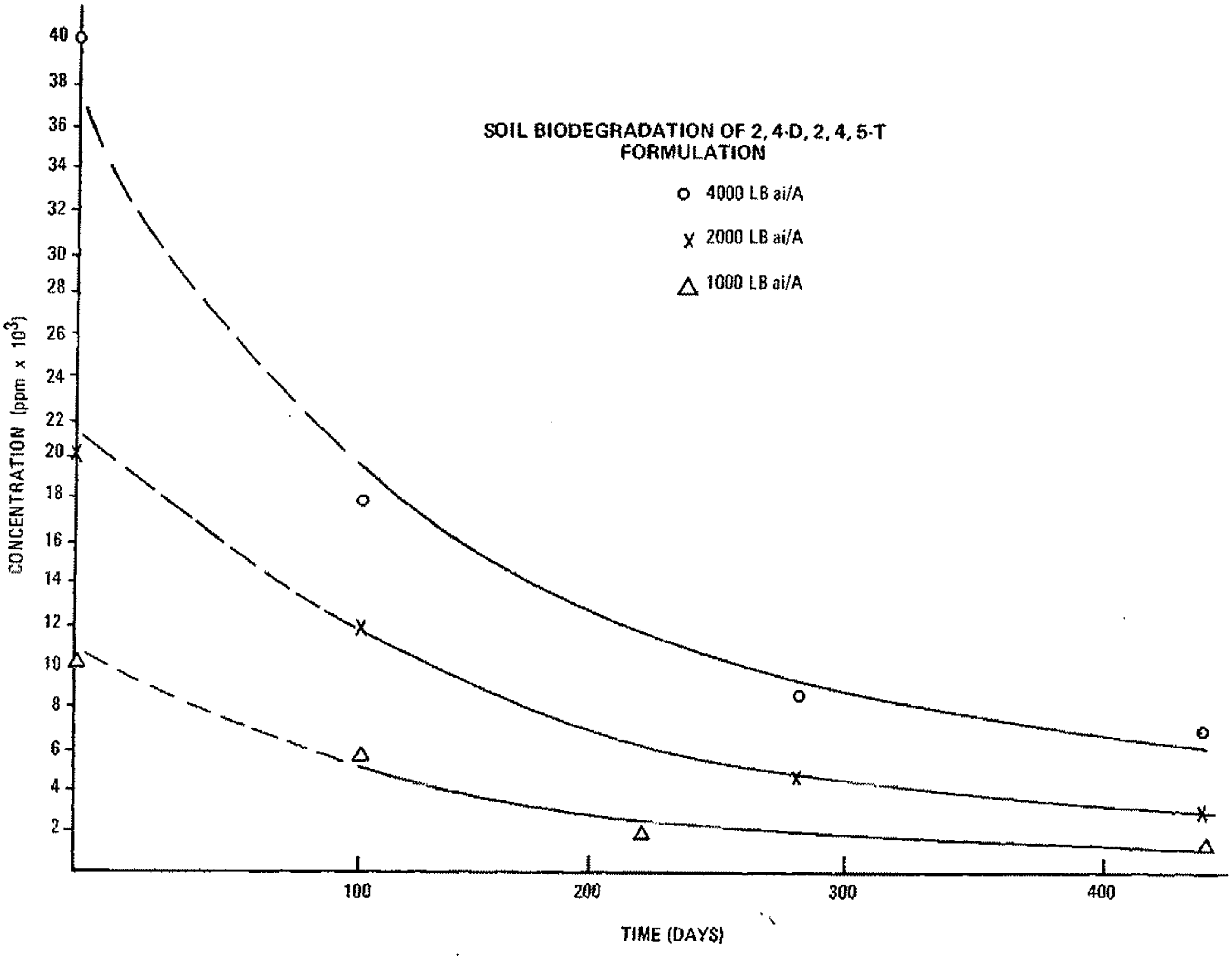

SOIL BIODEGRADATION OF 2, 4-D, 2, 4, 5-T FORMULATION
4000 LB ai/A
2000 LB ai/A
1000 LB ai/A
CONCENTRATION (ppm x 10^3)
40
38
36
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
100
200
300
400
TIME (DAYS)

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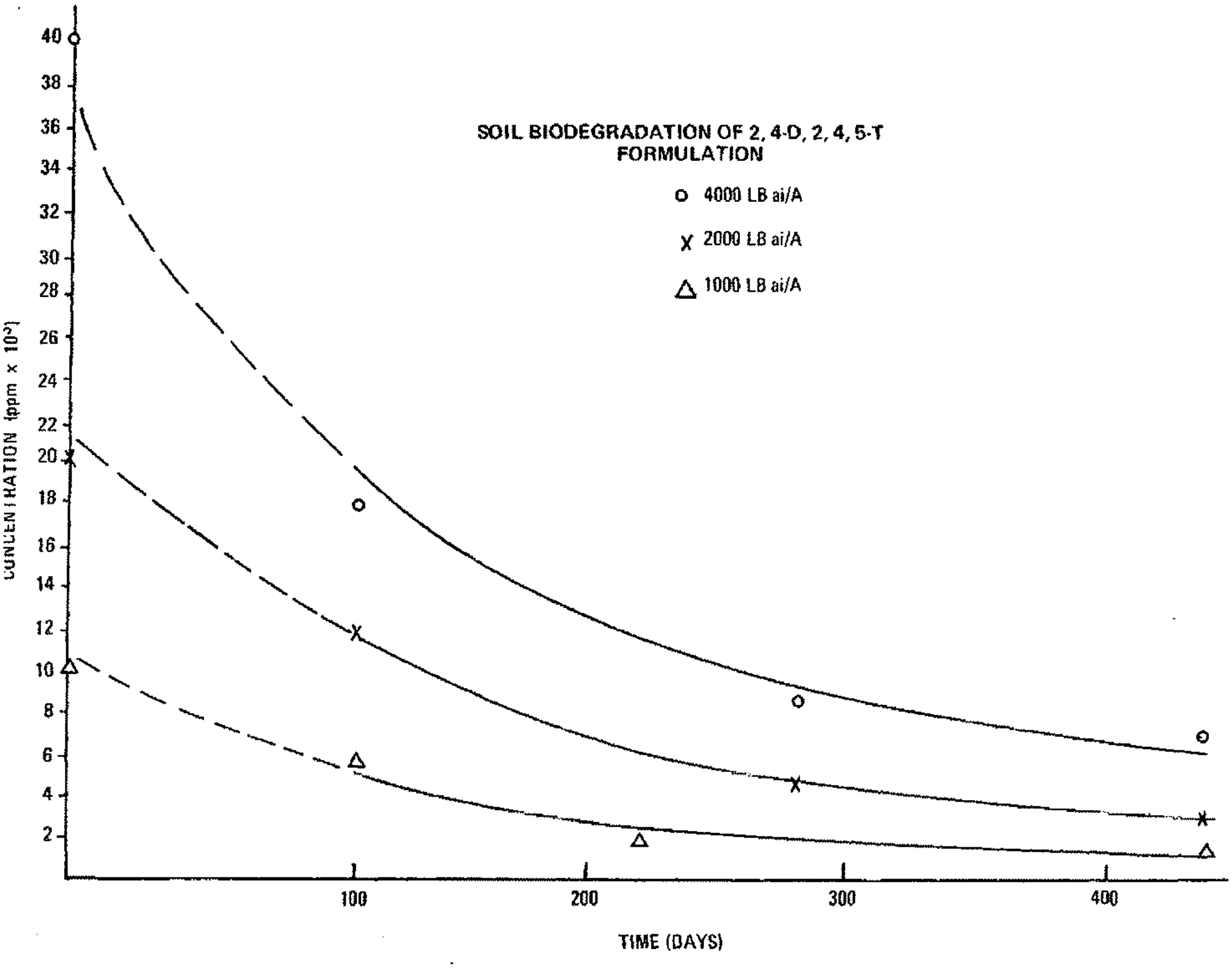
SOIL BIODEGRADATION OF 2, 4-D, 2, 4, 5-T
FORMULATION
4000 LB ai/A
2000 LB ai/A
1000 LB ai/A
CONCENTRATION (ppm x 10²)
40
38
36
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32
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28
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2
100
200
300
400
TIME (DAYS)

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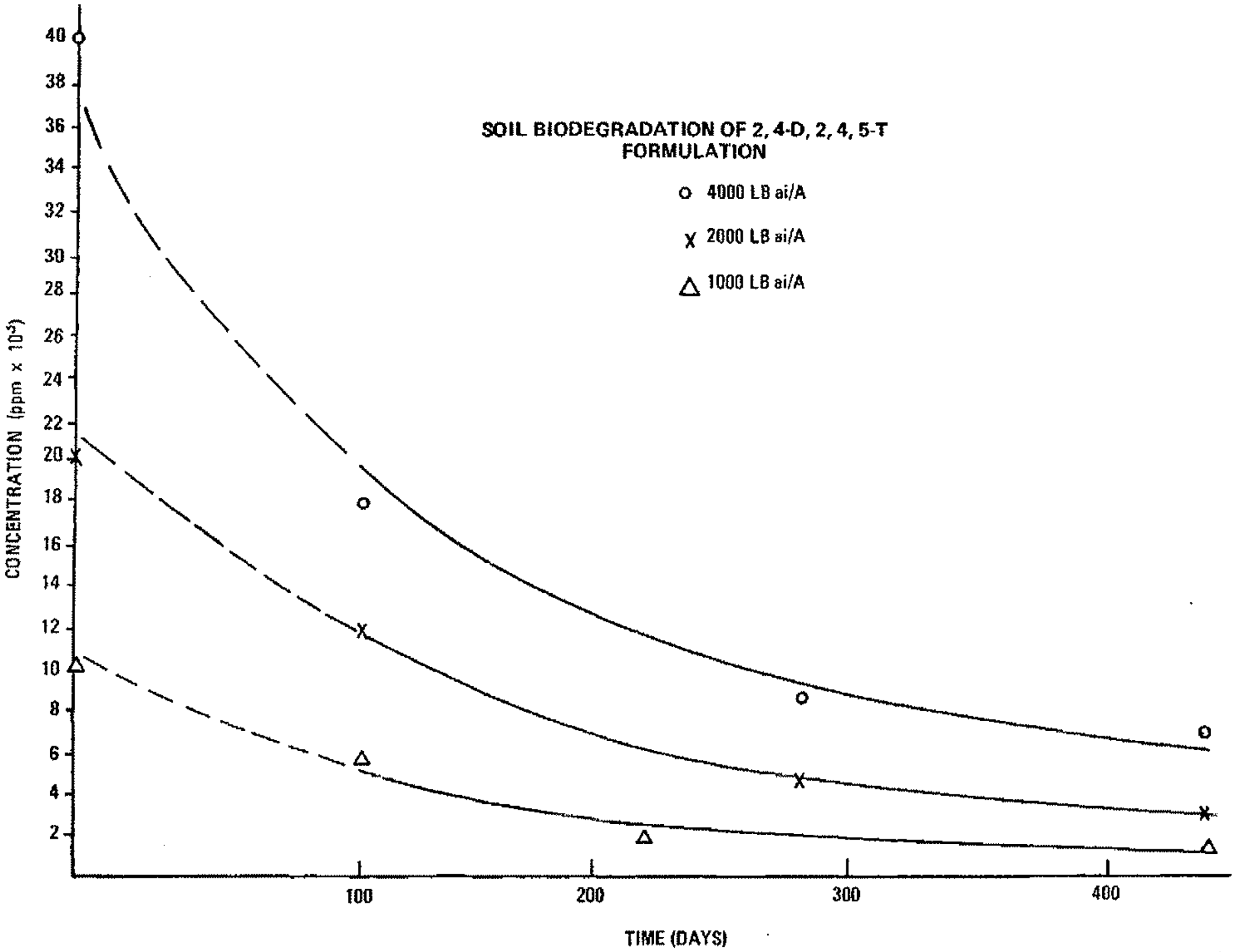

SOIL BIODEGRADATION OF 2, 4-D, 2, 4, 5-T FORMULATION
4000 LB ai/A
2000 LB ai/A
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CONCENTRATION (ppm x 10⁻³)
TIME (DAYS)
40
38
36
34
32
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6
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2
100
200
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400

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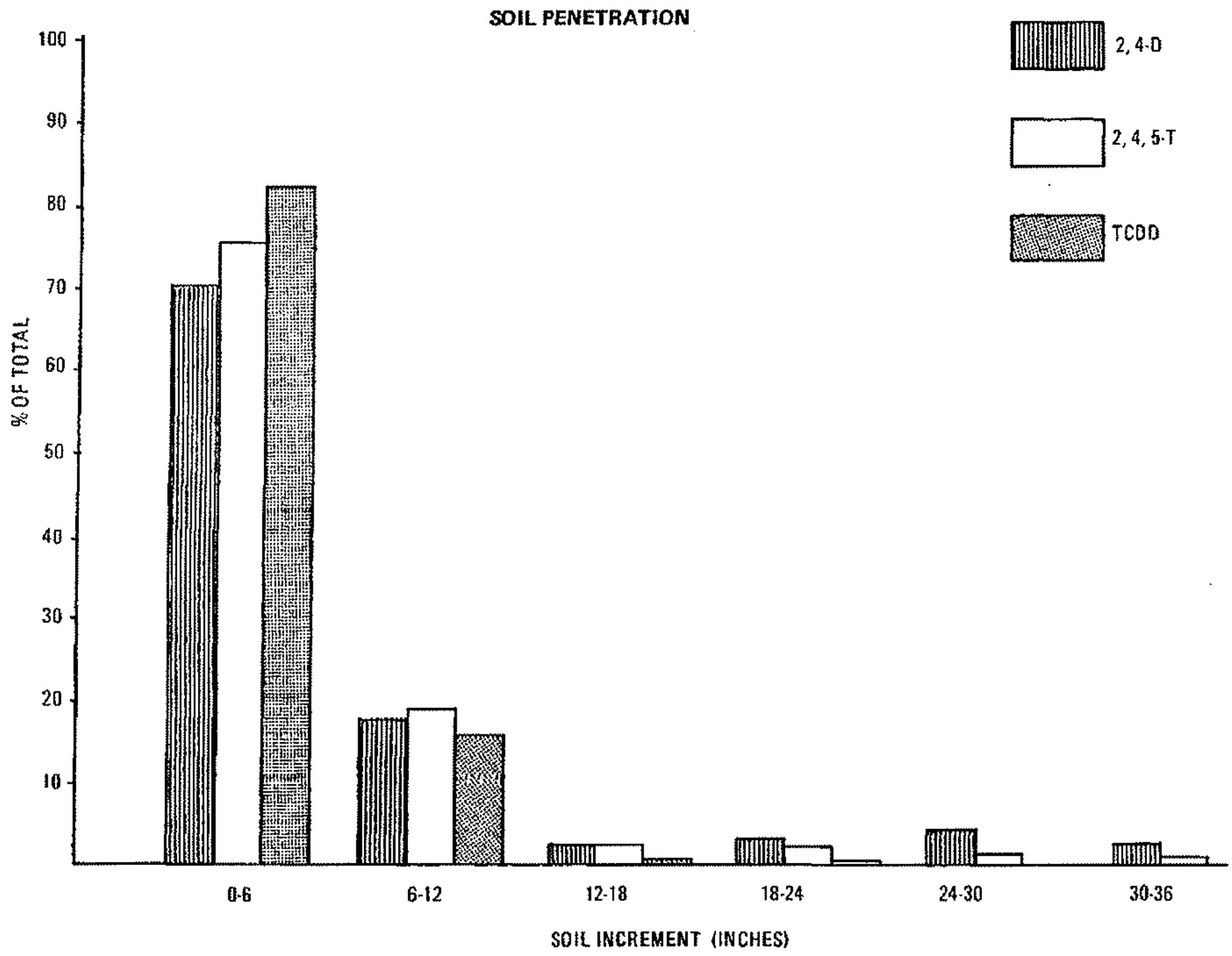
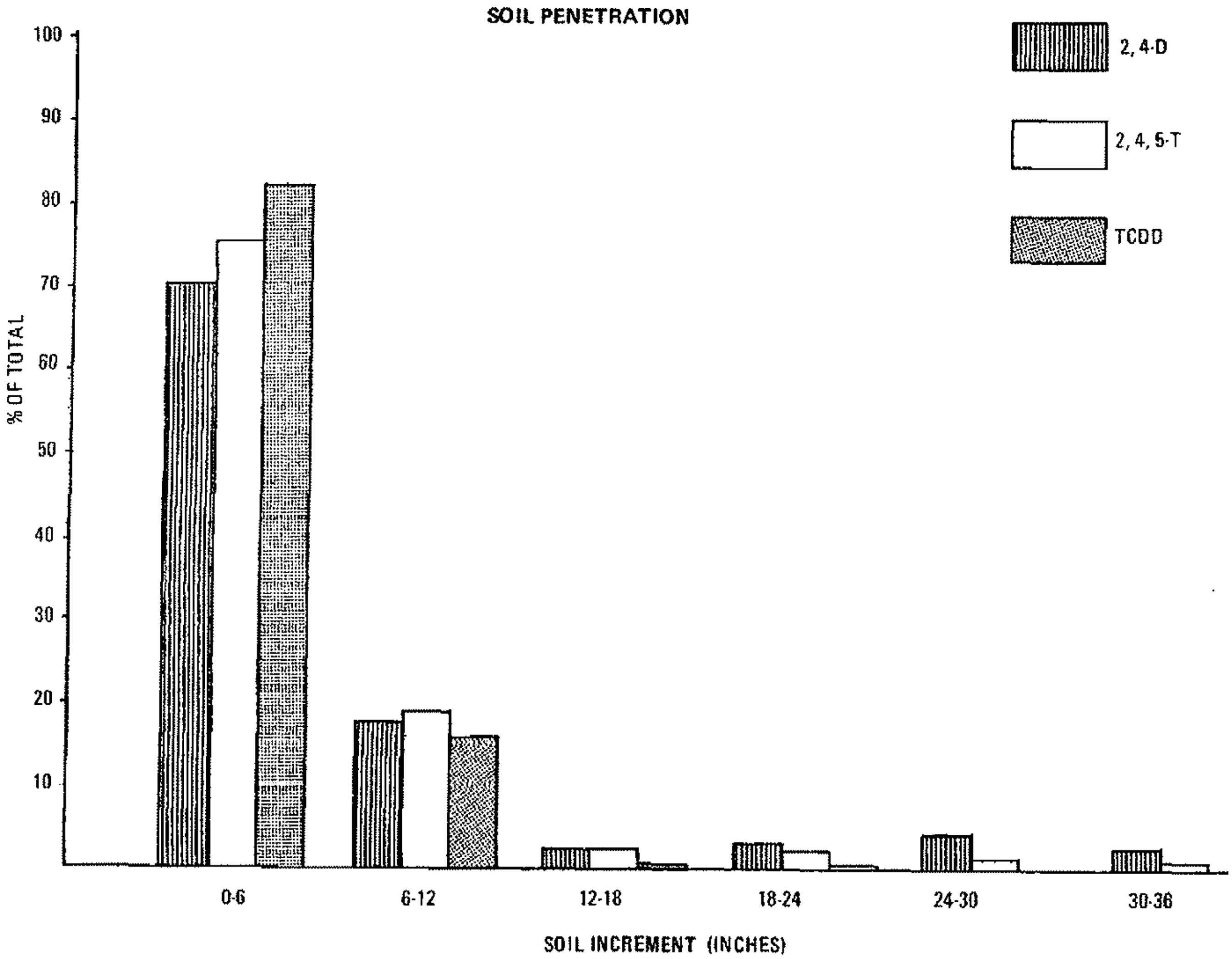
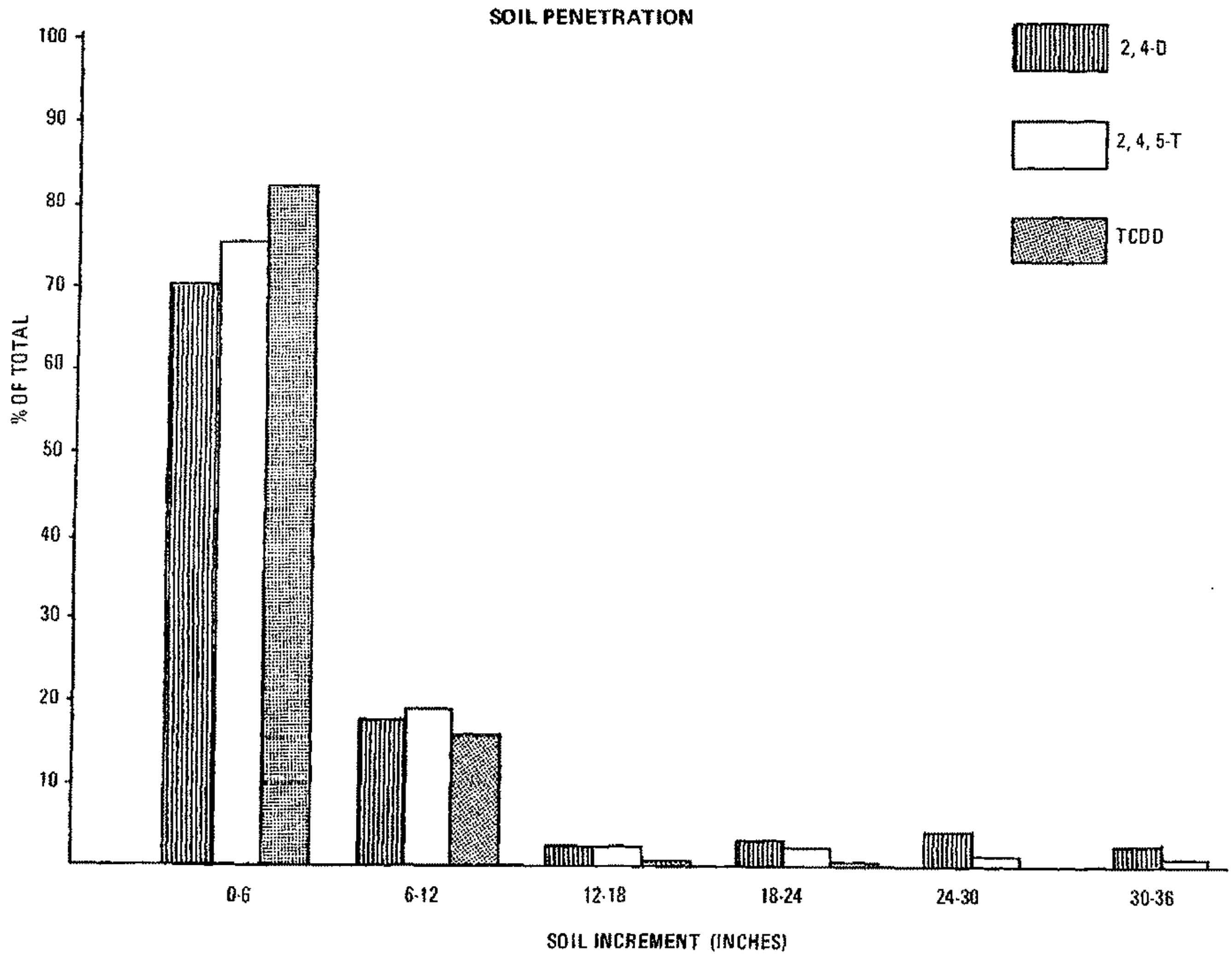
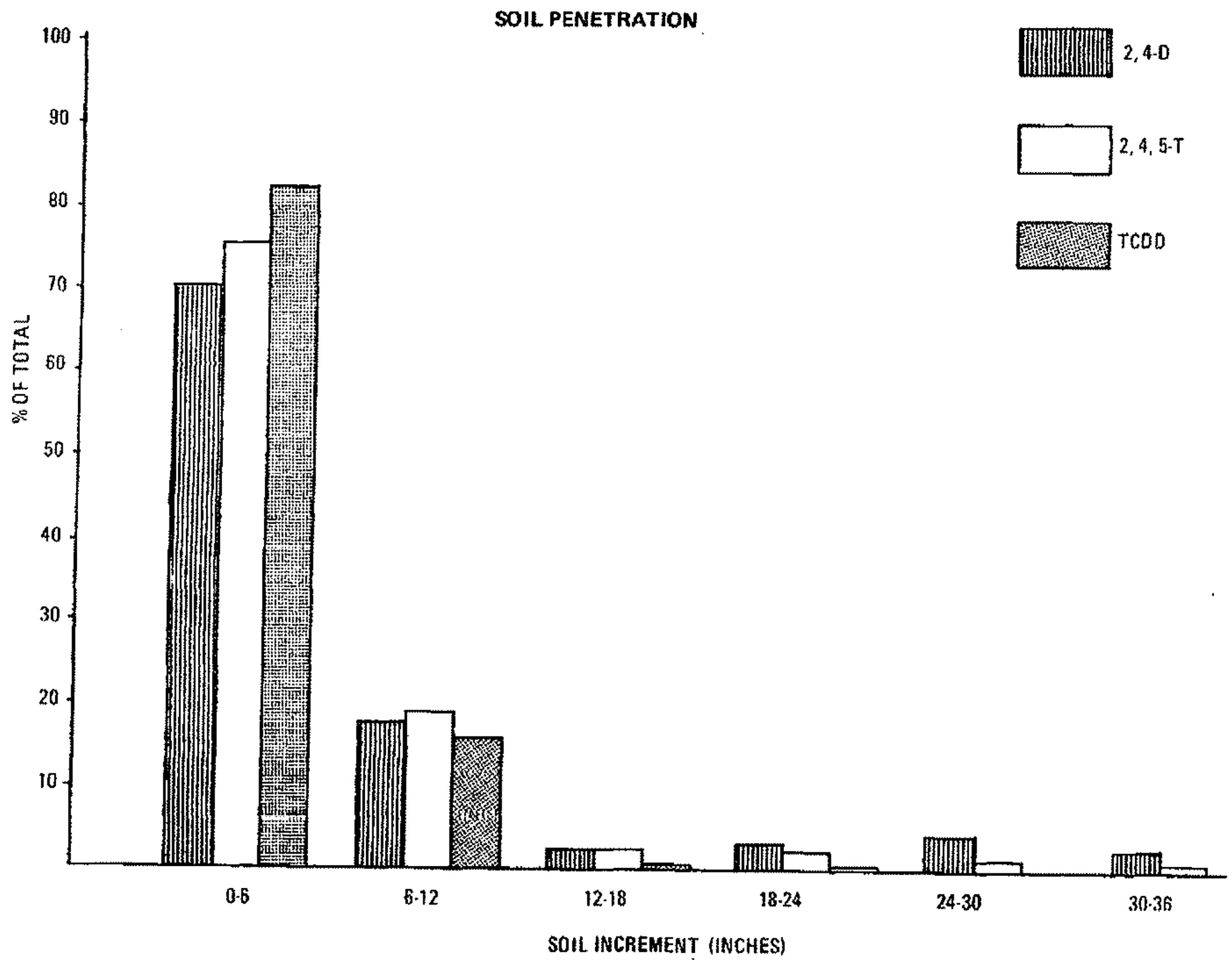

SOIL PENETRATION
% OF TOTAL
100
90
80
70
60
50
40
30
20
10
0-6
6-12
12-18
18-24
24-30
30-36
SOIL INCREMENT (INCHES)
2, 4-D
2, 4, 5-T
TCDD

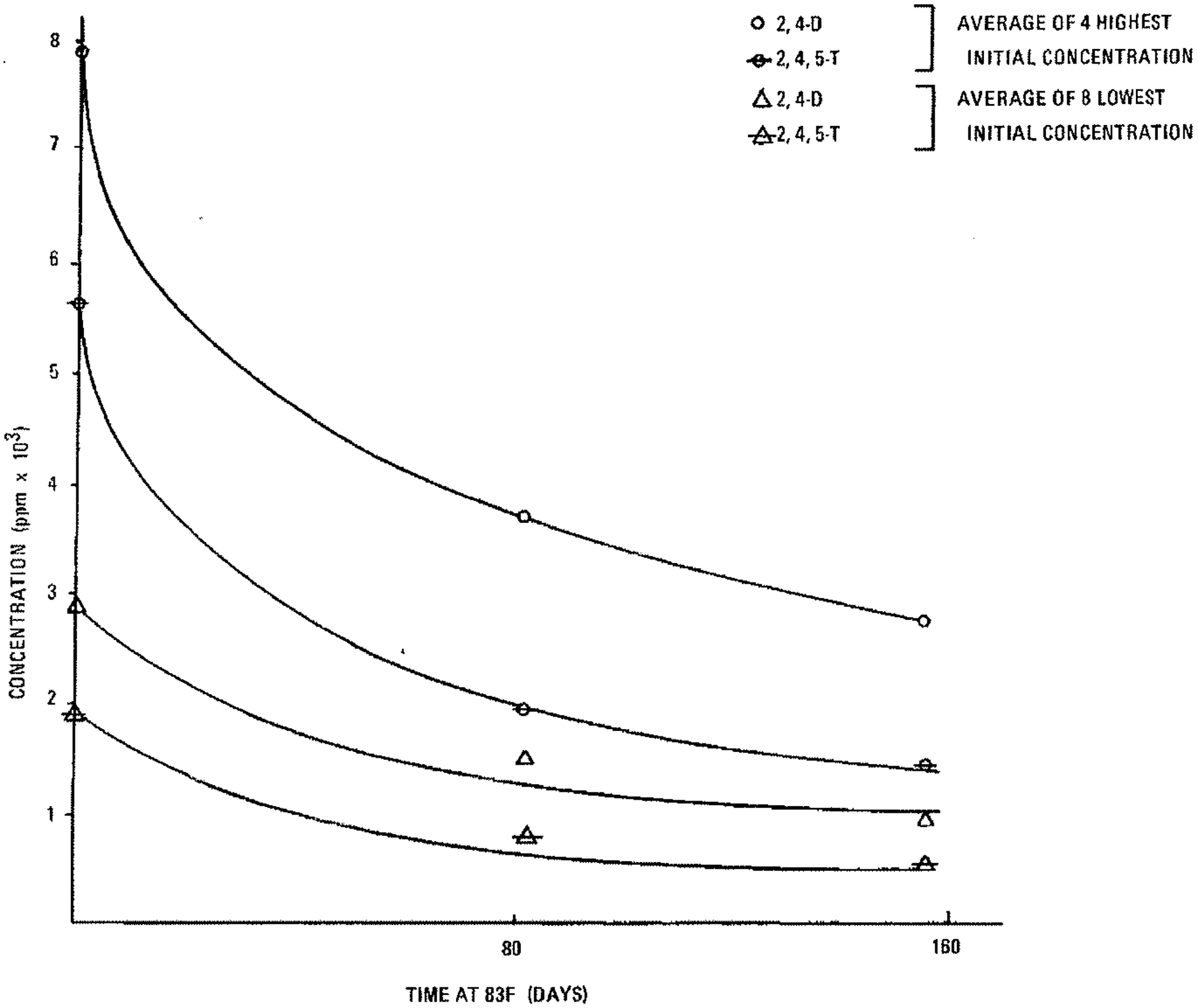

SOIL PENETRATION
100
90
80
70
60
50
40
30
20
10
% OF TOTAL
2, 4-D
2, 4, 5-T
TCDD
0-6
6-12
12-18
18-24
24-30
30-36
SOIL INCREMENT (INCHES)


SOIL PENETRATION
2, 4-D
2, 4, 5-T
TCDD
% OF TOTAL
100
90
80
70
60
50
40
30
20
10
0-6
6-12
12-18
18-24
24-30
30-36
SOIL INCREMENT (INCHES)



SOIL PENETRATION
100
90
80
70
60
50
40
30
20
10
% OF TOTAL
2, 4-D
2, 4, 5-T
TCDD
0-6
6-12
12-18
18-24
24-30
30-36
SOIL INCREMENT (INCHES)

LABORATORY BIODEGRADATION



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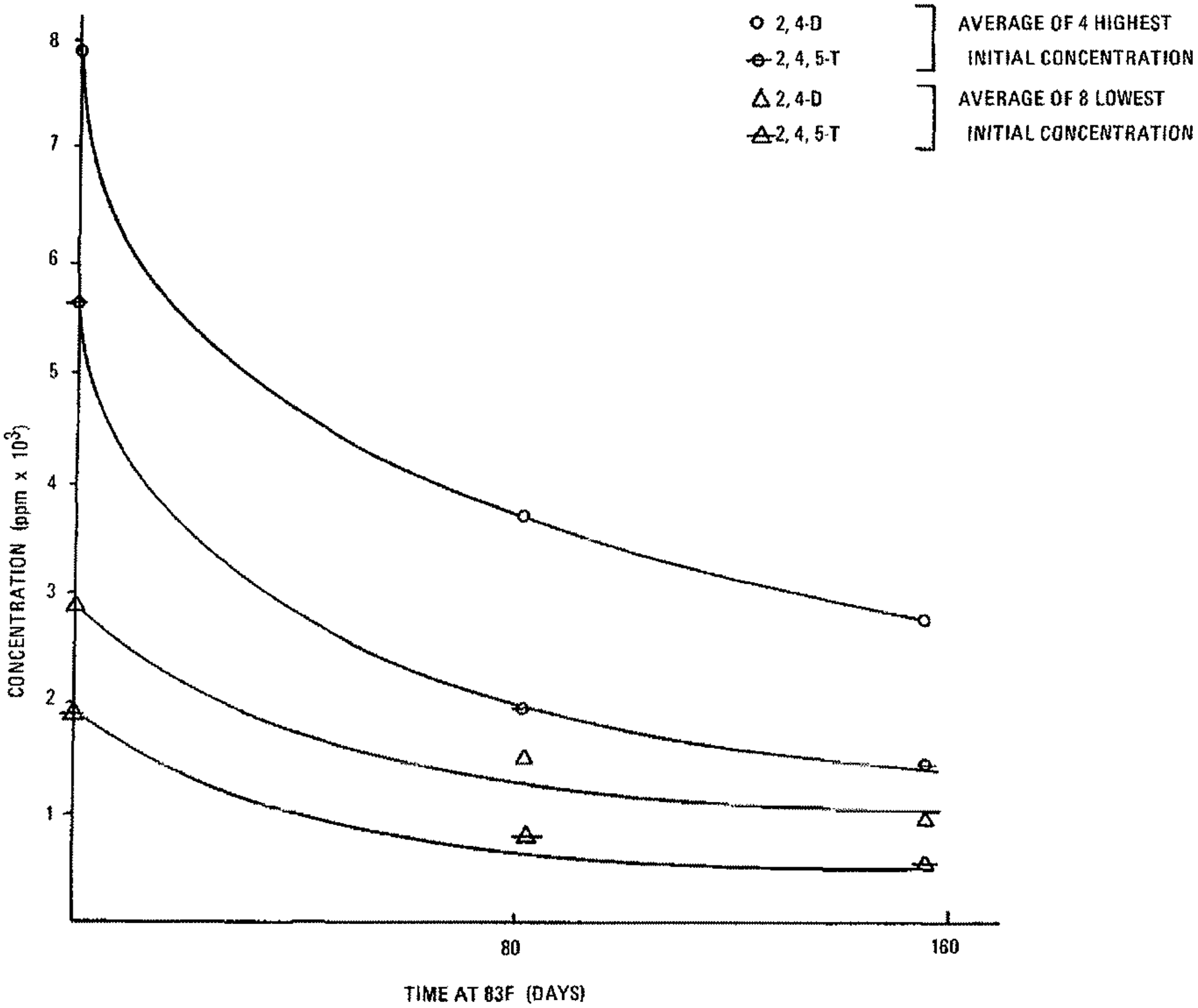
LABORATORY BIODEGRADATION



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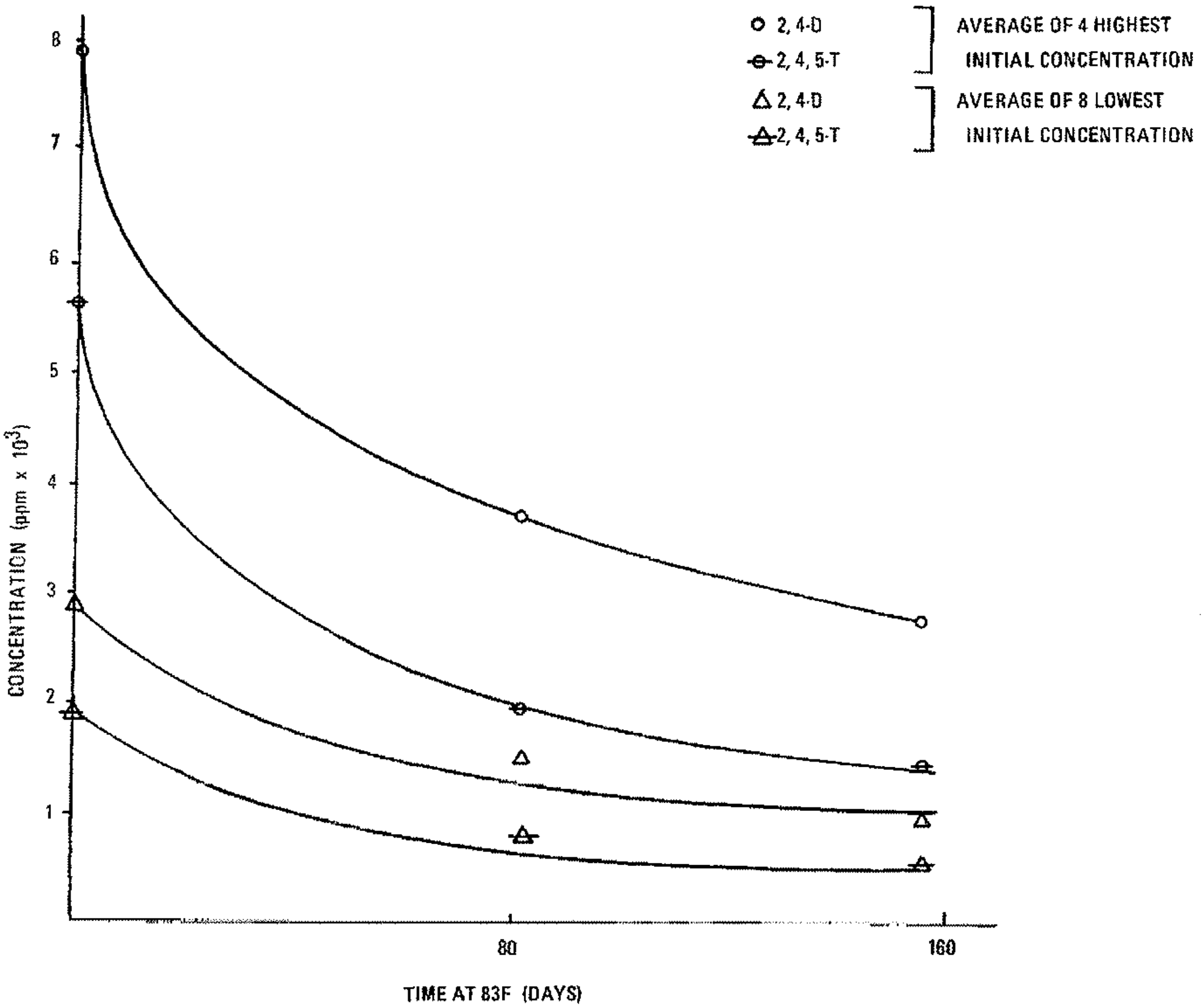
LABORATORY BIODEGRADATION



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LABORATORY BIODEGRADATION

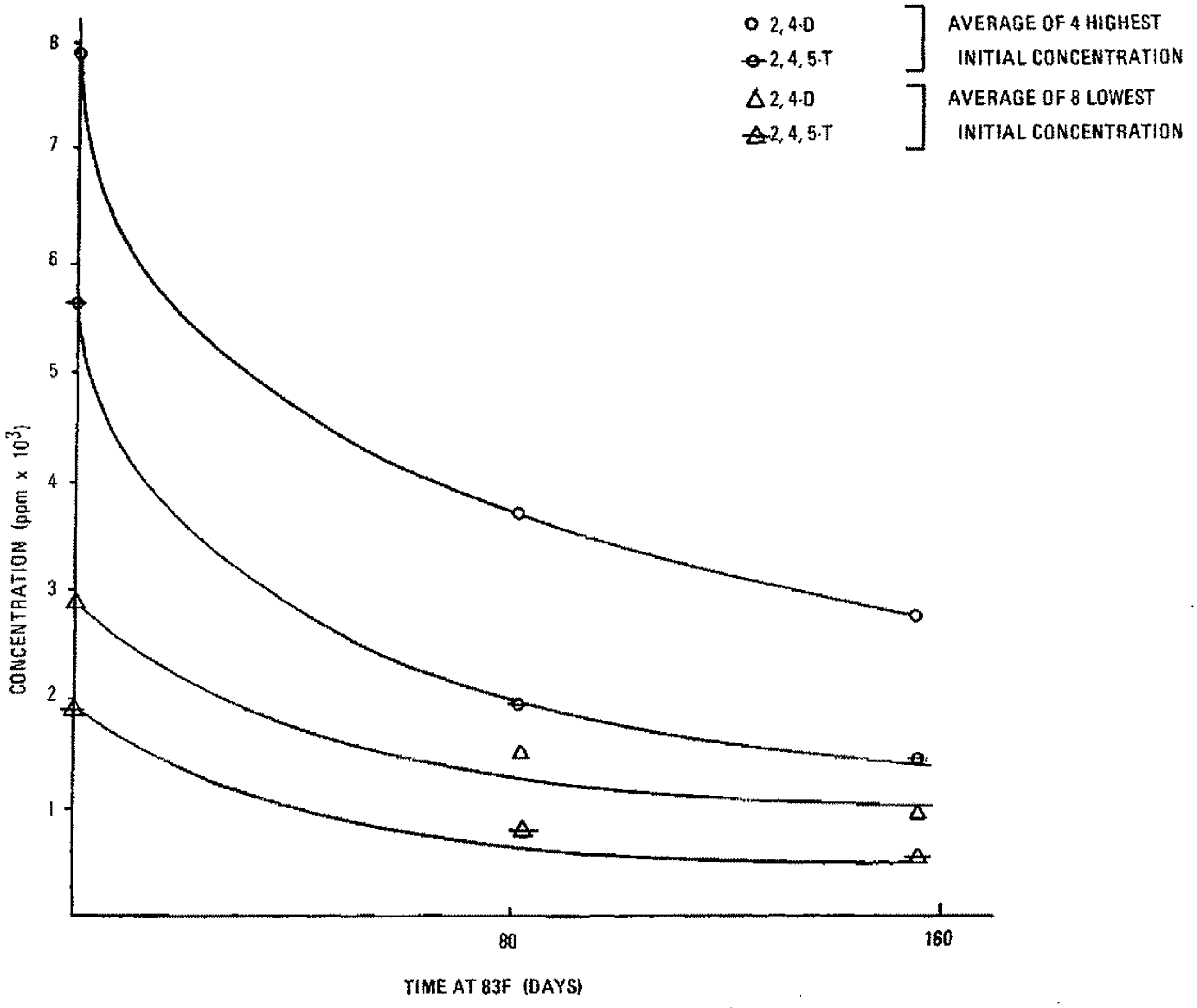

TABLE 1. Soil analysis for potential sites for soil incorporation of Herbicide Orange[a]

LOCATION	Inches	pH	Organic Carbon (%)	Electrical Conductivity (EC x103)[b]	Ca/Mg meq/100g soil	K meq/100g soil	Na meq/100g soil	Sand (%)	Silt (%)	Clay (%)	Moisture at Saturation
AFLC	0-6	7.8	0.82	28.0	23.7	3.9	13.4	27	53	20	31.1
Test Range, Utah	6-12	7.9	0.95	31.0	23.8	3.9	13.2	26	52	22	34.2
Nellis AFB, Nevada	0-6	8.5	0.70	0.40	21.8	5.5	1.6	67	13	20	ND[c]
Luke AFB, Arizona	0-6	8.2	0.70	0.28	24.1	1.9	0.2	64	18	18	ND
Mountain Home AFB, Idaho	0-6	7.2	1.60	0.24	14.6	0.8	0.5	41	38	21	ND

a Determined by Soils Laboratory, Utah State University, Logan, Utah, and the Soils Laboratory, Kansas Agricultural Experiment Station, Garden City, Kansas.

b Electrical conductivity in millimhos per cm at 25 C.

c ND = not determined

TABLE 1. Soil analysis for potential sites for soil incorporation of Herbicide Orange[a]

LOCATION	Inches	pH	Organic Carbon (%)	Electrical Conductivity (EC x103)[b]	Ca/Mg	K	Na	Sand	Silt	Clay	Moisture at Saturation
					meq/100g soil			(%)			
AFLC	0-6	7.8	0.82	28.0	23.7	3.9	13.4	27	53	20	31.1
Test Range, Utah	6-12	7.9	0.95	31.0	23.8	3.9	13.2	26	52	22	34.2
Nellis AFB, Nevada	0-6	8.5	0.70	0.40	21.8	5.5	1.6	67	13	20	ND[c]
Luke AFB, Arizona	0-6	8.2	0.70	0.28	24.1	1.9	0.2	64	18	18	ND
Mountain Home AFB, Idaho	0-6	7.2	1.60	0.24	14.6	0.8	0.5	41	38	21	ND

a Determined by Soils Laboratory, Utah State University, Logan, Utah, and the Soils Laboratory, Kansas Agricultural Experiment Station, Garden City, Kansas.

b Electrical conductivity in millimhos per cm at 25 C.

c ND = not determined

Report SAM-TR-75-37

AERIAL MEASUREMENTS OF HYDROGEN CHLORIDE OVER THE INCINERATOR SHIP VULCANUS

December 1975

Interim Report for Period December 1974 - January 1975

USAF SCHOOL OF AEROSPACE MEDICINE
Aerospace Medical Division (AFSC)
Brooks Air Force Base, Texas 78235

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NOTICES

This interim report was submitted by personnel of the Bioenvironmental Analysis Branch, Environmental Sciences Division, USAF School of Aerospace Medicine, Aerospace Medical Division, AFSC, Brooks Air Force Base, Texas, under job order 7164-16-06.

This technical report has been reviewed and is approved for publication.

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[redacted], USAF
Project Scientist

[redacted] b6
[redacted] Ph.D.
Supervisor

[redacted] b6
[redacted], Colonel, USAF, MC
Commander

2063

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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4. TITLE (and Subtitle) AERIAL MEASUREMENTS OF HYDROGEN CHLORIDE OVER THE INCINERATOR SHIP VULCANUS		5. TYPE OF REPORT & PERIOD COVERED Interim Report Dec 1974 - Jan 1975
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) b6 [redacted] 2d Lt, USAF [redacted] Ph.D.		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS USAF School of Aerospace Medicine (VNL) Aerospace Medical Division (AFSC) Brooks Air Force Base, Texas 78235		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 62202F 7164-16-06
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		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Hydrogen chloride · Coulometry
Chemiluminescence · Aerial pollution monitoring

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Environmental Protection Agency asked the USAF School of Aerospace Medicine to aid in monitoring aerially a chemical-waste-incineration exhaust plume to obtain HCl concentration data as a function of altitude and distance. This report details the monitoring instrumentation, calibration procedures, and results obtained. Maximum concentration recorded during 3 monitoring missions was 3 ppm (below threshold limit value of 4 ppm) and occurred at about 800-ft altitude (243.8 m) and 0.25 miles (0.4 km) from the ship Vulcanus.

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2064 SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

AERIAL MEASUREMENTS OF HYDROGEN CHLORIDE

OVER THE INCINERATOR SHIP VULCANUS

INTRODUCTION

The dumping of chemical waste in the ocean has concerned the Environmental Protection Agency (EPA) for many years. Recently chemical companies were required to discontinue this method of disposal. In an effort to find an alternate to ocean dumping, the EPA permitted the Shell Chemical Company to test the use of a specially designed ship, the Vulcanus, to incinerate chemical waste. The Vulcanus, which sails under Dutch registry, is uniquely designed to burn waste liquid organic materials at temperatures from 1400° to 1650°C, with greater than 99% efficiency. However, when the wastes contain chlorinated hydrocarbons, the combustion products include hydrogen chloride (HCl) vapor in addition to water and carbon dioxide. Thus, depending upon the chemical makeup of the waste, the projected concentrations of HCl in the exhaust plume from the Vulcanus ranged from zero to as high as 100 parts-per-million (ppm) by volume. Because of the potential hazard associated with HCl mist, the issuance of a permit to experimentally burn waste chlorinated hydrocarbons was contingent upon an extensive monitoring program to assure the environmental safety of the incineration process.

Two experimental tests of the Vulcanus were conducted. Each involved 4200 metric tons (9,261,000 lb) of waste chlorinated hydrocarbons (approximately 66% chlorine by weight), and both were conducted in an area 40 by 46 miles (64 X 74 km) in the Gulf of Mexico approximately 165 miles (265 km) from Galveston, Texas. The first test was conducted 16-28 October 1974 and was monitored by instrumentation located on a surface ship, the Oregon II, which traversed the sea-level exhaust plume behind the Vulcanus at distances ranging from 0.2 to 1.9 miles (0.3-3.1 km). Although the maximum surface concentration of HCl measured in this test was approximately 1.2 ppm, the need to measure plume concentrations at altitude became apparent to satisfy environmentalist concern.

Hence, a second test was scheduled for 2-9 December 1974, during which the Vulcanus exhaust plume was aerially monitored to obtain HCl concentration data as a function of altitude and distance from the Vulcanus. Because of Air Force experience in monitoring HCl in solid-rocket motor exhaust, the USAF School of Aerospace Medicine was requested by EPA to aid in this endeavor. This report details the instrumentation used for HCl aerial monitoring, the calibration procedures, and the results obtained.

METHODS

Three airborne monitoring missions were flown; one each on 2, 3, and 4 December 1974, which corresponded to the first three days of a programmed 9-day continuous burn. The sampling platform was a C-45 (Beech) transport aircraft modified with turboprop engines. The onboard instrumentation included a USAFSAM microcoulometer (repackaged Dohrmann model C-200-B, Fig. 1) for chloride detection, a chemiluminescent analyzer (Geomet Model 401, Fig. 2) for HCl, and an EPA condensation nuclei counter for Aitken nuclei. The sampling probe for the HCl instruments was a 1/4-in-OD (0.6 cm) polypropylene tube, sheathed in a 2-in-OD (5 cm) aluminum tube which projected about 3 feet (0.9 m) from the aircraft nose (Fig. 1). The polypropylene line supplied ambient air sample to both the microcoulometer and chemiluminescent analyzer at a total flow rate of 9 liters/min, with a ram air pressure of 5.5-in H_2O (10.3 mmHg) above ambient at 130 knots. The actual (demand) sampling rates drawn by each instrument were 100 cm^3/min to the microcoulometer and 1600 cm^3/min to the chemiluminescent analyzer. The sample velocity in the polypropylene tube was 20.2 ft/sec, which gave a time delay of about 0.8 seconds between aircraft contact with the plume and instrument reaction.

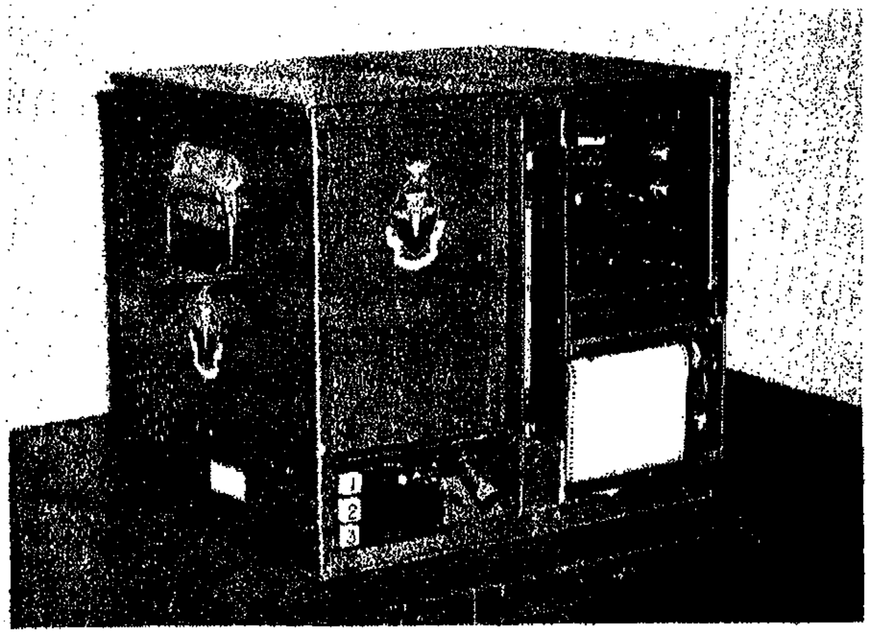


Figure 1. Repackaged Dohrmann model C-200-B microcoulometer for airborne tests.

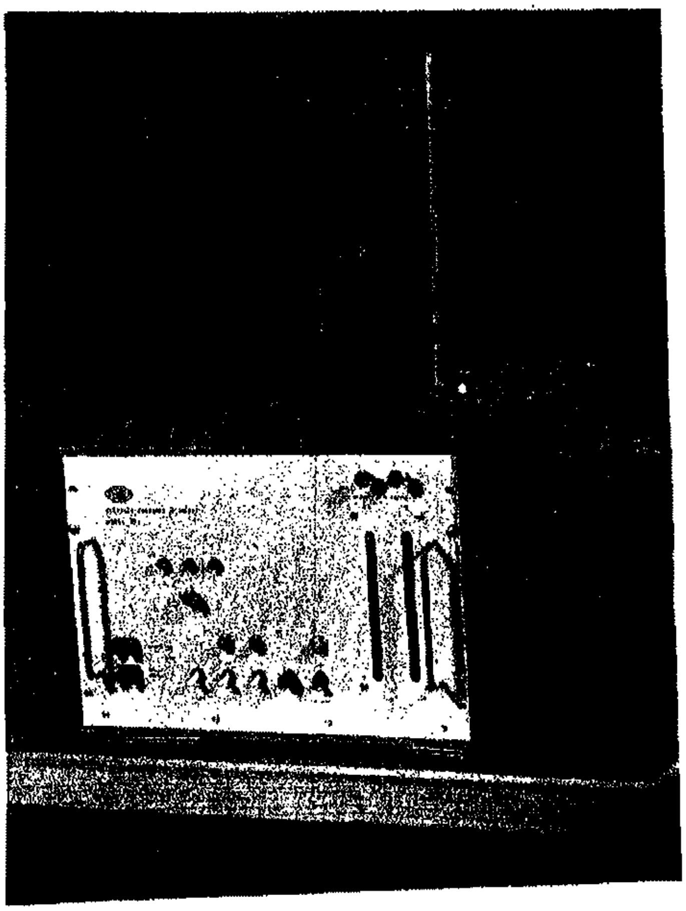


Figure 2. Geomet model 401 chemiluminescent HCl analyzer deployed for airborne tests.

Microcoulometer

The microcoulometric detection of HCl is based on automatic titration of chloride ion as silver chloride precipitate. The continuous-monitoring instrument consists of a microcoulometric titration cell, electronic control console, integrating recorder, air pump, and flowmeter. The heart of the system is the titration cell, which contains acetic acid electrolyte, and four electrodes--a sensing pair (silver vs. silver acetate) and a generating pair (silver vs. platinum). The concentration of silver ions in the cell is adjusted to 10^{-7} molar by applying a bias potential of 250 millivolts across the sensing electrode pair. The sensing electrodes detect any change in silver concentration (by precipitation of AgCl) as a potential difference which leads through the coulometer amplifier to generation of silver titrant at the generator electrodes. The current required is recorded, via a precision series resistance, on a potentiometric recorder. The peak area provides the quantity of electricity, in coulombs, required for the reaction. Because Faraday's laws are obeyed and the reaction is stoichiometric, the microcoulometer is a primary standard for chloride and the quantity of chloride in the sample is easily calculated from:

$$w = \frac{35.453}{96,501} \times 10^6 \frac{A}{R} = 367.4 \frac{A}{R} \qquad (1)$$

where w = weight of chloride, ng
A = coulogram peak area, mV-sec
R = series resistance, ohms

The detection limit for batch samples is about 3 nanograms of chloride ion.

In the continuous sampling mode, the response and dynamic range of the microcoulometer can be varied by adjusting the sample flow rate and/or instrument range (series resistance). Again, since Faraday's laws apply, the steady state concentration of HCl may be calculated from:

$$y = 13,927 \left(\frac{E}{fR}\right)\left(\frac{T}{273}\right)\left(\frac{760}{P}\right) \qquad (2)$$

where y = HCl concentration in ppm
E = steady state response, mV
f = sample flow rate, cm^3/min
R = range ohms
T = sample temperature, ^oK
P = ambient pressure, mmHg

In the continuous sampling mode the instrument lag time is about 7 seconds, and the response time to 90% of full scale is approximately 35 seconds. The threshold detection limit for the coulometer in the continuous sampling mode is about 0.10 ppm at a range setting of 50 ohms and a sampling rate of 100 cm^3/min.

Chemiluminescent Analyzer

The chemiluminescent detection of HCl is based on exothermic oxidation of luminol (5-amino-2,3 dihydro-1,4-phthalazinedione) in alkaline solution by hypochlorous acid. The intensity of light generated by this reaction is linearly proportional to the HCl concentration in the incoming gas stream and is monitored by a photomultiplier detector. The analyzer contains two reaction cells, one for detecting HCl and the other for reference. The hypochlorous acid is formed in the detector cell inlet by reaction of HCl with a sodium bromate/bromide coating of a 40-cm x 2-mm-ID alumina tube. An identical but uncoated tube is used in the reference cell inlet to account for any interferent gases of which molecular chlorine is the only known signal contributor. At a nominal sample flow rate of 1600 cm^3/min, the response time of the chemiluminescent HCl detector is 1 second to 90% full-scale deflection, with an HCl detection limit of about 0.01 ppm. The instrument may be operated on any one of three operating ranges to provide nominal HCl detection capability over zero to 0.5 ppm (1X scale), zero to 5 ppm (10X scale), and zero to 50 ppm (100X scale).

Calibration Procedure

The coulometer was used as a primary standard for on-site calibration of the chemiluminescent analyzer. The coulometer itself was standardized daily by injection of 5 microliters of a standard solution of sodium chloride (26 ng/μl). The average chloride recovery from at least three injections was 99.2 ± 1.1%, 97.4 ± 4.3%, and 102.7 ± 4.7% on each of the three days.

For calibration of the chemiluminescent analyzer, several calibration points were obtained before and after each mission, using a pressurized HCl-in-nitrogen source standard and ambient air diluent (Fig. 3). Flight-sampling flow rates were simulated by a 2 liter/min air pump attached to the end of 30-ft sample line in parallel with the two instruments. Varied concentrations of HCl were obtained by adjusting the HCl flow from the standard cylinder with a micrometer valve. Each calibration concentration was held constant until steady state responses were achieved by both instruments. The actual HCl concentration (ppm) was calculated from the microcoulometer response using Equation 2, and correlated with the chemiluminescent response (V) at a given scale setting.

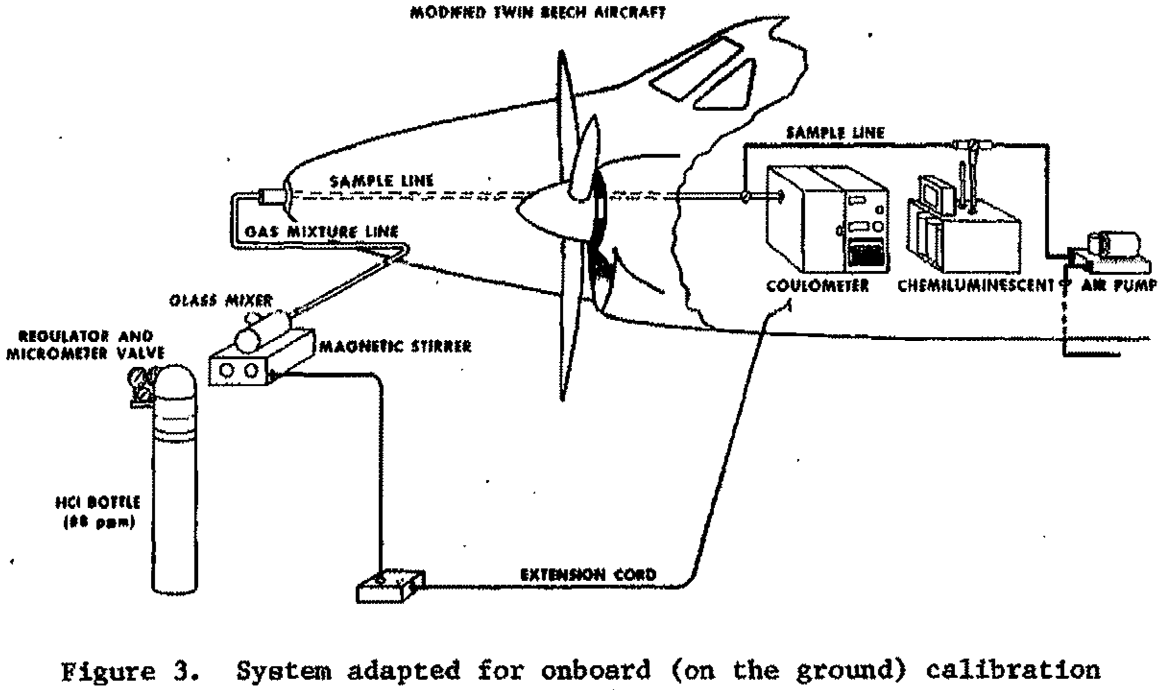
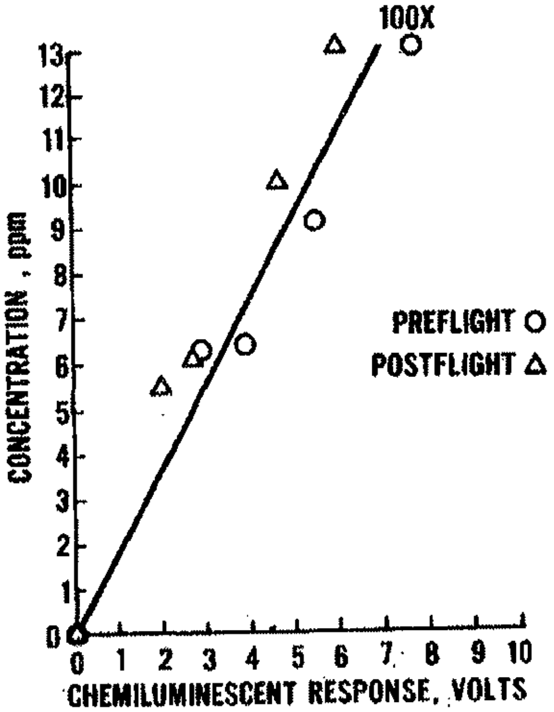


Figure 3. System adapted for onboard (on the ground) calibration of chemiluminescent analyzer.

For the chemiluminescent responses for each mission to be interpreted, the pre- and postflight calibrations had to be combined into a single line. This was done by fitting each of the pre- and postflight calibration lines to a least squares curve and averaging the coefficients. The resulting single calibration curve for each mission is shown by the solid line in Figures 4, 5, and 6.

The numerical data for these plots is tabulated in Tables 1, 2, and 3. Owing to minor complications and a tight schedule, the preflight calibration was not accomplished for Mission II. On Mission III, the relatively large variation observed between pre- and postflight calibrations was due in part to large changes in temperature and humidity from early morning to late afternoon.



Least Squares Equation: 100X Scale: y = 1.9X

Figure 4. Vulcanus Mission I chemiluminescent analyzer calibration curve.

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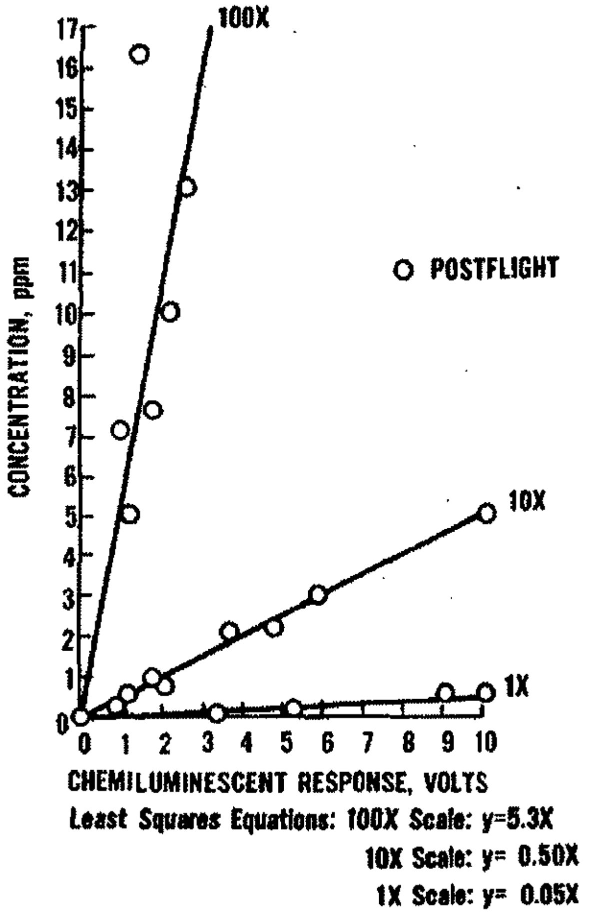

Figure 5. Vulcanus Mission II chemiluminescent analyzer calibration curve.

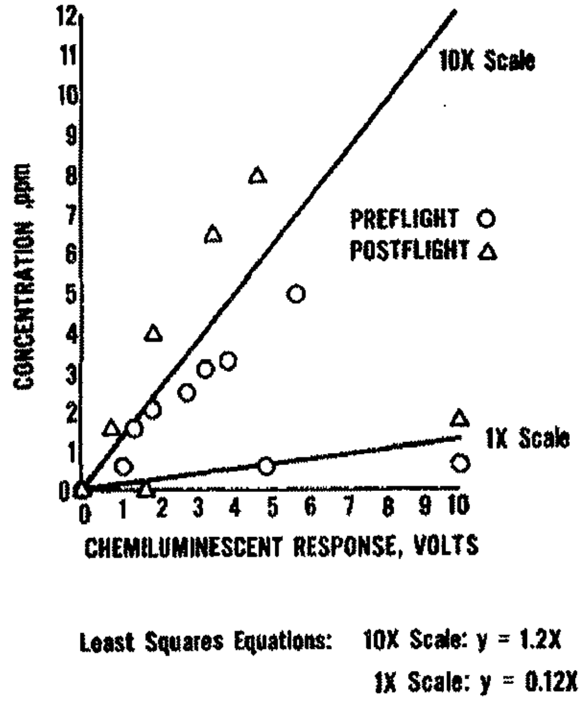

Figure 6. Vulcanus Mission III chemiluminescent analyzer calibration curve.

RESULTS

Each aerial monitoring mission was flown from the Corpus Christi Naval Air Station, Texas, escorted by a radar-equipped Coast Guard aircraft to locate the Vulcanus. Each flight lasted about 4 hours, which permitted 70–100 minutes of measurements and data collection. While on station, the aircraft flew low-level crisscross and circular flight patterns over and around the Vulcanus to locate the essentially invisible exhaust plume. Hydrogen chloride measurements were then made at various distances and altitude combinations. Distances ranged from 0.25 to 3 miles (0.4–4.8 km), and altitudes ranged from 100 to about 4800 feet (30.5–1464 m). The lower altitude range (100–1600 ft or 30.5–488 m) was monitored in 100- and 200-ft (30.5 m, 61 m) increments, to obtain a comprehensive profile of plume concentration.

The HCl measurements at each distance/altitude are tabulated in Tables 4, 5, and 6 for Missions I, II, and III respectively. These tables list essentially every measurable response recorded by either the chemiluminescent analyzer or the microcoulometer. For convenience the data have been grouped by plume penetration, which, because of plume transparency, necessarily correlated with instrument response. The coulometric concentrations have been estimated by two techniques: area and slope. Concentration estimates by the area method were calculated by assuming all HCl associated with the coulometric peak was admitted during the titration rise (time from initial response to peak apex). Concentration by slope is based on laboratory correlation, which shows linear relationship between HCl concentration and rate of instrument response (mV/min) (Fig. 7). The maximum concentration recorded by the chemiluminescent analyzer was lower than by the coulometer in almost every penetration, thus substantiating the specificity of the chemiluminescent instrument for gaseous HCl only, and of the coulometer for total chloride (gaseous plus aerosol). The concentration listed for each penetration reflects the maximum value recorded, above baseline, for each instrument. No microcoulometric data are listed for Mission I because the coulometer was used for cabin monitoring throughout that mission.

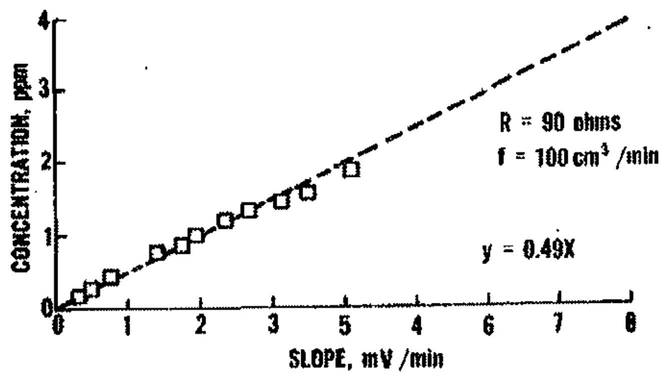

Figure 7. Slope calibration for coulometer peak analysis.

The chemiluminescence concentration data in Tables 4, 5, and 6 reflect a spike in some penetrations, and in others, a spike immediately followed by a more prolonged response. In Tables 5 and 6, the more prolonged response was very closely correlated with the response recorded on the microcoulometer (e.g., see Figs. 8, 9, and 10). Because of this close correlation in both peak size and shape, the more prolonged response on the chemiluminescence analyzer is believed to more closely represent the actual plume concentration. In penetration 13 (Fig. 8) two single chemiluminescent spike responses were recorded, with no response from the microcoulometer. The phenomenon of a chemiluminescence spike immediately followed by a longer response has not been reproduced in the laboratory and, although of some concern, is not considered representative of plume concentration. The relatively large spike associated with a longer chemiluminescent response is apparently due to the 1X scale (compare, for example, with Fig, 9 on 10X scale). The 10- to 15-sec time delay in the coulometric peak was expected, because of its known initial lag and response time delay.

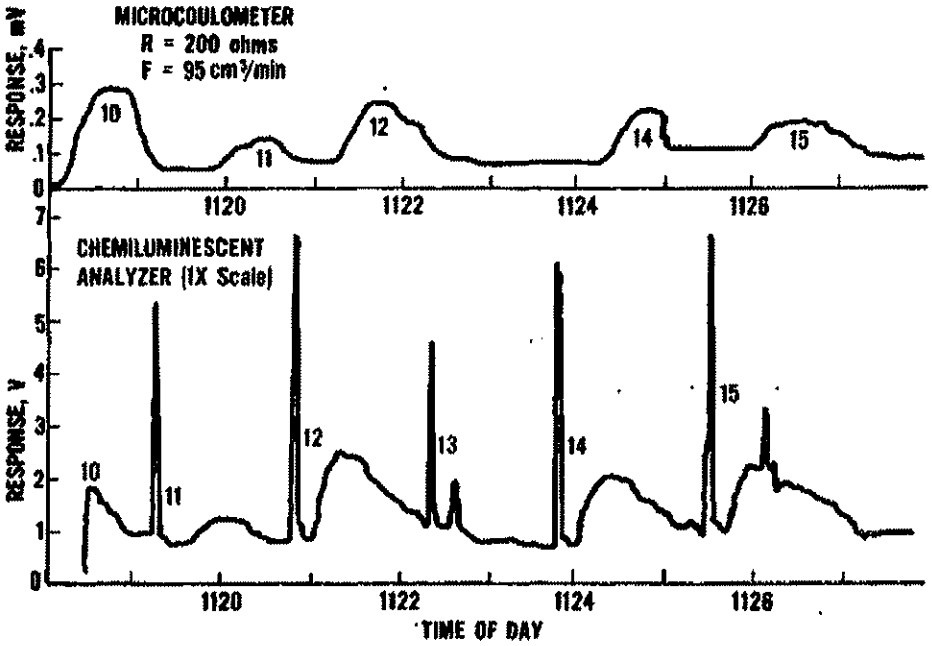

Figure 8. Vulcanus Mission II instrument response. (1118-1128 hours)

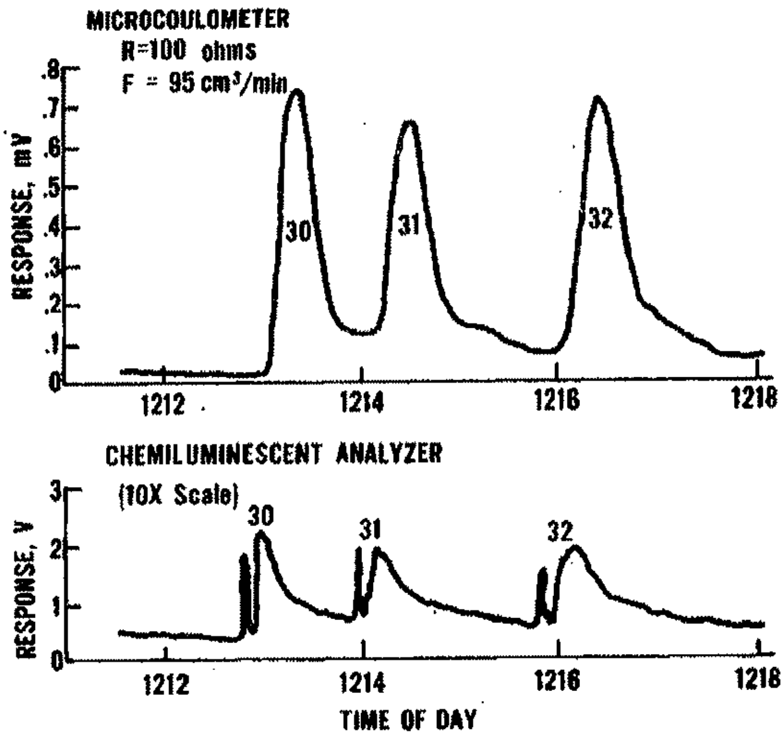

Figure 9. Vulcanus Mission II instrument response.
(1211-1218 hours)

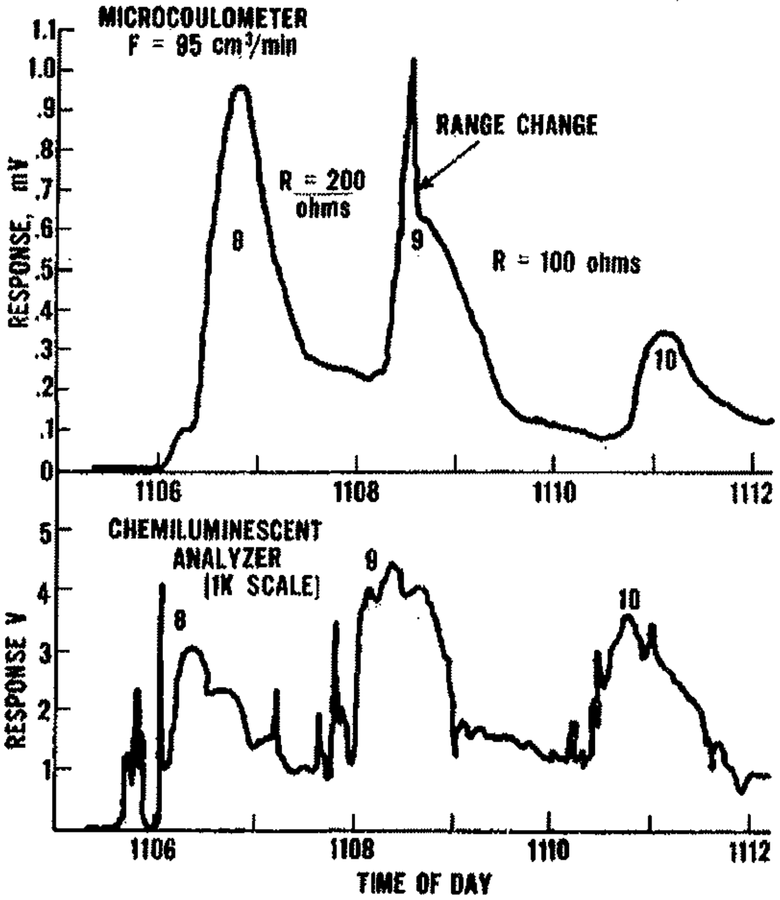

Figure 10. Vulcanus Mission III instrument response. (1105-1112 hours)

The HCl concentration data for the three missions are summarized in Figures 11 and 12 as functions of altitude and distance, respectively, from the Vulcanus. The dashed lines represent our best estimate of the maximum concentration profile. The variation in response with replicate penetrations was almost certainly due to the problem of plume invisibility and the attendant difficulty of replicating centerline penetration by the aircraft. Hence the bulk of the recorded data must be considered to represent nonmaximal concentrations.

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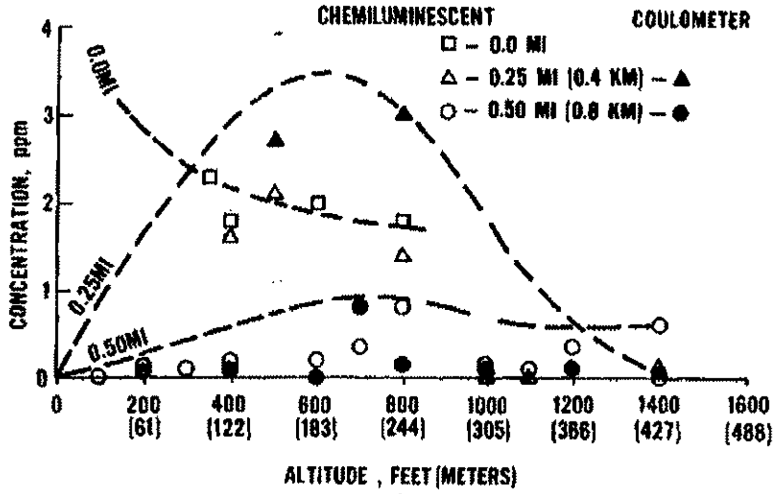

Figure 11. HCl concentrations as a function of altitude at various distances behind the Vulcanus.

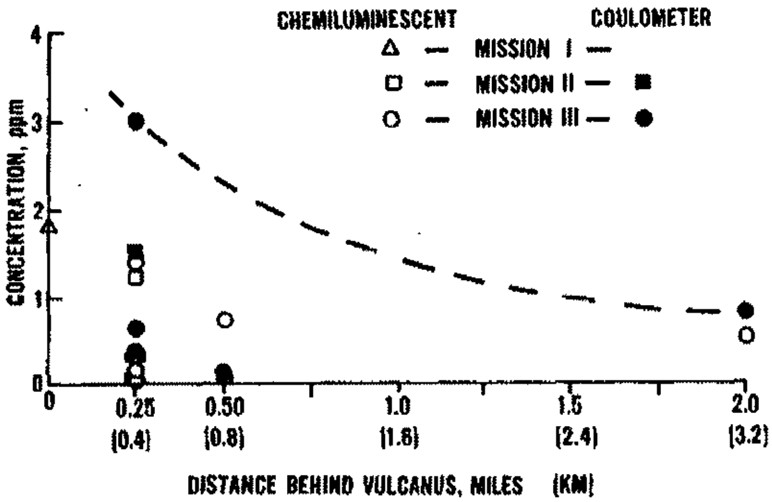

Figure 12. HCl concentrations as a function of distance behind the Vulcanus at an 800-ft (244-m) altitude.

DISCUSSION

The measured concentrations of HCl were considerably lower than had been predicted in court depositions and technical hearings. The maximum concentration recorded during the three monitoring missions was 3.0 ppm, estimated by slope of the coulometer response. This measurement occurred during Mission III at an altitude of about 800 feet (244 m) and a distance of 0.25 miles (0.4 km) from the Vulcanus. On Missions I and II, the maximum concentrations were 2.3 ppm [350 ft (107 m) directly overhead] and 1.8 ppm (unknown position) respectively. While perhaps lower than expected, these values nonetheless correlate well with previous sea-level measurements recorded by NASA using similar instrumentation during the October test of the Vulcanus. Overall, the test results submit to several conclusions:

(1) The close correlation of real time response between the chemiluminescent and coulometric analyzers, after known response corrections, provides mutual substantiation of measured HCl exposures and concentration.

(2) The variation in pre- and postflight calibration data for the chemiluminescent analyzer indicates a maximum uncertainty in this instrument of plus or minus 100%.

(3) The maximum HCl concentration, obtained by slope analysis of the microcoulometer titration curve, may be assigned a maximum uncertainty of plus or minus 20%, based on laboratory verification of theoretical response.

(4) Despite evident scatter in replicate plume penetrations, apparently due to nonoptimal aircraft penetration, the recorded maximum concentrations are well below the threshold limit value concentration for HCl (4 ppm) and hence support the safety of the incineration method for disposal of chlorinated hydrocarbon waste material.

TABLE 1. CALIBRATION DATA, VULCANUS MISSION I

Coulometer (mV)	Range (ohms)	Concentration (ppm)	Chemiluminescent analyzer (V)	Scale
		Preflight		
0.0	10	0.0	0.0	100X
0.49	10	6.4	3.9	100X
0.69	10	9.1	5.5	100X
0.96	10	13	7.7	100X
0.48	10	6.3	2.8	100X
		Postflight		
0.0	10	0.0	0.0	100X
0.40	10	6.1	2.7	100X
0.66	10	10	4.7	100X
0.86	10	13	6.0	100X
0.36	10	5.5	2.0	100X

Equation of least squares line: 1X scale: ppm = 0.02 · V
10X scale: ppm = 0.19 · V
100X scale: ppm = 1.9 · V

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TABLE 2. CALIBRATION DATA, VULCANUS MISSION II

Postflight

Coulometer (mV)	Range (ohms)	Concentration (ppm)	Chemiluminescent analyzer (V)	Scale
0.0	10	0.0	0.0	100X
0.80	10	13	2.6	100X
0.66	10	10	2.2	100X
0.48	10	7.6	1.8	100X
0.32	10	5.0	1.2	100X
0.45	10	7.1	1.0	100X
1.03	10	16	1.4	100X
0.0	10	0.0	0.0	10X
0.32	10	5.0	10.1	10X
0.19	10	3.0	5.9	10X
0.13	10	2.1	3.7	10X
0.05	10	0.79	2.1	10X
0.02	10	0.32	0.9	10X
0.40	100	0.63	1.2	10X
0.66	100	1.0	1.8	10X
0.14	10	2.2	4.8	10X
0.0	100	0.0	0.0	1X
0.09	100	0.14	3.4	1X
0.15	100	0.24	5.3	1X
0.34	100	0.54	9.1	1X
0.37	100	0.58	10.1	1X

Equation of least squares line:
1X scale: ppm = 0.05 · V
10X scale: ppm = 0.50 · V
100X scale: ppm = 5.3 · V

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TABLE 3. CALIBRATION DATA, VULCANUS MISSION III

Preflight

Coulometer (mV)	Range (ohms)	Concentration (ppm)	Chemiluminescent analyzer (V)	Scale
0.0	50	0.0	0.0	1X
0.17	50	0.54	4.9	1X
0.19	50	0.60	10.0	1X
0.19	50	0.60	1.1	10X
0.46	50	1.5	1.4	10X
0.63	50	2.0	1.9	10X
0.19	10	3.0	3.3	10X
0.15	10	2.4	2.8	10X
0.20	10	3.2	3.9	10X
0.31	10	4.9	5.7	10X
0.35	10	5.5	0.8	100X
0.61	10	9.6	1.0	100X
0.90	10	14	1.6	100X

Postflight

Coulometer (mV)	Range (ohms)	Concentration (ppm)	Chemiluminescent analyzer (V)	Scale
0.0	90	0.0	0.0	1X
0.0	90	0.0	1.7	1X
0.88	90	1.7	10.0	1X
0.43	50	1.5	0.8	10X
0.23	10	3.9	1.9	10X
0.38	10	6.4	3.5	10X
0.47	10	7.9	4.7	10X

Equation of least squares line: 1X scale: ppm = 0.12 · V
10X scale: ppm = 1.2 · V
100X scale: ppm = 12 · V

TABLE 4. HCl MEASUREMENTS, VULCANUS MISSION I

Plume penetration	Time	Altitude (ft)	Distance (mi)	Chemiluminescent analyzer Volt	Scale	Conc[a] (ppm)
1	1317	600	1.5	4.1	1X	0.08
2	1318	1000	1.5	5.4	1X	0.11
3	1319	700	0.5	6.0	1X	0.12
4	1319	600	1.5	6.0	1X	0.12
5	1320	300	0.5	0.6	10X	0.11
6	1327	600	0.25	6.0	1X	0.12
7	1329	500	0.25	13.0[b]	1X	0.26
8	1331	400	0.25	8.5	10X	1.6
9	1335	400	0	9.6	10X	1.8
10	1339	350	0	12.0[b]	10X	2.3
11	1343	400	0	4.4	10X	0.84
12	1345	600	0	10.4[b]	10X	2.0
13	1347	800	0	9.6	10X	1.8
14	1356			4.6	10X	0.87
15	1359			13.7[b]	10X	2.6

[a]Concentration over background (average background: 0.11 ppm)
[b]Offscale response, voltage estimated by peak triangulation.

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TABLE 5. HCl MEASUREMENTS, VULCANUS MISSION II

Plume penetration	Time	Alt. (ft)	Dist. (mi)	Chemiluminescent Volt	Scale	Conc[a] (ppm)	Coulometer Conc. (ppm) Slope	Area
1	1059			8.6	1X	0.43	NQ[b]	
2	1102	800	1.1	1.8	1X	0.09		
3	1104	600	1.0		1X			
4	1106	400	1.0		1X			
5	1107	200	1.0		1X			
6	1110	1000	1.0		1X			
7	1111	1600	0.5		1X			
8	1112	1200	0.5	7.1	1X	0.36	NQ	
9	1116	1400	0.5	11.6[c]	1X	0.58	NQ	
10	1118	1200	0.5	2.5	1X	0.13	0.11	0.25
11	1120	1000	0.5	1.6	1X	0.08	0.07	0.14
12	1121	800	0.5	1.8	1X	0.09	0.13	0.32
13	1122	600	0.5	1.3	1X	0.07	NQ	
14	1124	400	0.5	1.4	1X	0.07	0.09	0.11
15	1126	200	0.5	1.9	1X	0.10	0.07	0.22
16	1130			2.2	1X	0.11		
17	1134	1100	3.0	2.4	1X	0.12	0.17	0.30
18	1143	1400	0.25	2.7	1X	0.14	0.06	0.15
19	1148	1100	0.25		1X			
20	1150	1000	0.25		1X			
21	1151	800	0.25	7.2	1X	0.36		
22	1152	600	0.25	0.7	1X	0.04	NQ	
23	1155	800	0.25	0.9	1X	0.05	NQ	
24	1157	800	0.25	7.2	1X	0.36	NQ	
25	1200	800	0.25	24.6[c]	1X	1.23	1.5	1.4[d]
26	1205	700	0.5	0.7	10X	0.35	0.81	1.1
27	1206	700		1.6	1X	0.08	NQ	
28	1207	700		4.1	1X	0.21	NQ	
29	1209			2.1	10X	1.10	1.6	1.3[d]
30	1213			1.8	10X	0.90	1.8	1.4
31	1214			1.5	10X	0.80	1.3	1.2
32	1216			1.5	10X	0.80	1.2	1.3

[a] Concentration over background (average background: 0.17 ppm).
[b] NQ = coulometer response not quantifiable.
[c] Offscale response, voltage estimated by peak triangulation.
[d] Offscale response, area estimated by peak triangulation.

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TABLE 6. HCl MEASUREMENTS, VULCANUS MISSION III

Plume penetration	Time	Alt. (ft)	Dist. (mi)	Chemiluminescent Volt	Scale	Conc[a] (ppm)	Coulometer Conc. (ppm) Slope		Area
1	1044	1100	1.0	0.4	1X	0.05		NQ[b]	
2	1049	800	0.5	6.2	1X	0.74	0.13		0.17
3	1050	600	0.5	1.7	1X	0.20		NQ	
4	1052	400	0.5	1.7	1X	0.20		NQ	
5	1054	200	0.5	0.8	1X	0.10		NQ	
6	1056	100	0.5	0	1X	0			
7	1059	1100	0.5	1.1	1X	0.13			
8	1106	800	0.25	2.9	1X	0.35	0.63		1.1
9	1108	800	2.0	4.4	1X	0.53	0.81		1.5
10	1110	800		3.6	1X	0.43	0.49		1.0
11	1114	2600	0	2.4	1X	0.29		NQ	
12	1123	2600	7.8	0.8	1X	0.10		NQ	
13	1125	2700	0-3.4	0	1X	0			
14	1130	2800		1.2	1X	0.14			
15	1136	800	0.25	0.3	1X	0.04		NQ	
16	1137	800	0.25	1.4	1X	0.17	0.39		0.71
17	1139	800	0.25	12.0[c]	1X	1.4	3.0		2.8[d]
18	1141	500	0.25	17.4[c]	1X	2.1	2.7		2.4[d]
19	1150	500	0.25	4.0	1X	0.48		NQ	

[a] Concentration over background (average background: 0.25 ppm).
[b] NQ = coulometer response not quantifiable.
[c] Offscale response, voltage estimated by peak triangulation.
[d] Offscale response, area estimated by peak triangulation.

Report OEHL TR-78-87

CEEDO-TR-78-38

LAND BASED ENVIRONMENTAL MONITORING AT JOHNSTON ISLAND
- DISPOSAL OF HERBICIDE ORANGE -

PREPARED BY:

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

As a part of the U.S. Air Force final Environmental Impact Statement of incineration of Herbicide Orange from Johnston Island, the Air Force stated that a monitoring program would be conducted to demonstrate that the land-based transfer operations were carried out in an environmentally safe manner. Battelle, Columbus Laboratories conducted these monitoring programs on Johnston Island. The monitoring of at-sea incineration operations were conducted by TRW and have been reported elsewhere.

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19.

Concentrations of 2,4-D and 2,4,5-T found in the ambient air and water samples were minimal. No TCDD was detected in any air or water samples. No changes that could be attributed to the operations were noted in indigenous plant or bird populations. Results of quality control sampling revealed that the required level of drum cleaning was achieved. Industrial Hygiene evaluations of the land-based operations revealed that only minor accidents or injuries occurred and exposure of workers to airborne 2,4-D and 2,4,5-T were well below permissable levels.

No adverse consequences of the minimal release of Herbicide Orange into the Johnston Atoll environment were observed.

This report was submitted in fulfillment of Contract No. F08635-76-D-0168 by Battelle, Columbus Laboratories, under sponsorship of the U.S. Air Force. This report covers the period May 1977 to Sept. 1978.

PREFACE

Headquarters US Air Force Logistics Command, Wright-Patterson AFB, OH, the office of primary responsibility for the project to dispose of Herbicide Orange, designated the US Air Force Occupational and Environmental Health Laboratory (USAF OEHL) as the agency responsible for land based environmental monitoring of this project. The Armament Development and Test Center, Tyndall AFB, FL negotiated and monitored this contract with Battelle Columbus Laboratories, Columbus, OH. Personnel of the USAF OEHL served as Technical Representatives of the Contracting Officer.

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USAF CEEDO TR-78-38

FINAL REPORT

on

LAND BASED ENVIRONMENTAL MONITORING AT JOHNSTON ATOLL - DISPOSAL OF HERBICIDE ORANGE

to

U.S. AIR FORCE OCCUPATIONAL AND ENVIRONMENTAL HEALTH LABORATORY

September, 1978

PART I

by

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U.S. Air Force Project Officer: [redacted] Maj., USAF

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DETAILED ENVIRONMENTAL ANALYSIS
OF PROJECT PACER HO

I. INTRODUCTION MATERIAL

This report is Part I of a three-part report on the environmental consequences of a project conducted on Johnston Island, labeled Project Pacer HO, designed to remove and incinerate the stocks of Orange Herbicide stored on Johnston Island since 1972. The three parts to the report are as follows:

Part I Executive Summary

Part II Detailed Environmental Analysis of Project Pacer HO

Part III Supporting Data

In April, 1970, the Secretaries of Agriculture, HEW, and Interior jointly announced the suspension of certain uses of 2,4,5-Trichlorophenoxy acetic acid. As a result the Department of Defense suspended the use of Orange Herbicide since this herbicide consists of approximately 50 percent 2,4,5-T and 50 percent of 2,4-Dichlorophenoxy acetic acid. This suspension left the Air Force with 1.5 million gallons of Orange Herbicide (HO) in Vietnam and 0.8 million gallons in Gulfport, Mississippi. In September, 1971, the Department of Defense directed that the Orange Herbicide in Vietnam be returned to the United States and that the entire 2.3 million gallons be disposed of in an ecologically safe and efficient manner. The 1.5 million gallons were moved from Vietnam to Johnston Island for storage in April, 1972.

The cost of maintaining the storage areas, and the ever present danger from the stored HO stocks, let the Air Force to conduct a study to develop procedures for the ecologically safe, efficient, and, if possible, low-cost disposal of the approximately 2.3 million gallons of HO.

As part of their final EIS,* the Air Force stated " a monitoring

* The final EIS for incineration of HO at sea. There were public hearings, and an EPA ocean dumping permit was issued.

program will be conducted to document herbicide exposures and environmental exposures should they occur. It is anticipated that this program will generate sufficient data to demonstrate that personnel and environmental safety of this operation". This report contains the results of the land-based monitoring program conducted during the HO disposal program on Johnston Island.

2. THE ORANGE HERBICIDE DISPOSAL PROGRAM

The Orange Herbicide stored on Johnston Island represented approximately 25,000 drums of 55-gallon capacity. These were stored in rows stacked three high in an area of about 3.5 acres on the northwest corner of the island, where the prevailing winds rapidly removed any atmospheric HO away from Johnston Island and the atoll and dispersed it in the open Pacific. There were no other locations containing HO.

Prior to the disposal operation, the sea environment caused drums to corrode and thus leak. The leakers were taken to a dedrumming facility where they were allowed to drain and were redrummed and restacked, while the old drums were crushed and stacked. The leaked HO caused a persistent and intense odor downwind of the drumyard.

For the HO disposal program, the dedrum facility was modified to allow transfer of the material from drums to bulk carriers for transport to an incinerator ship. The facility and operation basically consisted of a concrete pad and two fabricated metal racks upon which the full drums were placed in four groups of 12 each. Drums were transported from the drum yard to the racks in sets of four. The drums were then drained into a collection sump and spray rinsed twice with diesel fuel, exceeding the quality EPA requirements of 90 percent confidence of 85 percent residual removal.

After drainage, the drums were carried to the crusher, which consisted of a large weight suspended between two I-beams. The drums were compressed along the longitudinal axis.

Crushed drums were bundled and placed in storage on the seaward (downwind) side of the dedrum/crushing area. A large plastic sheet was used to protect the crushed drums from rain. 2090

Herbicide was pumped from the collection sump into standard Air Force R-5* refueling trucks via a dry coupler bottom connection.

The refuelers transported the HO to the wharf via a road which was set aside for this purpose. Non-project related vehicle traffic was forbidden along this section of roadway.

Once the refueler had reached the main wharf, the procedure was essentially reversed. The same type of dry couplings and spill prevention equipment were employed to pump out the tank and bulk transfer the material to the M/V Vulcanus, a ship designed for the incineration of hazardous materials. The area in which the pumps and hoses were located was diked with sand bags and plastic so that potential spillage could be contained.

The drum rinsing activities were subjected to constant monitoring to assure compliance with the EPA requirements. The second rinse from every 100th drum was sampled and analyzed for HO. A quality control chart was compiled from these analyses to assure that EPA requirements were being met on continuous basis.

A certified industrial hygienist was present during the complete operation. In addition to preventing deficiencies in personal hygiene and safety, he was responsible for the siting and operation of personnel samplers.

3. AIR

Surface trade winds were essentially constant throughout the study period with winds from the ENE to ESE at 10 to 20 mph on most days. Being remote from other terrestrial environments, the air at Johnston Atoll is clean, with none of the pollutants normally associated with urban areas.

Air sampling for 2,4-D and 2,4,5-T was accomplished utilizing Chromosorb 102 as an adsorption medium, a granular polymer well suited for collection of chlorinated hydrocarbons. This material was packed in micropipet tubes through which a sample volume of 150 liters was pulled at the rate of 0.50 liters/minute.

* On termination of the project, all equipment was decontaminated with a diesel fuel wash, which was then loaded on the ship.

Air sampling for the herbicide contaminant, tetrachlorodibenzo-para dioxin (TCDD), was accomplished utilizing benzene as the absorption medium. The apparatus consisted of a train of four impinger columns, the first two contained benzene, and the final two contained activated carbon to trap evaporating benzene.

In order to determine the impact of dedrumming and transfer operations on the air environment, four monitoring areas were chosen for sampling. These were the meteorology building (located 2 miles upwind for use as a background station), the wharf (300 feet downwind of the loading area), the dedrum facility (to determine occupational exposures), and a point 310 feet downwind of the dedrum facility. The chromosorb samples taken over the duration of dedrumming and loading operations yielded the following observations:

- Concentrations in samples taken at the upwind meterology building ranged from levels below detection to trace amounts (less than 1 microgram per cubic meter).
- There was little difference between data recorded at the meterology building and that at the wharf. The impact on air due to the loading procedure at the wharf was negligible.
- Total herbicide* concentrations detected 310 feet downwind of the dedrum site ranged from 3 to 23 micrograms per cubic meter.
- Concentrations inside the dedrum facility were only slightly higher, from 7 to 27 micrograms per cubic meter.

The OSHA 8-hour time weighted average allowable concentration for either/or 2,4-D and 2,4,5-T acids is 10 milligrams per cubic meter. All of the ambient measurements were negligible in comparison to the OSHA TWA.

The analytical results on air samples in the dedrumming facility show that personnel exposures were two to three orders of magnitude below the TLV of 10 mg/cubic meter for either 2,4-D or 2,4,5-T. No injuries or illness that occurred during dedrumming could be attributed to HO exposure.**

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* Concentration reported as sum of 2,4-D and 2,4,5-T.

** Two cases occurred when HO was splashed in eyes. The eyes were immediately flushed without consequence.

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Analysis of twenty benzene impinger samples showed all samples to contain less than the minimum detectable limit (MDL) of TCDD. MDL's ranged from 6.6 to 20.3 nanograms per cubic meter.

The impact of the disposal operation on the atmospheric environment was thus found to be insignificant.

4. WATER

The existing water environment of Johnston Island consists of several components of the hydrologic cycle. The saltwater cycle is comprised of the lagoon circulation and the groundwater underlying the island while the freshwater cycle includes the rainfall and the drinking water and sanitary system. Johnston Island's water system uses both fresh and saltwater.

The saltwater around Johnston Island and the freshwater system have been monitored for the presence of 2,4-D and 2,4,5-T since 1973. The maximum concentrations observed in the offshore area near the herbicide storage were on the order of 3 ug (micrograms) 2,4-D/liter and 0.6 ug 2,4,5-T/liter and those near the saltwater intake were 2.3 and 0.7 ug/l, respectively. The other two offshore sites exhibited maximum concentrations below 0.5 ug/l. Sample taken in the distillation plant never showed measurable concentrations, yet one sample from the storage reservoir showed 1.6 ug/l of 2,4,5-T. By comparison, most stringent standard appears to be the National Interim Primary Drinking Water Standard at 0.1 mg 2,4-D/l.

The sampling program for the water environment during the operation consisted of four offshore sites and two onshore sites. Samples were taken of the water near the main wharf at two points just off of the bow of the ship at 10-11 meters of depth. The saltwater intake for the desalination plant was sampled daily at about the same times as for the wharf samples and at a depth of five to six meters (about one meter from the bottom). The third offshore location sampled on a regular basis was the sewage outfall on the south side of the island. The fourth offshore site, sampled four times, was the shallow offshore area near the drum storage yard.

The location of one of the onshore samplers was in the fresh-water system equilization tanks immediately downstream from the desalination plant and prior to chlorination. The other onshore sampler monitored sewage in a sump near a lift station.

The water in the vicinity of the intake for the desalination plant was monitored on a daily basis. The level of herbicide ranged from below detection limits (0.1ppb) to 3.43 ppb. Over 50 percent of the samples analyzed had concentrations below 0.2 ppb, a factor for 500 less than the drinking water standard.

Potable water samples taken before the operation showed trace concentrations of 2,4-D in one sample. During the operation, herbicide concentrations* were found at trace levels (0.1 - 0.2 ppb) in 20 percent of the samples, again a factor of 500 below the drinking water standard.

Water samples were taken on alternate days in proximity to the sewage outfall, which is approximately 550 feet offshore. Only trace level of either 2,4-D or 2,4,5-T (0.1 - 0.2 ppb) were detected in the samples analyzed.

The sewage samples, contaminated from the washing of work clothes showed concentrations of herbicide** of from 20.7 ppb to 137.8 ppb. An estimated total of 0.94 pounds of herbicide was released into the sewage system, a markedly small figure in comparison to the amount handled.

Water samples were taken offshore and downwind of the dedrum facility four time during the operation. One sample contained trace levels of 2,4,5-T while all other samples analyzed had no detectable levels.

Water samples were taken on a daily basis in the vicinity of the wharf, which included special grab samples during the two deballasting periods from the M/V Vulcanus. The water in the immediate vicinity (10 feet) of the deballast discharge contained levels of herbicide that ranged from below detection to 8,117.7 ppb. The concentrations of these chemicals in the composited water samples at the wharf in the days following the deballasting illustrated an effective dilution process. The concentrations of herbicide dropped from 8116.7 to 1.90 to .75 ppb in the 2 days following the second deballast period. Including the deballasting periods, the concentrations of both 2,4-D and 2,4,5-T stayed below 0.2 ppb (trace) in over 50 percent of the samples taken.

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* Concentration is reported as sum of 2,4-D and 2,4,5-T.
** Concentration is reported as sum of 2,4-D and 2,4,5-T.

The 11 water and sewer samples analyzed to date for TCDD show no measurable concentrations (MDL's ranged from 3.6 to 8.0 nanograms per liter).

With the exception of the deballast operation, the effect of the disposal operation on the aquatic environment was found to be insignificant. The deballast operation produced no signs of biotic impact, and aquatic concentrations decreased rapidly to nearly undetectable levels after deballasting.

5. BIOTA

The terrestrial environment of Johnston Atoll has been extensively studied. Although large numbers of aquatic, terrestrial, and avian species have been identified at Johnston Atoll, there is a paucity of native species, the atoll being a link in a migratory chain.

The large number of birds present on the atoll were nearly exclusively found on the three islands, unaffected by the presence of the disposal operation on Johnston Atoll. No signs of aquatic distress or change were noted in any aquatic community during disposal operations.

Young, potted tomato plants, Lycopersicon esculentum, 25-38 cm in height were used as biomonitoring organism to detect the presence of Orange Herbicide in the air. Tomato plants were used because of their sensitivity to HO damage in the parts per trillion range. The injury symptom typical of HO damage, know as epinastic growth, is described as a curling and/or twisting of the apical portion of the plant. Fourteen air biomonitoring sites or stations were selected on Johnston Island.

Three days of preoperational observations indicated that concentrations of Orange Herbicide sufficient to cause injury to the tomato plants only at two of the 14 stations. These two stations were approximately 500 feet from the dedrumming site and directly downwind. During the operation, these two stations experienced the most frequent and most severe injury. Occasional damage was experienced at two peripherally downwind stations.

However, during the monitoring program, no significant physical or morphological changes were noted in any indigenous plant species on Johnston Island attributable to Orange Herbicide. 2095

6. QUALITY CONTROL OF DRUM RINSING

Statistical sampling was made of drum rinse samples to assure the residual in the drums was less than that which would be left by the EPA triple rinse procedure. The drum rinse procedure was modified several times to improve removal; the drums on the average exceeded the required triple rinse efficiency.

7. SITE RECLAMATION

The U.S.A.F. has developed a continuing soil sampling program on Johnston Island, in the area of the drum storage yards. The purpose of the program is to monitor the degradation of HO in the old seepage areas from drum storage, so as to assure that the residual poses no environmental threat.

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