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16. ABSTRACT
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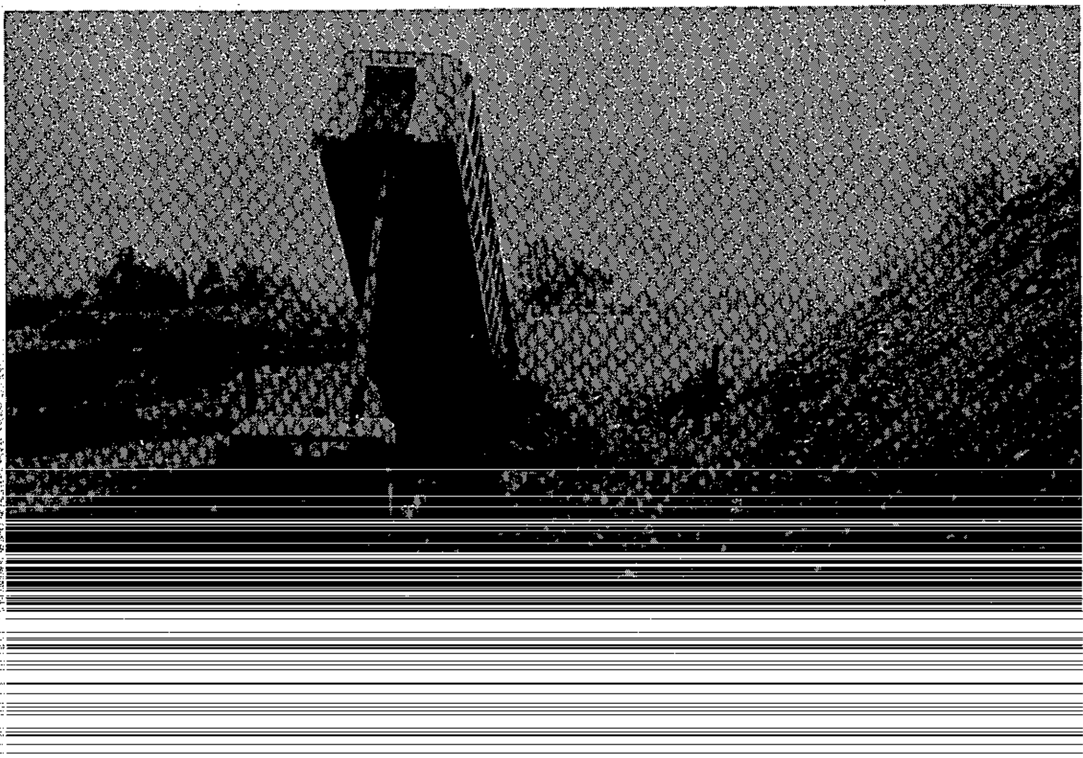

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CALIFORNIA DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

September 1978

FHWA No. A-8-7
TL NO. 657084

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information this final research project report titled:

ANALYSIS OF SOLID WASTE MATERIALS IN
HIGHWAY OPERATIONS

Study made by .... Enviro-Chemical Branch

Under the Supervision of .... Earl Shirley, P.E.

Principal Investigator .... Richard B. Howell, P.E.

Report Prepared by .... Richard B. Howell, P.E. and
Karl L. Baumeister, P.E.

Very truly yours,

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

Attachment

RBH:lb

ACKNOWLEDGEMENTS

The research was conducted under the direction of Richard Howell. The project engineers who had a major part in the study included:

Eric Torguson	1973-74	Now with Water Resources Control Board
Richard Wasser	1974-75	" " " "
Karl Baumeister	1977-78	TransLab

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Joe Halterman	Now with State Energy Commission
Martin Nolan	TransLab
Joe Pantalone	Now with Air Resources Board
Donald Nakao	TransLab
David Smith	"
Patrick Monahan	"
Philip Caruso	"
James Racin	"
Gary Winters	"
Richard Spring	"

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Jim Bouler	Resident Engineer, District 04
Jim Ross	Environmental Section, District 04
Joe Bowles	Materials, District 04
Charles Jackson	Headquarters Construction
George Chulick	Headquarters Maintenance

Delineation of the final graphs was completed by Marion Ivester and the manuscript was typed by Lydia Burgin.

To all of these individuals, we give our sincere thanks.

Special thanks is given to Byron Lord of the Federal Highway Administration Washington Office for his review and helpful comments.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The National Environmental Policy Act of 1969 and the California Environmental Quality Act of 1970 require that all potential environmental impacts associated with proposed projects be discussed. In reviewing Caltrans environmental documents, one area that appeared to need additional information was the environmental aspects related to surface and groundwater of the disposal of solid wastes that are generated either during construction or during maintenance.

Solid wastes that may be generated during construction include: 1) brush, timber and other vegetal matter from clearing and grubbing; 2) debris from obliterated pavements, bridges, and other structures; 3) rocks, soil, and debris; and 4) wastes from the contractor's equipment or operation.

Maintenance wastes include items such as: 1) litter and roadside debris; 2) vegetal material from landscaped areas; 3) sediments, rocks, and boulders resulting from erosion; 4) downed trees and other materials; and 5) animal carcasses.

Procedures for quantifying possible amounts of various solid waste for proposed route alternatives are not readily available. During the project's design, most construction-related solid waste is identified from field surveys. Estimates of solid waste quantities for maintenance are usually determined from knowledge of experienced personnel in the area and records of maintenance program activities.

Guidelines for the disposal, recovery, or recycling of solid waste are not readily available. Most information that is available is related to processing urban wastes or a specific industrial waste. Much of the current literature is related to resource recovery and energy development.

This study was initiated to fill in the above-mentioned gaps in knowledge. Specifically, it was to provide environmentalists, designers, construction and maintenance personnel, with information on: 1) estimating possible solid waste quantities for construction projects and long-term maintenance activities, 2) alternative disposal methods, and 3) the effects on groundwater of utilizing brush and other vegetation within highway embankments.

There were several delays during the course of the study due to personnel transactions and construction cutbacks during the Caltrans funding crisis. Five persons who were directly involved with portions of the study left Caltrans during various stages of the project. Thus, although work began on the study in March of 1973, there was an 18 month period from September 1975 to March 1977 when no work was accomplished.

The slowdown in new construction also precluded performing field studies on several construction projects that involved solid waste disposal features. Only one field site was analyzed in detail as a result.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are derived from the study:

1. There were no significant impacts on groundwater or surface water in 19 months of monitoring over a 3 year period due to underground disposal of vegetation from the contractor's clearing operation at Geyserville.

2. At the Geyserville vegetation disposal site, the results show that leachate from the decomposing vegetation has higher levels of Chemical Oxygen Demand, Biochemical Oxygen Demand (5-day) and color units, and contains more Tannin and Lignin than groundwater. The filtering action of the soil, additional chemical reactions, or dilution, apparently reduced the effects of the leachate on groundwater as observed in downstream wells.

3. Significant quantities of solid waste are found along most sections of California's highways. Disposal constitutes a major maintenance effort. Waste quantities from mechanical sweepings and manual litter pickup did correlate with vehicle miles total (VMT). No significant correlations were found for the other materials.

4. In the more mountainous regions of the state, significant quantities of sediments and rocks are cleared from the highway right-of-way annually. The most common disposal methods were stockpiling for future use, filling low spots, or side-casting in emergency situations.

5. There are feasible alternatives to the present methods for the disposal of some solid wastes generated in the annual maintenance of highways. The most promising alternatives appear to be:

a. Recycle the metals.

b. Reuse sand, aggregate, and other soil materials in embankments, and resurfacing.

c. Sell some materials to the public or commercial users.

d. Chip brush and timber and utilize as mulches.

e. Recycle abandoned tires as an energy source, erosion control matting, or embankment reforcement.

6. Coordination with local municipalities or regional governments in cooperative disposal of wastes appears to be limited mainly to the use of existing dumps and land fills.

7. New construction has decreased significantly in California and does not appear to be an important source of solid waste materials in the near future.

8. The three most common difficulties for the disposal of construction wastes mentioned by resident engineers are: burning restrictions, lack of conveniently located disposal sites, and high costs for disposal at land-fill sites.

As a result of these findings, the following recommendations are made:

1. Since there were no significant impacts on groundwater or surface flows as a result of burying vegetal wastes in a highway embankment, it is recommended that this method of disposal be used where feasible and when properly engineered.

2. Any further monitoring of groundwater or surface flows related to buried vegetal wastes should be restricted to: 1) areas of high rainfall in California, and 2) areas where groundwater is within 10 feet of the elevation of the disposal site, or 3) sites where high-quality surface flows exist within 100 feet of a disposal site. Any monitoring should be a joint effort of the Regional Water Quality Control Board, Solid Waste Management Board, and/or Department of Health.

3. Solid wastes associated with new construction should be incorporated within the project or recycled to the extent possible. Chipping trees and brush for a mulch and burying pavement and other debris, are methods that should be considered in design. Disposal sites on, or near, the construction project should be developed where feasible.

4. Further research on leachate impacts from buried wastes should be conducted in the laboratory, rather than in the field, using soil columns in cylindrical tanks. Various methods of burying the wastes could be examined and alternate hydraulic loading schemes utilized on different soils to study potential impacts and develop appropriate guidelines.

5. Wastes such as steel-mill slag, abandoned tires and processed sewage sludge should be considered in the design stage for possible use in embankments.

6. Further studies should be conducted to develop correlations for estimating potential quantities of waste from small slides, ditch cleaning and garbage from rest stops.

(1 ft = .305 m)

7. In areas where disposal locations are being decreased, it may be advantageous to develop a regional plan for the disposal, re-use or recycling of solid wastes. The plan may include locations or materials and be developed in conjunction with other state or local agencies.

IMPLEMENTATION

Copies of this report will be distributed to Caltrans Districts and Headquarters Offices and the Federal Highway Administration for implementation. Other interested parties, such as the Solid Waste Management Board, will be provided copies.

The Offices of Maintenance and Construction will be responsible for implementing the recommentations and findings of this study. The TransLab will assist in technical aspects as requested. The Caltrans Districts can utilize this information in the preparation of environmental documents.

This report also can serve as the basis for additional studies on solid waste disposal and environmental effects as outlined in the Conclusions and Recommendations.

ESTIMATES OF SOLID WASTES FROM HIGHWAY MAINTENANCE

To estimate potential quantities of solid wastes from maintenance, past records of maintenance activities were reviewed. The Caltrans Office of Maintenance maintains records of the quantities of material associated with various maintenance activities. A detailed listing of this information is shown in Appendix A. A summary of the statewide information for 1974-75 is shown below.

Maintenance Program Activity	Statewide Quantity		Statewide Total Cost
Dig out pavement or base	56,600	cy	$2,564,000
Manual litter pick up	63,100	cy	2,524,000
Ditch cleaning (invert 10')	9,542,000	lf	1,700,000
Mechanical sweepings	44,200	cy	1,486,000
Remove drift or storm deposited material	297,200	cy	932,000
Drainage structure cleaning (horiz. drains, underdrains, slotted drains)	150,700	ea	925,000
Litter/Freeway Patrol	911,000	man-miles	887,500
Roadside section restoration (bench cleaning, scaling)	339,200	cy	736,000
Roadside material replacement	202,300	cy	621,000
Trimming trees (includes chipping)	44,300	ea	442,000
Remove small slides	192,000	cy	439,000
Chipping (shrubs or brush cuttings)	28,750	cy	372,000
Channel cleaning (invert 10')	156,470	cy	359,000
Drainage structure cleaning (drop inlets, culverts, or overside drains)	8,550	cy	258,000
Prune or remove small trees or shrubs (no chipping)	38,600	ea	177,000
Tree removal (includes chipping)	6,360	ea	164,000
Mulching	498,000	cf	151,000
Mowing non-lawn areas	1,775	ac	30,000
Garbage from roadside rests	52,000	cy*	-
Animal disposal	10,630	ea	-

*1977 data

1 cy = 0.76 m^3
1 cf = 0.028 m^3
1 ft = 0.305 m
1 mi = 1609 m
1 ac = 0.4047 hectare

A breakdown of the various quantities by district is shown in Appendix A. Figure 1 shows the geographical boundaries of each Caltrans district.

The number of miles of highway for both rural and urban areas varies from district to district as do the vehicle-miles that are traveled. The following table shows this information for the 1974-75 period.

Table 1

Mileage Data by District

District	Lane-Miles	Log Miles			Vehicle Miles Total (VMT) (Millions)		
		Urban	Rural	Total	Urban	Rural	Total
01	2,647	25	994	1,019	145	996	1,141
02	4,018	50	1,626	1,676	224	1,400	1,624
03	4,580	215	1,252	1,467	1,982	2,513	4,495
04	5,890	669	696	1,365	12,482	2,316	14,798
05	6,335	148	915	1,063	1,058	2,070	3,128
06	5,290	144	1,640	1,784	867	2,932	3,800
07	8,148	941	490	1,431	23,680	2,215	25,895
08	6,225	272	1,345	1,617	2,602	2,796	5,398
09	2,264	5	963	968	21	768	789
10	4,422	129	1,366	1,495	1,062	2,826	3,888
11	4,420	276	962	1,238	4,257	1,531	5,788
Statewide	54,239	2,874	12,249	15,123	48,380	22,363	68,844

1 mi = 1609 m

To develop a method for estimating quantities of waste for a given route, correlations were tried between the solid waste quantities and vehicle miles total, lane-miles, log-miles, and precipitation. Correlations were developed for two solid wastes as follows:

Solid Waste	Correlation	Correlation Coefficient
Mechanical sweepings	Vehicle miles total	0.975
Manual litter pickup	Vehicle miles total	0.959

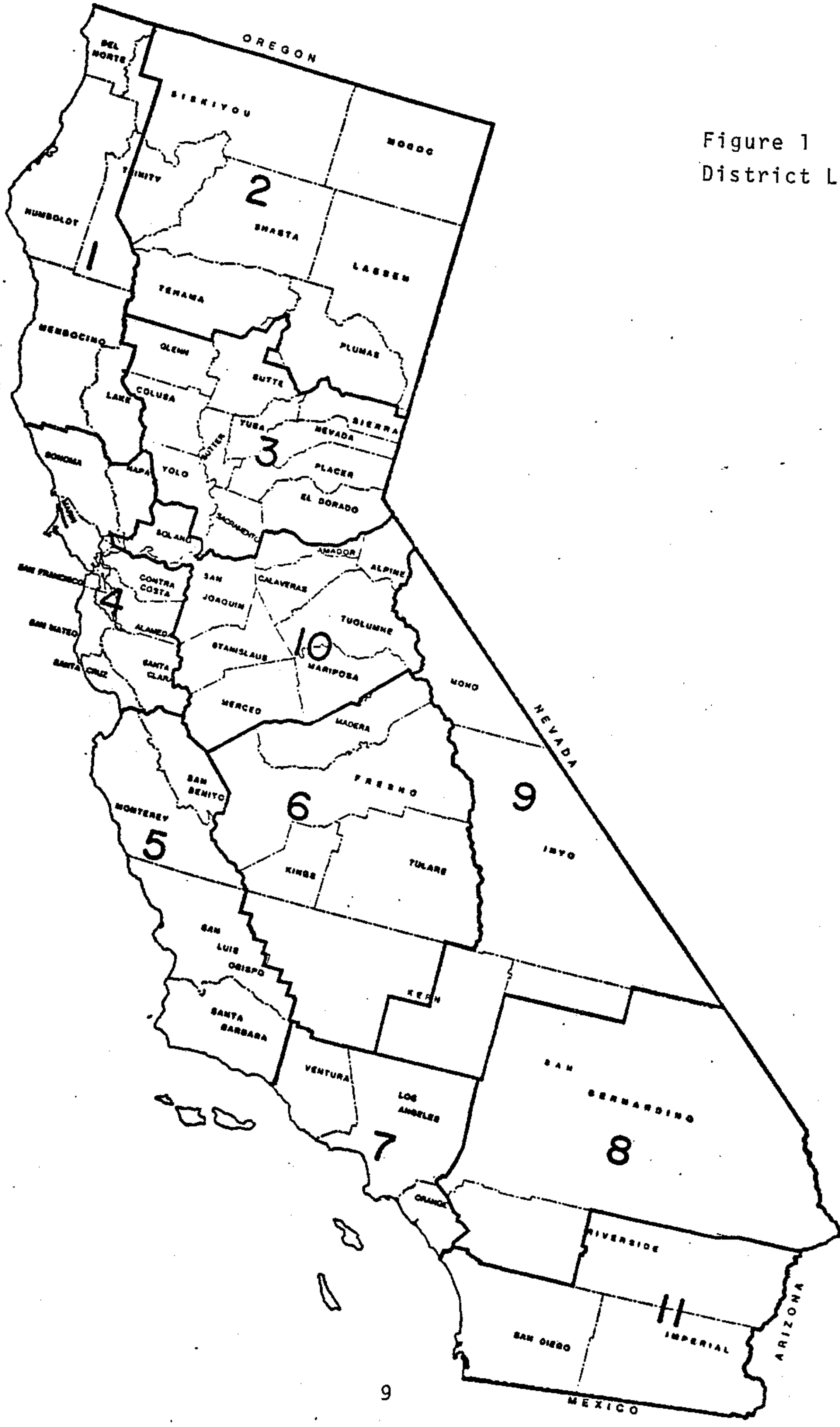


Figure 1
District Locations

Other maintenance activities did not correlate very well. A more in-depth analysis of the data would be required to determine why this was so and possibly how to segregate the data to develop localized or regional predictive equations.

Four specific maintenance activities were reviewed in detail. The remaining activities were reviewed briefly and are lumped together under "other wastes".

1. Mechanical Sweepings

The quantities of mechanical sweepings and vehicle miles total in 1974-75 for each district are as follows:

Table 2

Quantities of Mechanical Sweepings

District	Mechanical Sweepings CY/YR	Vehicle Miles Total x 10^6
01	680	1,140
02	540	1,624
03	2,760	4,495
04	11,470	14,800
05	2,070	3,130
06	2,340	3,800
07	14,400	25,895
08	2,480	5,400
09	610	790
10	2,080	3,890
11	4,770	5,790
Statewide	44,200	68,844

1 CY = 0.76 m^3
1 mi. = 1609 m

The quantities of sweepings only includes the material collected with mechanical street sweepers and not with manual or other methods.

A regression analysis of the data exhibited good correlation as shown in Figure 2. The relationship between the quantity of mechanical sweepings (M_s) in cubic yards/year and vehicle miles total/year (V_m) is expressed by:

$$M_s = 152 + 0.60\ V_m\ (10^{-6})$$

This relationship can be used to estimate the probable annual amount of mechanical sweepings that will be generated on future projects.

2. Manual Litter Pick up

Quantities of manual pick up and vehicle miles for 1977-78 were available and are more representative of recent data than 1974-75. They are as follows:

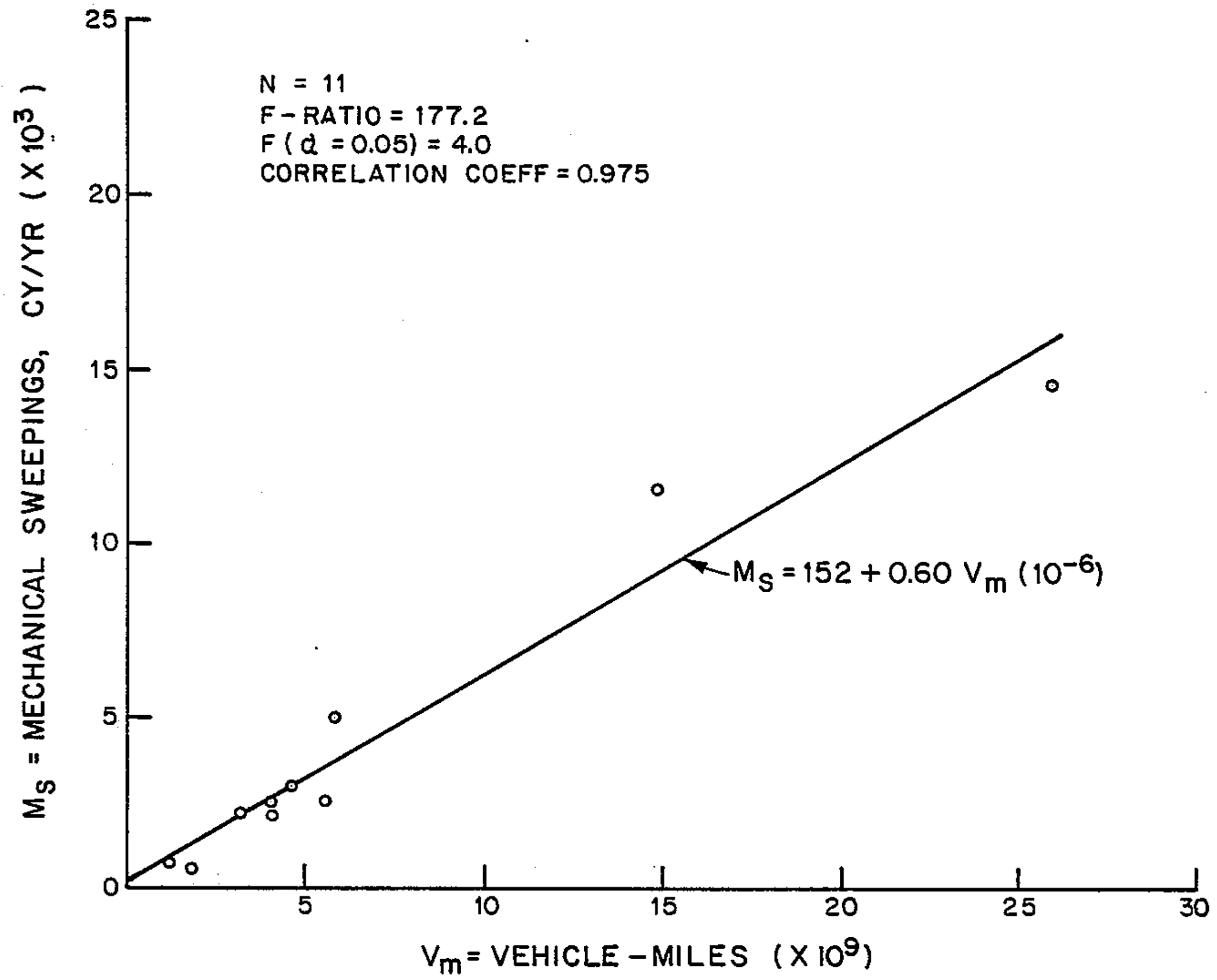
Table 3

Quantities of Litter*

District	Litter CY/YR	Vehicle Miles Total X 10^6
01	1,300	1,350
02	965	1,660
03	5,330	5,240
04	18,980	16,840
05	1,735	3,510
06	3,345	4,425
07	29,220	29,300
08	7,920	6,430
09	290	940
10	1,140	7,660
11	1,180	6,675
Statewide	71,400	84,030

1 CY = 0.76 m^3
1 mi. = 1609 m

*1977-78 data



MECHANICAL SWEEPINGS VS VEHICLE MILES TOTAL
(1974-75 DATA)

1 cy=$0.76m^3$
1 mi = 1609m

FIGURE 2

The litter quantities reflect the general litter pick up along roadways and do not reflect quantities of wastes derived from waste cans at vista points or other roadside facilities. The Litter Freeway Patrol, which patrols and picks up litter from the roadway to prevent accidents, is also reported as a separate maintenance activity.

A regression analysis of the data indicates a good correlation as shown in Figure 3. The following equation shows the relationship for estimating litter quantities (L_m) in cubic yards/year and vehicle miles/year (V_m):

$$L_m = -1586 + 1.057\ V_m(10^{-6})$$

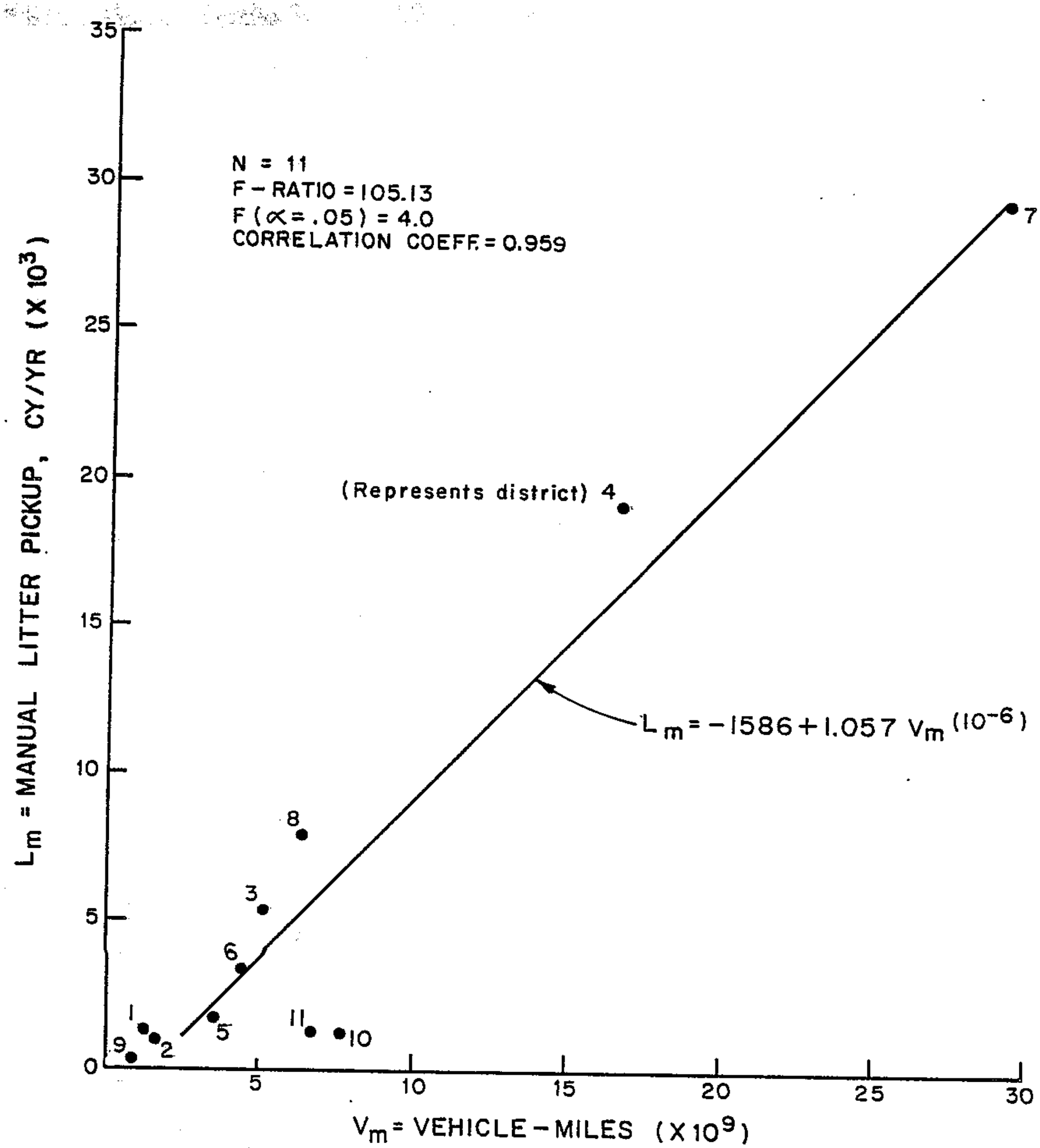
This relationship can be used to estimate the probable annual amount of litter for future projects. In general, the average daily traffic (ADT) multiplied by the number of miles can be used to obtain a general estimate of the vehicle miles total (VMT).

3. Small Slide Removal

The quantity of material generated from small slides along highway slopes amounted to approximately 192,000 CY/YR for the 1974-75 fiscal year. The quantity for the two-year period, July 1972 to June 1974, amounted to 634,000 cubic yard. This shows the wide variability in the quantity from year to year.

There does not appear to be a single correlation factor for determining quantities of material from small slides. An analysis of data related to precipitation for 1974-75 showed a wide scattering of points with a correlation coefficient of 0.51. Apparently other factors such as geology and soil properties, geometrics of the slope, and site hydrology play

(1 cy = 0.76 m^3)



MANUAL LITTER PICKUP VS VEHICLE MILES

(1977–78 DATA)

1 cy = 0.76m³
1 mi = 1609m

FIGURE 3

an important role in determining the locations and amount of material from small slides. A more detailed analysis is required to develop a predictive relationship.

4. Ditch Cleaning (Invert 10')

Approximately 9,542,000 lineal feet of ditches were cleaned of sediment and other debris in the 1974-75 fiscal year making this the third highest maintenance activity in terms of expenditures.

There was no correlation with annual precipitation. The correlation coefficient was 0.45. Other factors such as soil types, source of sediment, and physical location of drainage facilities have a significant effect on determining the amount of material deposited each year. Until a correlation factor is developed, records of nearby projects should be used as a basis for estimating quantities on proposed project.

5. Other Wastes

Waste materials associated with the dig out of pavement or base, removal of drift or storm-deposited material, and roadside section restoration were not related to any one specific factor. A great variation existed in quantities reported from each district and from year to year. The Appendix shows the quantities compiled for 1972-75.

Garbage deposited at roadside rests also varied in amount, and no correlation was derived for estimating these quantities. The data for 1973 and 1977 are presented in the Appendix.

(1 ft = .305 m)

It appears that a more refined analysis, such as examining data associated with interstate travel, urban areas, recreational regions, etc., may lead to some correlation. This analysis was not accomplished under the current study because of additional data requirements and lack of manpower to successfully complete the analysis.

For estimating probable quantities of solid waste for proposed highway projects, the following summary shows the methods that can be used:

Waste	Method
Mechanical Sweepings	$M_s = 152+0.60\ V_m(10^{-6})$
Manual Litter Pickup	$L_m = -1586 + 1.057\ V_m(10^{-6})$
Ditch Cleaning	Use quantities from nearby projects*
Digout Pavement or Base	Use quantities from nearby projects*
Removal of Drift or Storm Deposited Material	Perform field survey to estimate potential quantities*
Roadside Section Restoration	Use quantities from nearby projects*
Garbage Deposited at Roadside Rests	Use quantities from information developed at other roadside rest facilities*

*Additional studies may develop predictive relationships.

DISPOSAL METHODS FOR MAINTENANCE WASTES

A questionnaire was sent to maintenance territories in each of the 11 Caltrans Districts, requesting information on the types, sources, and disposal (or reuse) of solid wastes derived in the annual maintenance program. The four major categories of waste sources were identified as follows:

Source	Type
Traffic	Litter Sweepings Garbage from Roadside Rests Scrap Metal (hub-caps, parts from vehicles) Dead Animals
Vegetation	Grass Clippings Tree Removal Trimming and Pruning Landscaped Areas
Highway Section	Dig out Slides Erosion Scrap Metal (guard rail, markers, signs, fences)
Drainages	Cleaning Drainage Structures Cleaning Ditches and Channels Scrap Metal (culverts, grates)

The methods of collecting various wastes were identified as follows:

Table 4

WASTE MATERIAL	Chipper	Sweeper	Mower	San-O-Vac	Loader Truck	Manual	Dozer	Motor Grader	Special Notes*
	Collecting Methods (No. of responses noted)								
Dig out					10	1		3	a
Clean Drain				3	4				d
" Ditch					7	1	2	2	
" Channel					7		4	3	
" Drift					6		1	3	
" Slides					8	1		3	
Sweeping		11		1	2	2			c
Litter					1	6			
Animal Disposal					1	3			
Mow Roadside									a
" Lawns			2						
Trim Trees	3								
Remove Trees	3				1				
Remove Shrubs	2								
" Weeds					1	1			b
Prune Shrubs	3								
Chip Shrubs	4								
Mulch	1								
Clean Sumps				3		1			d
Roadside Rest Garbage						3			
Scrap Metal					1	3			
Bench Cleaning					8	1	1	2	

*Special Notes

a. Chemicals are used to maintain areas other than lawns (Los Angeles).

b. About 40% of the weeds are hauled to dumps while about 60% are left in place (Long Beach).

c. One vacuum sweeper is used along with conventional power sweepers (Placerville).

d. An Ecolotec vacuum machine is used for small drainage and a San-O-Vac for the larger ones (Placerville).

The composition of solid waste was investigated for three types: Litter collected along highways, street sweepings, and wastes collected at roadside rests.

The composition of litter was determined from maintenance records developed during Caltrans' participation in a nation-wide litter study, "Keep America Beautiful", conducted by the Highway Research Board (1). Litter was collected from 11 sites throughout California for a period of 30 days in 1969. Each site was 0.2 mile in length. The results are shown in Table 5.

Table 5

LITTER COMPOSITION

ITEM	No. of Items/mile	% of Total
Newspapers or magazines	6	1.1
Paper packages or containers	53	10.1
Other paper items	133	25.3
Beer Cans	89	16.9
Soft Drink Cans	25	4.7
Food Cans	6	1.1
Other cans	15	2.9
Plastic packages or containers	16	3.1
Other plastic items	13	2.5
Auto Parts (not tires)	10	1.9
Tires (or tire pieces)	35	6.7
Lumber or construction items	60	11.3
Unclassified items	29	5.5
Returnable beer bottles	3	0.6
Nonreturnable beer bottles	13	2.4
Returnable soft drink bottles	5	1.0
Nonreturnable soft drink bottles	4	0.7
Wine or liquor bottles	5	0.9
Food bottles or jars	2	0.4
Other bottles or jars	5	0.9

1 mi. = 1609 m

(1) "Keep America Beautiful", A national study of roadside litter; summary of a report from the H.R.B., prepared by Research Triangle Institute, 1969.

Summarizing the above information into categories of paper, cans, plastic, glass, and miscellaneous items, the litter composition is as follows:

Table 6

Summary of Litter Composition

Item	Items/Mile	Percent of Total Items
Paper	192	36.4
Cans	135	25.6
Miscellaneous items	134	25.4
Bottles and jars	37	7.0
Plastic	29	5.6
Total	527	100.0

1 mi. = 1609 m

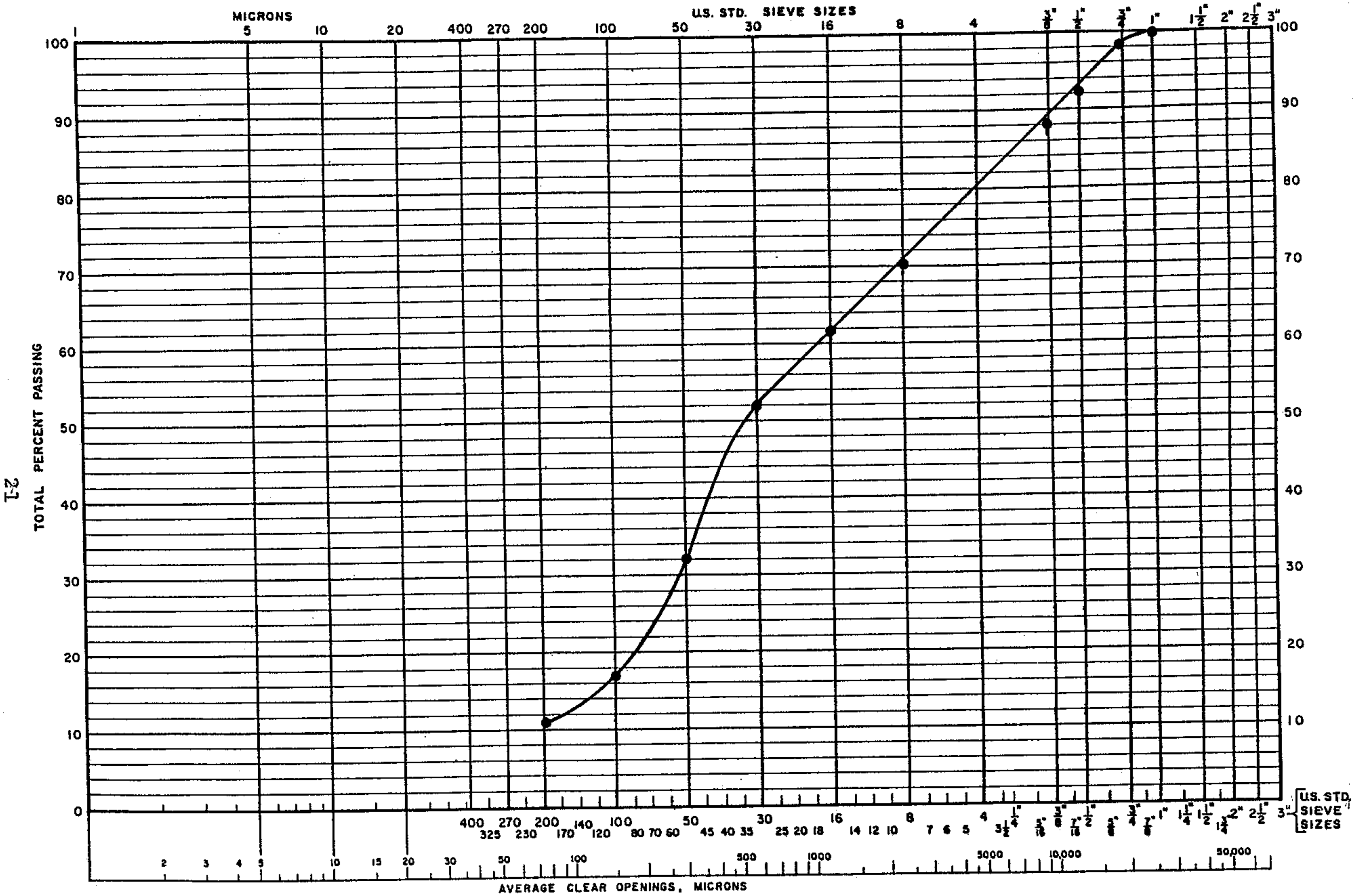
Caltrans performs maintenance sweeping along portions of some freeways. One sample was taken in August 1973 from a Sacramento street sweeper for determination of its composition. Table 7 shows the composition of the sweeper contents.

Table 7

Street Sweepings' Composition

Item	Weight (Grams)	Percent of Total Weight
Aggregate	17,240	96.1
Organic Material (wood, vegetal mater)	340	1.9
Rubber	140	0.8
Asphalt	90	0.5
Metals	60	0.3
Glass	50	0.3
Plastics	20	0.1
Total	17,940	100.0

A grading of the aggregate portion is shown in Figure 4. It is mainly composed of coarse materials.



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GRADING ANALYSIS OF MECHANICAL SWEEPINGS

Figure 4.

The composition of solid wastes collected from roadside rests was investigated at the Elkhorn rest area north of Sacramento on I-5; it consisted of two general categories. First there was the garbage collected from the cans located around the parking and picnic areas, which consisted of paper, glass containers, aluminum cans, tin cans, food and vegetable products, dead animals (occasionally), and the polyethylene bag used to line the can. The second category of waste was the paper towels collected from the rest rooms. This item is collected separately from the garbage can wastes.

In the 1973 Questionnaire, each District Maintenance Engineer was asked to describe the methods used for disposing of various wastes. Table 8 is a summary of the Districts' responses.

Table 8

WASTE MATERIAL	Disposal Method (No. of responses noted) Recycle	Commercial Disposal Site	Animal Shelter	Rendering Plant	Buried in R/W	Trans. Trailer	Special Notes*
Dig out	4	3					
Clean Drain	5	2					
" Ditch	6	1					
" Channel	5	2			1		
" Drift	2	3					
" Slides	5	2					
Sweeping	2	5					
Litter		9				1	
Animal Disposal	1	1	3	2	7		a,b,d
Mow Roadside	2	1					
" Lawns	3	2					
Trim Trees	9	5					c,e
Remove "	7	7					c,e,f
" Shrubs	3	5					f
" Weeds		3					
rune Shrubs	4	3					
hip Shrubs	4	4					c,g
lch	1						
lean Sumps	1	2					
oadside Rest Garbage		5					
crap Metal	5	2					h
Cleaning	5	1					

*Special Notes (See Table 8)

a. Small dead animals cannot be buried in Los Angeles County and are hauled to the local animal shelter for disposal. Larger dead animals such as horses are loaded and hauled by State forces to rendering companies that will accept them. (Los Angeles)

b. Small animals are buried on the roadside. Large animals are removed by the tallow works. (Fresno)

c. About 2/3 is used as landscape mulch and slope erosion control while the rest is disposed of at commercial dumps. (Fresno)

d. About 90% of dead animals are buried along roadway while 10% are hauled to tallow works. (Eureka)

e. About 80% is chipped and used as mulch while 20% is hauled to commercial dump. (San Bernardino)

f. Logs and stumps are hauled to dumps. About 75% of slash is chipped and scattered as mulch while 25% is hauled to dump. (San Bernardino)

g. Chips are either scattered or hauled to disposal site in accordance with U.S.F.S. regulations (80% scattered, 20% hauled). (San Bernardino)

h. About 25% of scrap metal is hauled to commercial dump. (San Francisco)

The three general methods of disposing of solid waste generated by maintenance include:

1. Disposal in Commercial or Public Dump
   a. Sanitary landfills
   b. Open dumps

2. Highway Disposal
   a. Reuse in highway cross section
   b. Stockpile for later use
   c. Shoulder buildup
   d. Mulching vegetation
   e. Riprap

3. Recycling
   a. Metal salvage
   b. Repair and reuse structural materials such as guard rail, signs, posts, etc.

A more detailed item-by-item discussion of disposal methods by maintenance program activity is shown in Table 9.

Table 9

METHODS FOR THE DISPOSAL OF MAINTENANCE WASTES

Program Activity	Method
Dig out pavement or base	Use material to widen shoulders, fill low areas, as riprap or haul to disposal site
Drainage structure cleaning, ditch and channel cleaning	Use material to fill low areas or haul to disposal site
Remove drift or storm-deposited material, and material from small slides	Stockpile for future use, fill low spots or washed-out areas or haul to disposal site
Roadside section restoration	Use material to fill low spots. Haul excess to disposal site. Some broken PCC, AC or rock can be used as riprap
Mechanical sweepings	Haul to disposal site, use as fill material, or in snow coun[illegible] the abrasives may be recycled
Manual litter pick up	Bag and haul to disposal site
Animal disposal	Bury along roadway, take to animal shelter or disposal site or to rendering company
Ground cover, brush and weed removal	Portions may be used as mulch. Haul excess to disposal site
Mowing	Leave cuttings in place as a mulch
Tree removal	Leave for firewood (public)*, sale to timber operator, use at maintenance station, chip for mulch, use as bumper guard, haul to disposal site
Scrap metal	Sell to salvage dealers where possible
Roadside rest garbage	Haul to dump or bury in remote areas

*Problems with leaving wood for firewood useage by the public: access, safety, tort liability (State), and insurance (contract

Districts 01, 02, 03, 06, 09, 10 and 11 reported that wastes generated by shoulder drop-off or slides, cleaning of drainage structures, ditches and channels, and sweepings from roadways were used to widen narrow shoulders and fill washouts. San Diego reported that 20% of the sweepings were screened and recycled as fine aggregate.

Although most of the soil or aggregate waste was used within the right of way for fill material, there appeared to be considerable variation. For example, San Diego reported hauling 80% of slide (and erosion) generated waste to nearby state-owned storage sites and using 20% within the right of way for maintenance, whereas Eureka reported using 80% within the right of way and hauling most of the remainder to U.S. Forest Service (USFS) disposal sites. Yreka reported recycling 70% within the right of way, hauling 30% to USFS disposal sites. The volume of slide waste produced and recycled in this area was so great that it was recommended that disposal sites be purchased near problem areas for stockpiling and drying slide waste for future use.

Districts 04, 07, 08 and portions of 06, which are largely urban, generally hauled waste from road sweepings, vegetative waste, and roadside rests to public land fill sites. This type of waste was also readily accepted at disposal sites in National Forests. Usually, highway litter was hauled to public land fill sites.

In most areas, brush and tree trimmings were chipped and used as mulch for ground cover or erosion control. This method of recycling reduces the amount of water and fertilizer application necessary to be applied in landscaped areas. During the 1974 survey there appeared to be a shortage of chipping equipment in the San Jose and San Francisco Bay areas resulting in a minimal recycling of vegetal waste as mulch. In urban areas, most vegetal waste was hauled to landfill sites. There were some public complaints about chippers' noise in the urban areas. Even prior to hauling to disposal sites, some larger vegetal matter was chipped or ground by a rented "stump grinder" for ease of handling and to provide a more compact load, thus reducing hauling costs.

Chippers recently purchased by Office of Maintenance are less noisy than those in use in 1974 and though the chippers are now in constant demand, through pre-scheduling they are generally available to do the work, though they often cannot do the work the same day the brush is cut. Even in urban areas, such as San Jose and San Diego, practically all the chippings are recycled as mulch in landscaped areas.

In most areas, tree trunks were disposed of by cutting to convenient fireplace size and leaving the material stacked along the side of the roadway where it could be conveniently picked up by the travelling public. Generally, grass clippings were left in place and weeds were hauled to disposal sites.

Broken PCC or AC pavement was conveniently recycled as riprap where needed and, in other cases, it was crushed and used as aggregate base.

Scrap-metal waste consisted of waste collected along the right of way or Caltrans equipment or other items damaged beyond repair. This material was usually recycled by sale to junk dealers. In all areas, most of the damaged guard rail, guide posts, median-barrier posts and snow markers were repaired and reused. The most common comment with regard to scrap metal was that obsolete highway signs should be recycled by making modifications and reusing as new signs. The demand and prices for special items, such as tin cans, fluctuate with copper-mining operations in Arizona where they are used extensively.

Dead animals were usually buried along the right of way, or disposed of by maintenance personnel, or by the local animal control facility. Larger animals were usually accepted by rendering companies. Caltrans has issued instructions for this disposal.

The only type of paper waste that can be recycled is newspaper and cardboard boxes. There are no energy producing burners that could be used to burn the paper waste at the present time. Unfortunately the ashes from this type of operation would also have to be disposed of at Class I disposal sites, which are not always readily available.

The street sweepers in freeways within the City of Los Angeles collect about 15,000 cu. yds. per year. The waste paper picked up in this area in 1974 was about 35,000 cu. yds., making it the greatest disposal problem by volume. The Landscaping crews in this area lease three commerical trash bins to dispose of about 250 cu. yds. per month consisting of mainly vegetal waste. The waste is ultimately placed in a landfill.

The individual items that were mentioned as special problems were abandoned autos and large stumps. With modern equipment, recycling of auto bodies is cost effective.

It was noted that public disposal sites are practically nonexistent in the city of Los Angeles. San Francisco had only one public disposal site in the area. In the desert areas, waste disposal was no problem and in some cases handy

(1 cy = 0.76 m^3)

disposal sites were created by burial along the right of way. Maintenance forces in Eureka noted that the closing of county dumps in their area will result in increased hauling. In the Yreka area, there are some especially long haul distances (20 miles +) to county dump sites. The fact that chamical containers, unidentified chemicals, out-dated chemicals and pesticides had to be hauled and disposed of at far distant Class 1 waste disposal sites was noted in the Yreka, Fresno, and Riverside areas.

Especially in areas where haul distances are substantial, transfer stations or roll off bins would be useful. This was mentioned in this study survey in Long Beach, San Francisco, and Marin County. San Jose was beginning the use of transfer stations in 1974 and now has two transfer bins which are used to hold partial loads until there is sufficient material to dispose of economically.

In the San Diego area, there is a concerted effort to sort recyclable waste for sale to junk dealers. Items formerly difficult to dispose of are now salable - for example, used tires are now worth roughly $60 per ton. Mexican nationals are the primary buyers. They use the better tires for automobiles and the remainder for shoes, doormats, etc.

The California Solid Waste Management Board (SWMB) has delineated criteria for landfill and sanitary disposal sites throughout California. Since several Caltrans district maintenance departments use these facilities, Table 10 has been included in this report to show the Disposal Site Classifications and Group Wastes that can be deposited within these sites.

1 mi = 1.6 Km
1 ton = 907 Kg

The SWMB is continuing the process of identifying disposal sites throughout California for various group wastes. It appears that the current trend is towards eliminating many existing disposal sites because of the lack of environmental compatibility. The SWMB can provide further guidance on selection and use of disposal sites for highway-associated wastes.

Table 10

Solid Waste Disposal Classification (SWMB)

Group* Waste	Class of Disposal Site I	II	III
I	X		
II	X	X	
III	X	X	X

*I. Toxic substances and others detrimental to quality of usable waters, i.e.:

1) Saline fluids or brines from waste or water treatment, reclamation, food processing, or industry.
2) Incinerator ashes from municipal or industry sources.
3) Toxic or hazardous chemical waste from toilets, industry, laundries, mining, or drilling.
4) Pesticides, chemical fertilizers, or uncleansed containers of same.
5) Toxic waste related to chemical warfare.

II. Non-toxic chemically or biologically decomposable material incapable of significantly impairing water quality, i.e.:

1) Rubbish: paper products, cloth, glass, metal, rubber, roofing paper.
2) Garbage related to food products and household ashes.
3) Street refuse: Sweepings, dirt, leaves, litter, yard clippings, abandoned vehicles.
4) Dead animals, manure, plant residues, and approved infectious materials from hospitals or laboratories.
5) Sewage treatment and water treatment residue.
6) Magnesium and other highly flammable materials.

III. Non-water soluble, non-decomposable inert solids, i.e.:

1) Earth, rock, concrete, asphalt, plastics, rubber, plasterboard and inert demolition material.
2) Vehicle tires, clay products, glass, inert slag, and asbestos.

With this changing trend, it might be beneficial for Caltrans to consider developing regional plans for the disposal, re-use or recycling of solid wastes such as sediments, aggregate, rock, vegetation, garbage, litter, debris from pavements scheduled for reconstruction or abandonment, abandoned tires, and sludge from roadside rests.

Such a plan would need to incorporate factors such as economics, engineering feasibility, source and available quantity of waste, expected usage of waste by Caltrans, and other potential users or sources of waste. The plan would include coordination with other state and local governmental entities who are also involved with waste utilization and disposal.

DISPOSAL METHODS FOR CONSTRUCTION WASTES

Information on the type, quantity, and methods of disposal of solid waste generated during construction was developed from a questionnaire that was sent to resident engineers in the 11 Caltrans Districts in 1973. The survey was conducted in cooperation with the Headquarters Office of Construction.

From the responses to the questionnaire, the following materials appear to be the predominant wastes associated with construction:

Concrete (PCC)	Scrap Lumber
Asphalt Concrete (AC)	Metals
Tree Trunks	Fences
Tree Stumps	Unsuitable Material (Soil)
Tree Slash	Excess Roadway Excavation
Brush, Weeds, Grass	Miscellaneous Materials

Usually, each proposed project is inventoried during design to estimate quantities of materials from clearing the project in preparation for construction. Therefore, there does not appear to be a need for developing an estimating method for determining general quantities of waste for use in the environmental study if the inventory data are available.

Environmental factors must be discussed in regard to the disposal methods that are to be used for the estimated solid waste. The Caltrans Highway Design Manual states that "for projects requiring disposal of small quantities of concrete, tree removal waste, grooving waste, or other such 'unclean' material, it is necessary to locate an environmentally cleared disposal site. If the site is controlled by a local agency, the requirements of that agency should be satisfied.

Potential sites should be discussed as thoroughly as possible in the project's Environmental Statement or Negative Declaration."

Each district performs this analysis for each project. A statement concerning disposal of waste usually is made in the environmental document.

From the 1973 district survey, various disposal practices commonly used on projects were identified as shown in Table 11.

Table 11

DISPOSAL METHODS FOR CONSTRUCTION WASTES

Waste	Percent of Time Disposal Method Used: Haul to Dump	Place in Embankment	Recycle or Salvage	Place in Ramp Loops	Sold Locally	Other (Notes)
Concrete (PCC)	16	60	13	1	1	9 (c,e,f,h, l,n,p)
Asphalt Concrete (AC)	13	61	16	2	3	5 (e,k,o)
Tree Trunks	44	6	48	2	-	- (b,m)
Tree Stumps	79	12	-	2	-	7 (a,g,j)
Tree Slash	15	31	31	15	-	8 (a,d)
Brush, Weeds, Grass	67	31	-	2	-	-
Scrap Lumber	48	7	26	-	-	19 (q)
Metals	5	3	90	-	-	2
Fences	31	-	63	-	6	-
Unsuitable Material (soil)	-	-	86	-	14	- (i)
Excess Roadway Excavation	53	8	39	-	-	-

*Other Disposal Methods (see Table 11)

a. Mobile air curtain combustion chamber was used to burn trees and brush (District 01).

b. Trees and logs were cut and stacked for use by local residents (District 01).

c. Broken concrete was placed as for rock slope protection (District 02).

d. Oleanders from R/W were required to be disposed at Class II Disposal Site (District 03).

e. Broken concrete and AC disposed at an old borrow site on U.S. Forest Service property (District 03).

f. Old concrete pavement was given to Maintenance Department for slide correction (District 04).

g. Stumps were buried outside slope line but within R/W (District 05).

h. Ten septic tanks pumped and filled with sand (District 07).

i. Unsuitable material placed in State-owned excess materials site and compacted to 90% relative compaction (District 07).

j. Tree stumps sawed off and left in place in accordance with Std. Spec. (District 07).

k. AC pavement and concrete were reprocessed at a job-site plant to produce Class 1 and 2 Aggregate Base (District 07).

l. Broken AC, PCC, and Structural Concrete were recycled and used for aggregate subbase and base (District 07).

m. Arranged for Landscape firms to box and remove suitable trees after Caltrans Maintenance removed useful trees (District 07).

n. Broken concrete dumped on Southern Pacific R/W after which they hauled it away in railway dump cars for use as riprap in washouts (District 07).

o. Existing AC and Cement Treated Base was placed in scour hole in truck parking area (District 08).

p. Cans, bottles, and broken concrete are disposed of within roadway prism outside of a line projecting from shoulder down at 1:1 in contoured area (District 11).

q. Scrap lumber is burned about 19% of time.

Some difficulties in waste disposal identified by various resident engineers. The three most common difficulties mentioned were:

- °burning restrictions
- °lack of conveniently located disposal sites
- °high costs for disposal at landfill sites

Table 12 shows the occurrence of reported difficulties for various waste materials.

Table 12

PERCENT OF TIME THE IDENTIFIED DIFFICULTY OCCURRED FOR VARIOUS MATERIALS

Difficulty	Material				
	Combustible	Non-combustible	Concrete	Tree Stumps	Tires
Burning prohibited	36			17	40
Lack of disposal sites	17	38	50	17	40
Legal problems at disposal site	8	14			
Too large to bury		24	50	50	
High costs at disposal site	28	24		16	20
Special Provisions	11*				

*11% of the difficulty was attributed to the Special Provisions which encouraged dumping rather than recycling.

Resident engineers were asked to suggest methods for disposing of various materials based on their experience in construction. Table 13 presents their responses.

Table 13

SUGGESTED DISPOSAL METHODS BY RESIDENT ENGINEERS

Disposal Method	Material					
	PCC & AC	Tree Trunks	Tree Slash	Tree Stumps	Scrap Lumber	Earthen Materials
Bury in embankment	(32)%*	22%	27%	30%	13%	47%
Burn		12	13	25	18	
Chip		20	50	10	23	
Firewood		32			20	
Develop disposal site on project	42*	10	10	35	13	29
Sell or transfer to salvage co.	3					6
Give to Maintenance	10				3	6
Reprocess for reuse	45	2			10	12
Sell to paper or sawmill		2				
	100%	100%	100%	100%	100%	100%

*32% of time the developed disposal site was within the embankment.

The most commonly suggested disposal methods were: bury in the embankment, chip tree slash, and use scrap lumber and tree trunks as firewood. A considerable number of resident engineers suggested that disposal sites should be developed on or near the construction project. This suggestion may help alleviate one of the disposal difficulties identified in Table 12.

The resident engineers did caution that disposal sites should not become eyesores, particularly in urban areas or where visible to the travelling public. Some of the comments made on using a disposal site on the project included: place within R/W; screen the disposal site; develop so that the finished land surface has a secondary use, such as parking; landscape the finished site.

The sale of trees to timber harvesters or for public use does not appear to be encouraged when the project Special Provisions are prepared. This is perhaps due to potential problems such as public access, safety, tort liability (State) and insurance (contractor). The restrictive language usually presented in the Special Provisions was one of the main objects of criticism by resident engineers with regard to ways in which waste materials such as tree trunks could be better utilized.

In regard to scrap lumber, it was found that in 30% of the contracts studied in District 11, the material was taken to Mexico for reuse. This disposal appears to have limited use for District 11 only.

Recycling of desirable trees and shrubs was implemented on several contracts that were studied. On one project in District 07 (07-LA-2, PM 15.7/18.9), the Maintenance

Department removed several trees for use in landscaping. During the clearing operation, the contractor allowed some landscape companies to remove the remainder of the useful vegetation.

Another contract in District 07 (07-Ora-5, PM 6.1/R0.4) provided for transplanting 22 palm trees located in the right of way. Palm tree trunks are usually not accepted at landfill sites.

Only 5 of 80 contracts reviewed mentioned the disposal of abandoned tires. In each of the 5 cases, there was a problem with the disposal of tires. The two prevalent problems identified were nonacceptance at landfill sites and a prohibition of burning at the jobsite.

GEYSERVILLE FIELD STUDY

Beside hauling to a dump site, the most common method for disposal of vegetation such as tree trunks, stumps, slash, and brush, is to place it in an embankment during construction. Potential environmental impacts from decaying vegetative material on groundwater and/or surface flows have not been studied in detail. Most studies have concentrated on leachates associated with sanitary land-fill operations.

The objective of the Geyserville field investigation, conducted as part of this research project, was to monitor the quality of groundwater above and below a proposed embankment where vegetative materials were to be buried. Several projects were to be studied initially, but due to a decline in scheduled construction projects and manpower losses at TransLab, only one project was studied.

The project that was selected for field investigation was located on Route 101 at Geyserville (04-Son-101, PM 43), about 70 miles north of San Francisco (see Figure 5).

The project consisted of constructing a new 4-lane divided freeway that would bypass the town of Geyserville to the west. Geyserville is in the north coastal marine environment and receives about 45" of rain annually. Trees and shrubs covered the proposed route. Drainages flow across the project from southwest to northeast and empty into the Russian River, a major north coastal river, located about one mile east of the project.

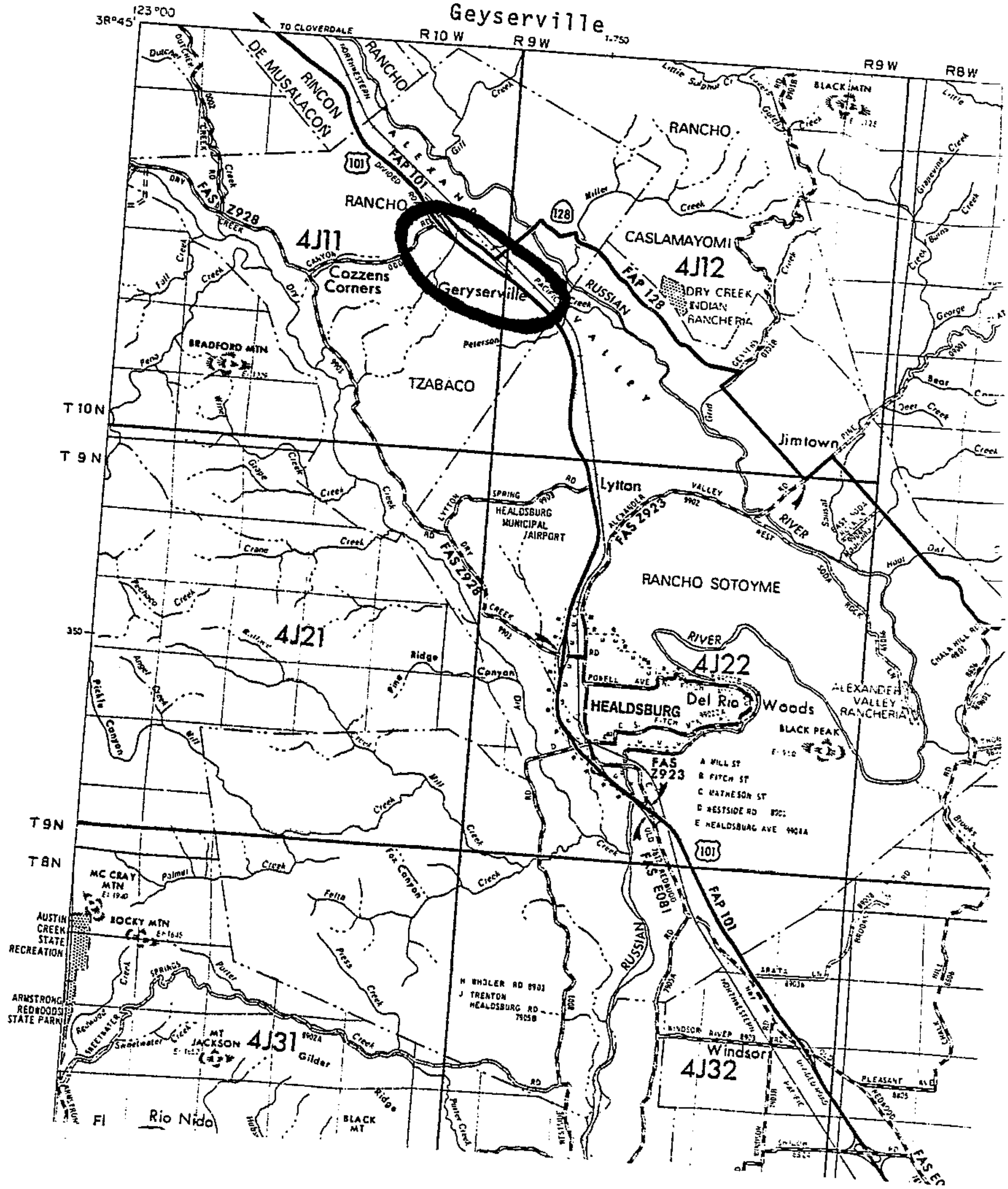
As construction proceeded in 1973, the cleared vegetative !astes were deposited in ravines on an adjacent property and covered with dirt. Leachate began to seep from the site and run into Peterson Creek during the winter of 1973-74 resulting in the issuance of a cease and desist order from the North Coast Regional Water Quality Control Board.

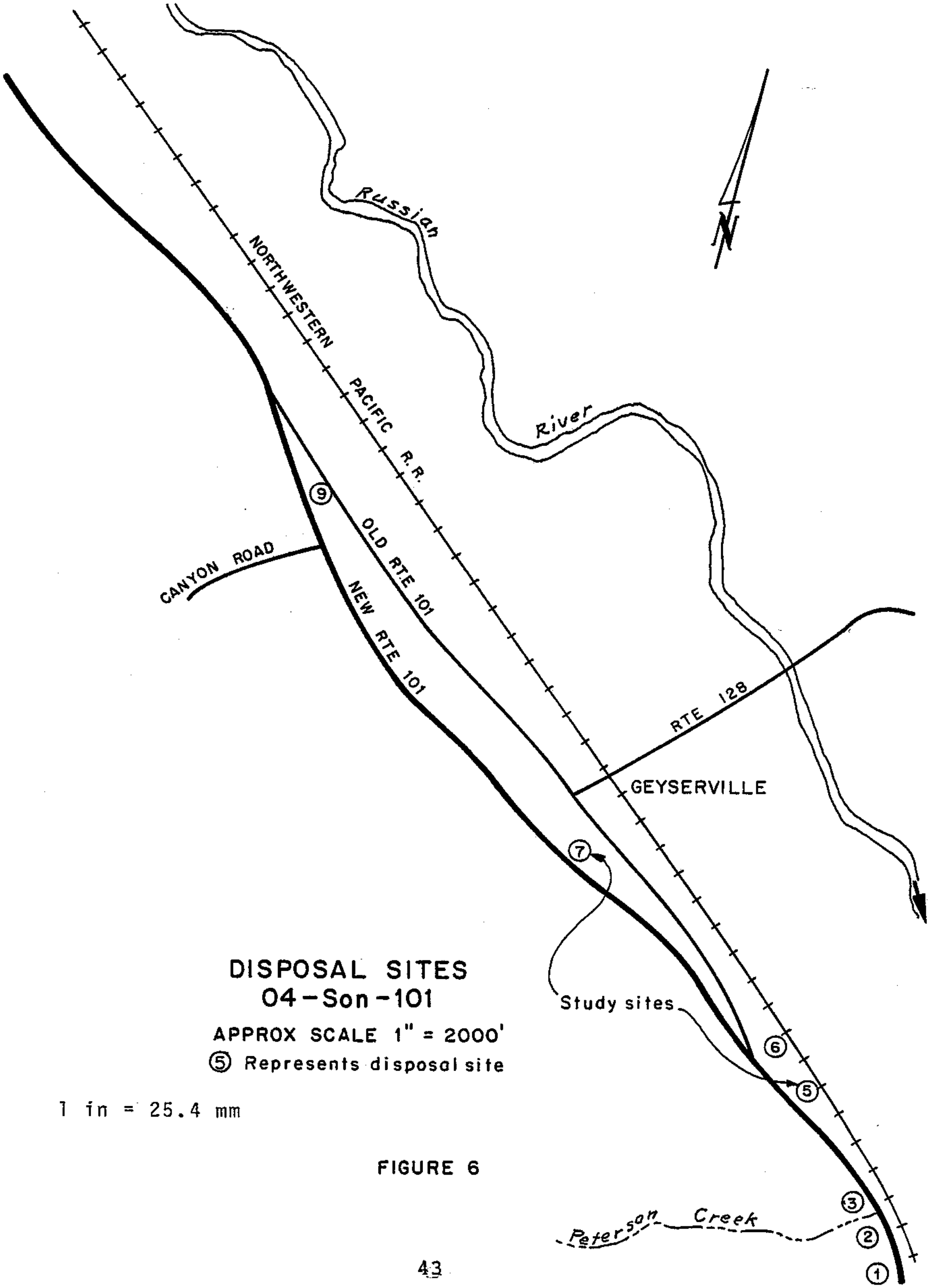
As a solution was sought for the pollution problem, three alternatives were considered: 1) haul the some 20,000 CY of waste to a landfill site, 2) burn the material, or 3) bury it within embankment sections of the new roadway.

The haul distance to an acceptable landfill site was determined to be too far to be economical. Caltrans also had a ban on burning of waste materials, thus precluding this alternative. The only reasonable alternative appeared to be disposal within the embankment sections. In meetings between Caltrans, the contractor, and the Regional Water ,uality Control Board, some 13 potential disposal sites were located on the project as shown in Figure 6. The contractor only used sites 1, 2, 3, 5, 6, 7 and 9, however.

1 mi = 1.6 Km
1 mi = 25.4 mm
1 cy = 0.76 m^3

FIGURE 5
LOCATION MAP





DISPOSAL SITES
04-Son-101

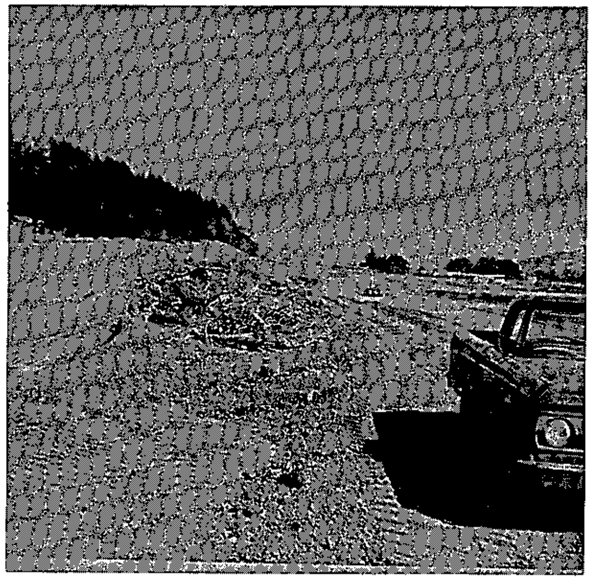
APPROX SCALE 1" = 2000'

⑤ Represents disposal site

1 in = 25.4 mm

FIGURE 6

Disposal consisted of placing the vegetative material above the natural ground's surface and at least five feet above expected high groundwater. The vegetal layer could not exceed the thickness of one tree stump's diameter. Each vegetal layer was covered by a well compacted layer of soil, one foot thick. This alternate layering was continued to within four feet of the final slope line. The vegetal disposal areas were under the nonstructural sections of the freeway. The following two photographs show the typical deposit of vegetation within the embankment section during construction.



Vegetation Disposal

1 ft = .305 m

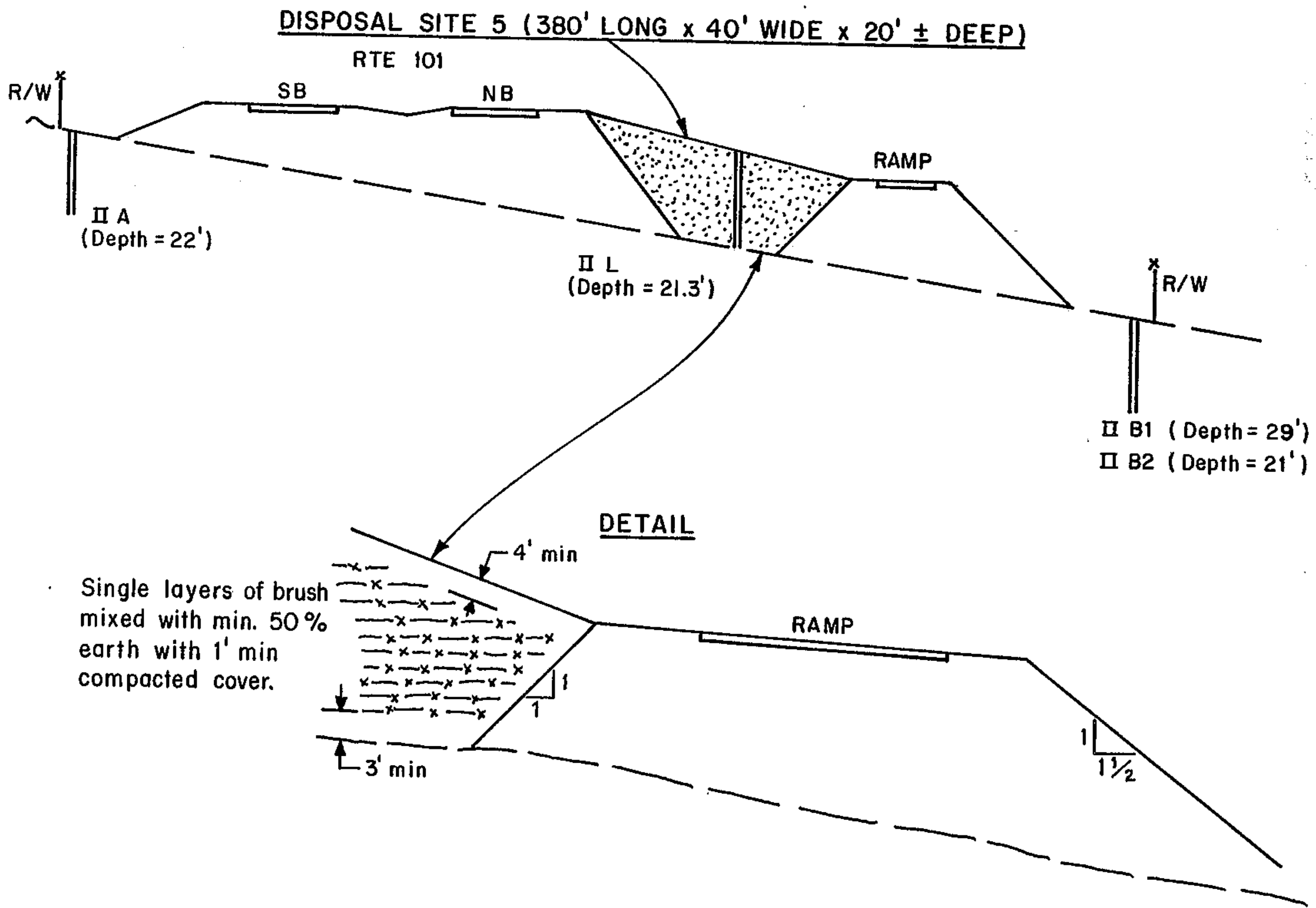
Site 5 (PM 41.3) was selected for studying any effect of leachate from the vegetal deposits on groundwater. Sites 5 and 7 (PM 42.3) were selected for monitoring the characteristics of the leachate. Figure 7 shows the locations of the disposal placement at Site 5. Approximately 4,020 CY of vegetative material were placed at Site 5 and 2,500 Cy at Site 7.

The soil profile at Site 5 was analyzed by excavating an exploration trench on February 4, 1974. The soil consisted of clayey, sandy silts and clayey sands that varied in depth from one to six feet. This material was underlain by moderately plastic silty, sandy, or gravelly clays. A detail of the exploration trenches and soil properties is shown in Figure 8.

In order to study the leachate and effects on groundwater's quality, observation wells were placed above and below the disposal location at Site 5. In addition, observation wells were placed within disposal Sites 5 and 7 to analyze the characteristics of the leachate. Groundwater wells were drilled to 10 feet below the existing groundwater's level and cased with a 12" diameter Corrugated Steel Pipe (CSP). The bottom foot of pipe had 1/8" holes drilled in it to allow water's percolation into the pipe.

To catch the leachate, a 15' x 30' plastic membrane was placed on the ground under a portion of the proposed disposal area. The photographs on page 49 show the installation process. The ground was shaped in the form of a V with 5% sloping sides and a 5% gradient towards the observation well which was placed at one end. A one-foot layer of gravel was placed over the plastic membrane to allow the seepage to drain towards the well. Figure 9 shows a typical section of the leachate-collection system.

1 cy = 0.76 m^3
1 ft = 0.305 m
1 in = 25.4 mm

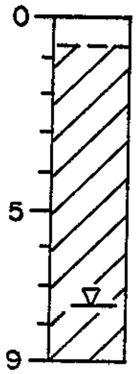


DISPOSAL SITE 5
04 - Son - 101, PM 41.3

1 ft = .305 m

FIGURE 7

TRENCH T-5 2-4-74



Fill

Silty Clay (CL): Brown to red-brown, firm, damp-moist, moderate plasticity.

Atterberg values: LL = 30-40, PI=5-15
Permeability (insitu) = 0.63 - 2.0 in./hr.

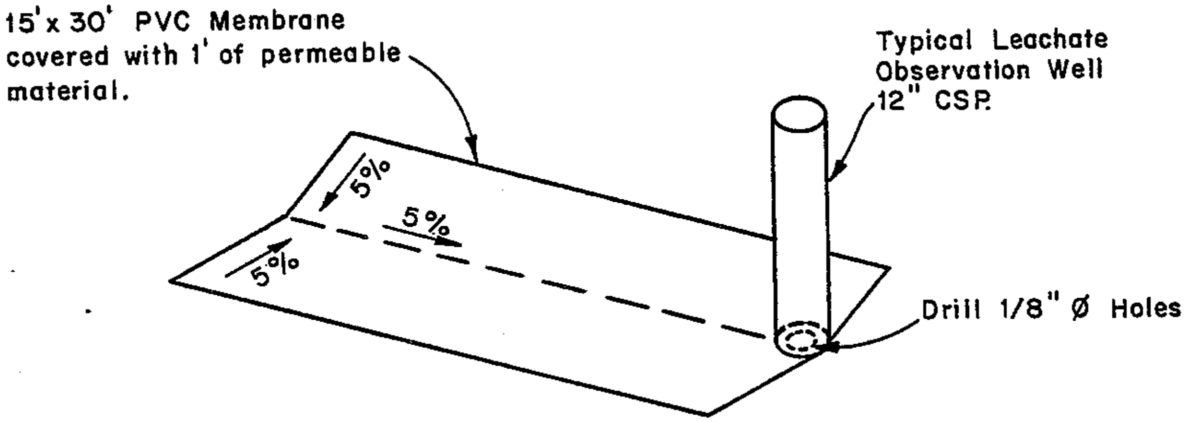
Wet below 7.5' depth.
No standing water.

EXPLORATION TRENCH SOIL LOG

SITE 5

1 in = 25.4 mm
1 ft = .305 m

FIGURE 8



LEACHATE COLLECTION SYSTEM

1 in = 25.4 mm
1 ft = .305 m

FIGURE 9

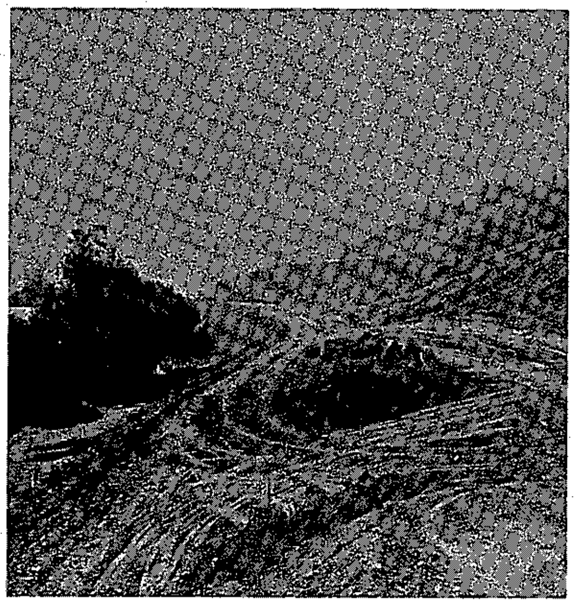
Layer of gravel being placed over membrane at leachate collection site.

Membrane in place at bottom of leachate collection system.

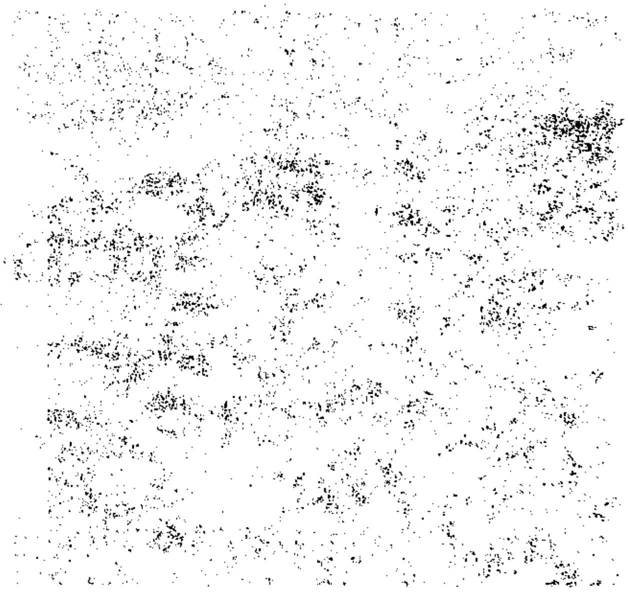
One well was placed upstream from the embankment location and two wells below the embankment to monitor effects on the groundwater from the embankment. Four wells were placed outside of the vegetal disposal areas about 500 feet south of Site 5 to compare effects on groundwater. These wells served as a control to compare with data from the wells placed at Site 5. Figure 10 shows the locations of the observation wells. The photographs on page 50 show the installation at Sites 5 and 7. A summary of the observation wells' locations is shown in Table 14.

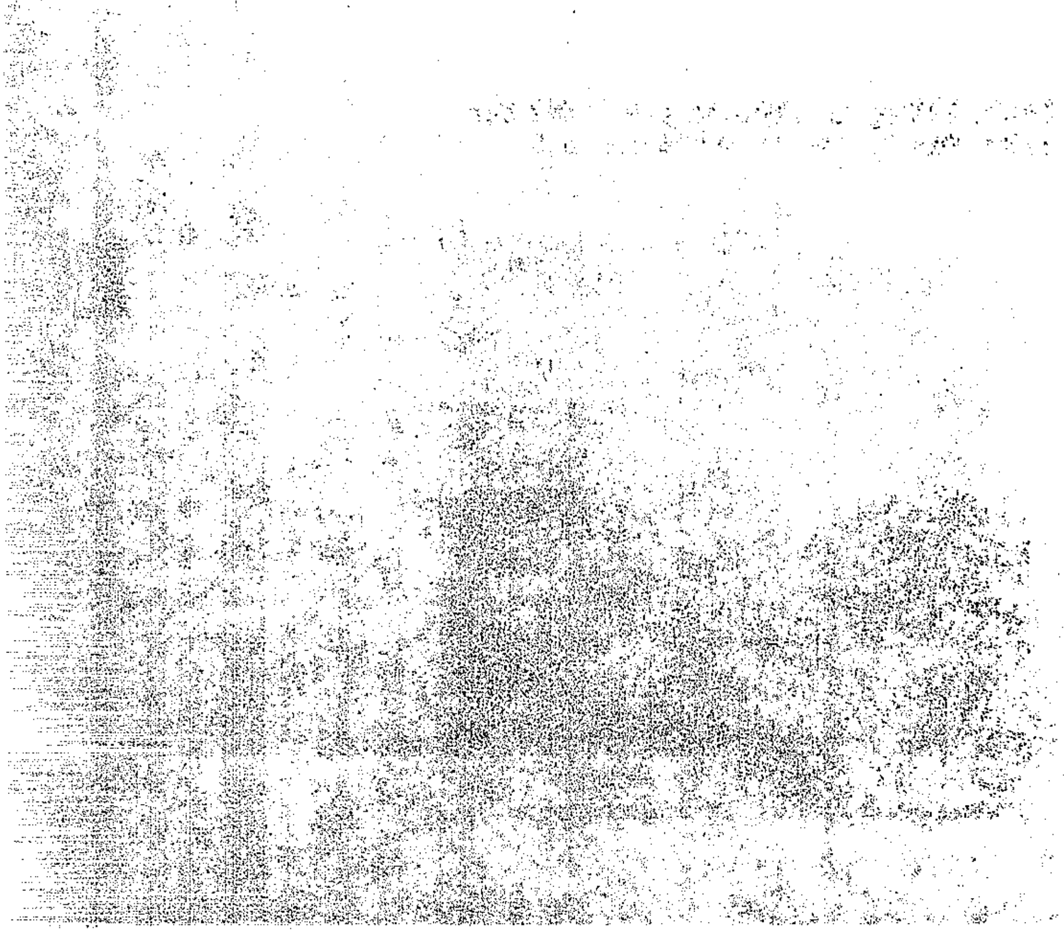
1 ft = .305 m

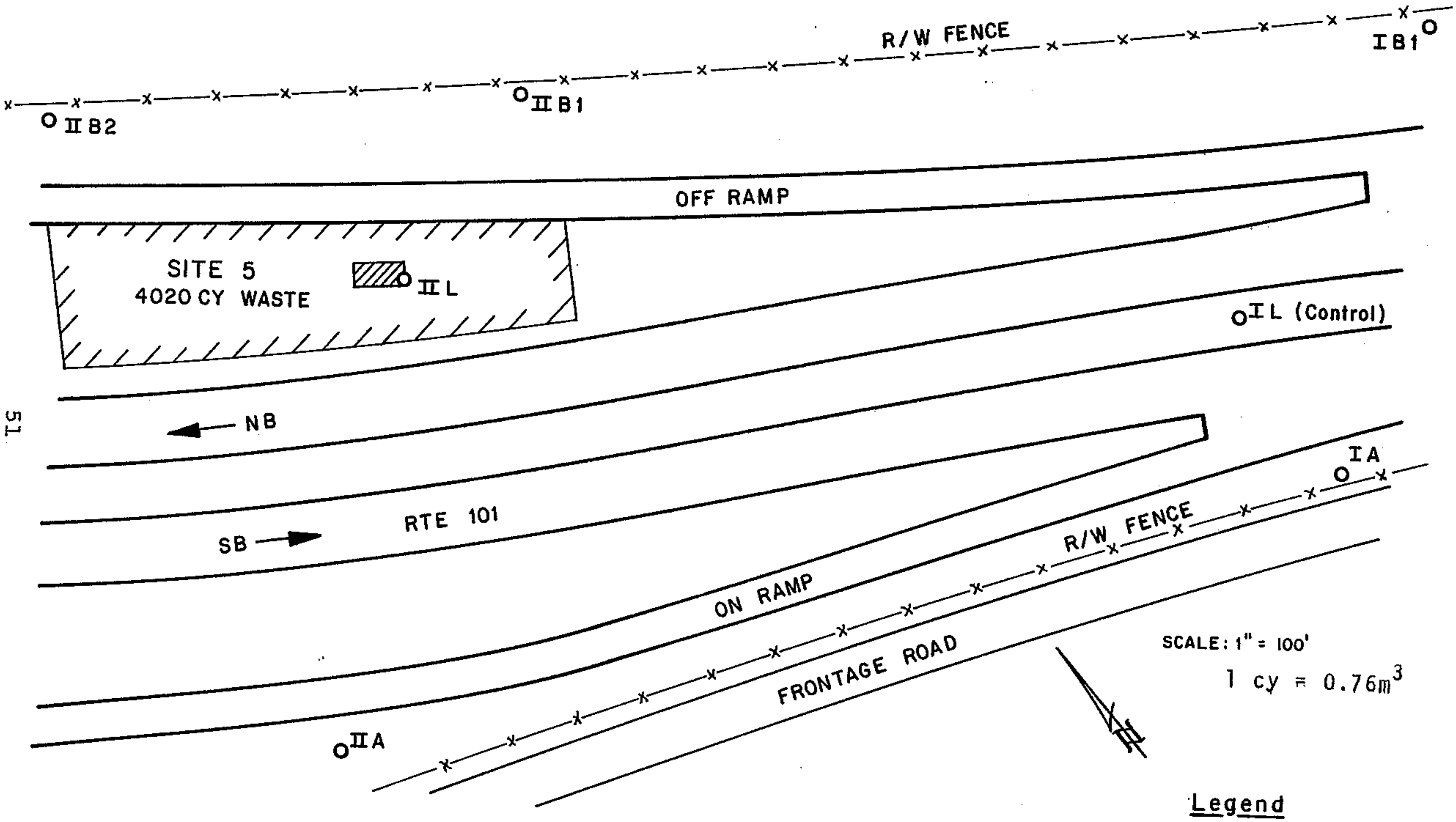
Installing upstream groundwater observation well at Site 5.



Leachate well in place as embankment's construction proceeds at Site 7.







OBSERVATION WELL LOCATIONS
SITE 5 AND CONTROL

FIGURE 10

Legend

O II A – Location of observation well and well number

▨ – Membrane to collect Leachate

Table 14

OBSERVATION WELLS FOR WATER QUALITY MONITORING

Well No.	Depth	Location
Control (No Vegetation Placed in Embankment)		
IA	59.5'	Above embankment location
IB1	16.9	Below embankment location
IB2	14.5	" " "
IL	23.0	Leachate from embankment with no vegetation deposits
Site 5		
IIB1	28.9	Below disposal site
IIB2	20.9	Below disposal site
IIL	21.3	Leachate from vegetation deposits
Site 7		
IIIL	21.3'	Leachate from vegetation deposits

1' = 0.305 m

All embankments and disposal of vegetation were completed by May 1974. Monitoring began in August of 1974.

Subsidence stakes were placed in the vicinity of Site 7. Figure 11 shows the location of the stakes. The stakes were placed at 50 foot intervals for 600 feet at 190 feet and 215 feet right of the center survey (AL) line. Table 15 shows the settlement that occurred (1) from February 19 to May 21, 1975 and (2) February 19, 1975 to June 14, 1977.

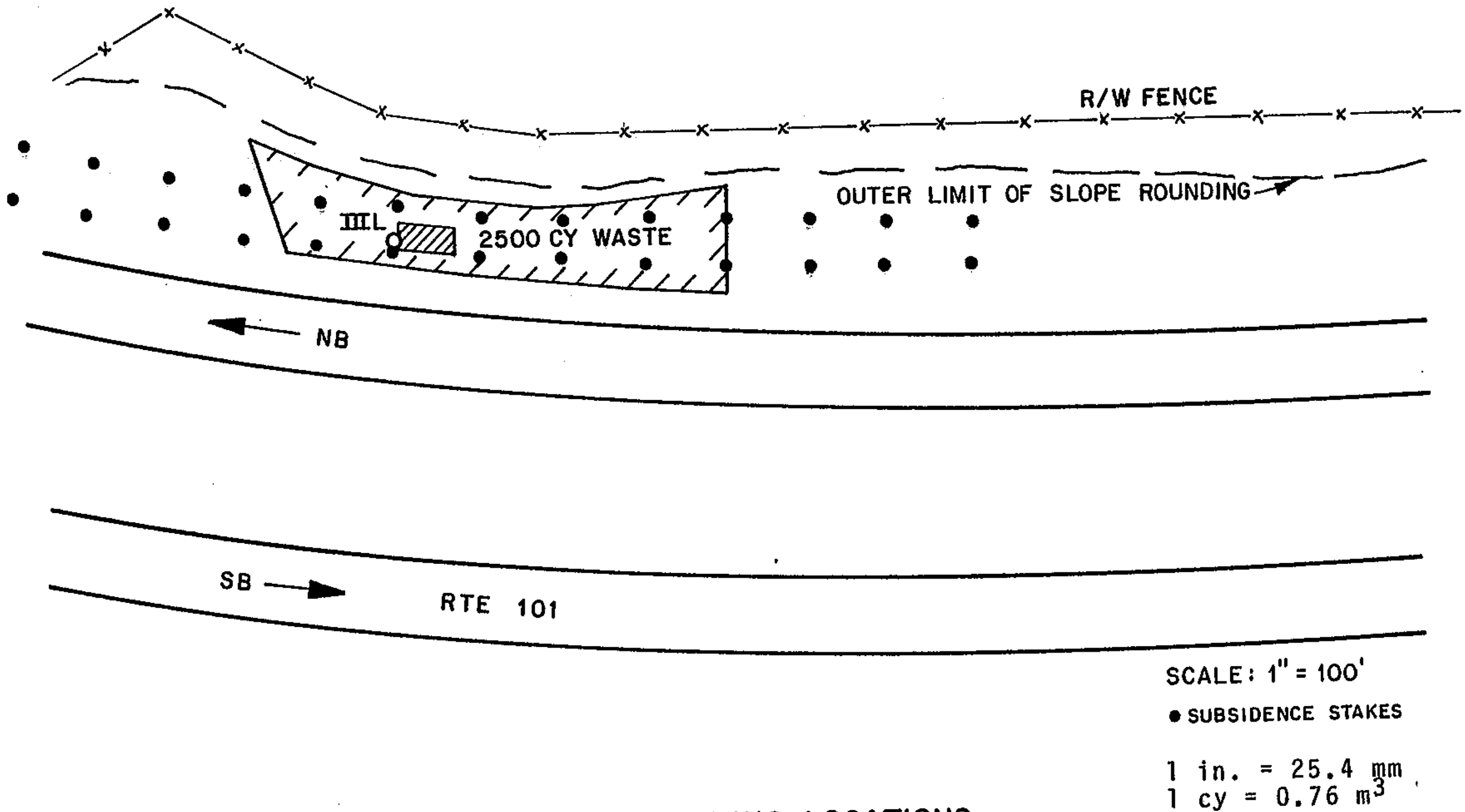
Table 15

EMBANKMENT SETTLEMENT

Sta. on AL line	Settlement, feet			
	190' right		215' right	
	1	2	1	2
357+50	Buried	Buried	0.25	Missing
358+00	"	"	0.18	"
358+50	"	"	0.15	"
359+00	"	"	0.11	"
359+50	"	"	0.13	"
360+00	"	"	0.05	"
360+50	"	"	0.01	"
361+00	0.14	Missing	0.03	"
361+50	0.13	0.27	0.10	0.16
362+00	0.10	0.27	0.08	Missing
362+50	0.31	Missing	0.21	"
363+00	0.32	"	0.27	0.50
363+50	0.12	"	0.05	0.09

1' = 0.305 m

Some stakes were covered during placement of the embankment and are identified in Table 15 as "Buried". Other stakes were accidentally removed or lost during the course of construction and are identified as "Missing".



SUBSIDENCE MONITORING LOCATIONS
SITE 7

FIGURE 11

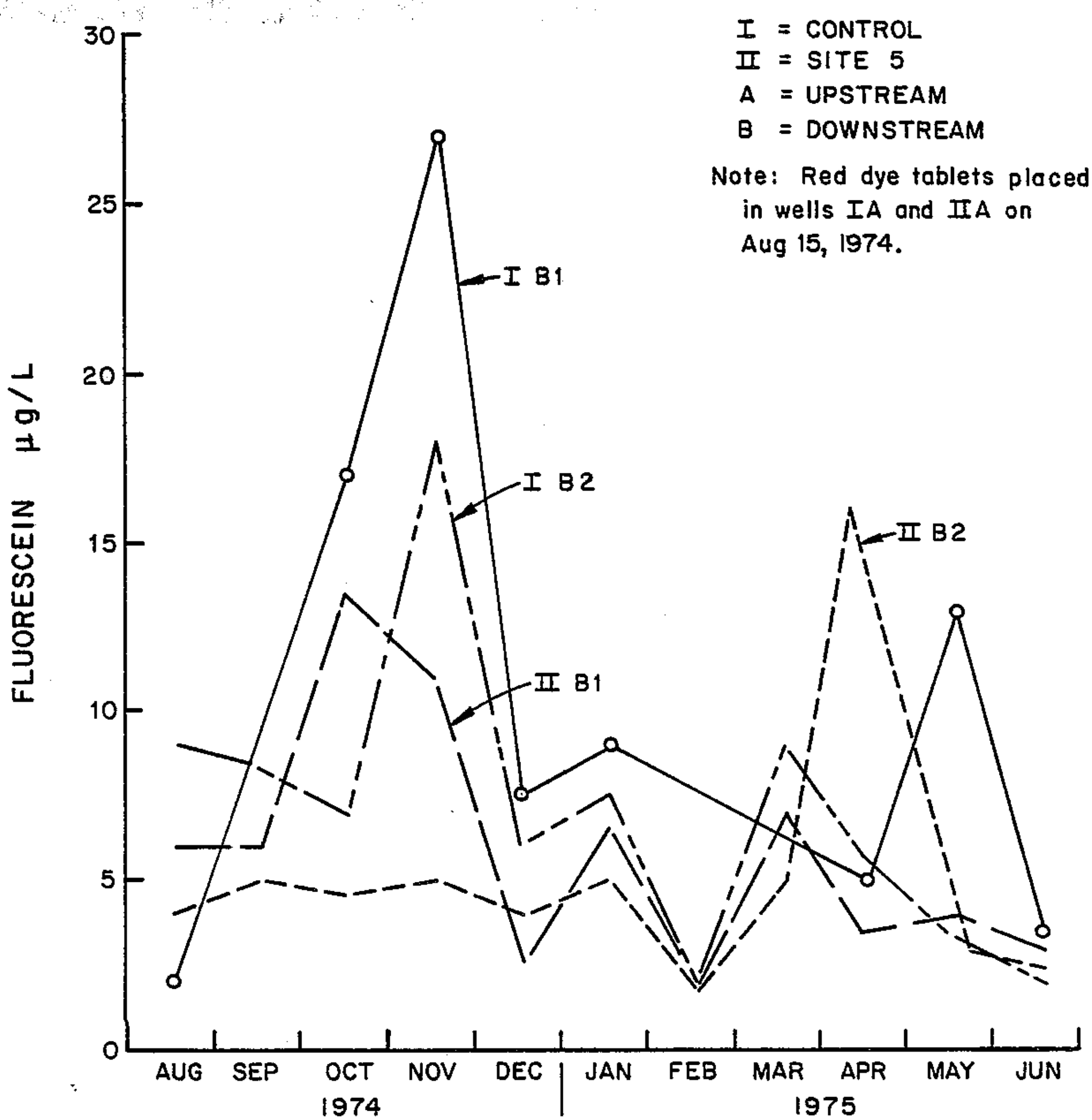
To obtain some idea of the groundwater's movement in the vicinity of Site 5, 500 fluorescein red dye tablets were placed in observation wells IA and IIA on August 15, 1974. Water samples were monitored in the downstream wells IIB1 and IIB2, and IB1 and IB2 until the peak concentration of fluorescein passed. The flow rate and direction were calculated from this information. The data from this test are shown in Figure 12. Table 16 shows the approximate flow rates.

Table 16

GROUNDWATER FLOW RATES

Well	Distance To Upstream Well	Time to Reach Peak Concentration	Approximate Flow Rate
IB1	135 feet	98 days	1.4 ft/day
IB2	152 "	98 "	1.5 "
IIB1	230 "	83 "	2.7 "
IIB2	230 "	210 "	1.1 "

1 foot = 0.305 m



FLUORESCEIN RED DYE TEST OF GROUNDWATER FLOW

FIGURE 12

The data show that the groundwater's flow apparently is in a northeasterly direction towards the Russian River Rainfall amounts recorded for the Geyserville area are shown in Table 17.

Table 17

RAINFALL GEYSERVILLE AREA

Period	Amount	Period	Amount
1975			
August	0.00"	July	0.25
September	0.00	August	0.10
October	1.50	*	
November	2.00	1977	
December	6.50	May	2.20
1976		June	0.00
January	1.50	July	0.00
February	14.00	August	0.00
March	12.00	September	3.30
April	2.00	October	1.15
May	0.00	November	6.80
June	0.00		

*project monitoring delayed

1" = 25.4 mm

The rainfall reflects the severe drought experienced in California during the 1976-77 winter (normal rainfall = 45 inches/year).

Variations in the groundwater elevations are shown in Figure 13. Groundwater's levels appear to vary with rainfall. Unfortunately, observation well IL was covered during construction and was monitored only for the January to April 1975 period. Well IIIL remained dry throughout the entire experiment. Therefore, IIL was the only well to yield information on the leachate's characteristics. Well IIL, however, was dry until January 1975.

Samples were taken from the observation wells and tested for pH, color, specific conductance, chemical oxygen demand (COD), biochemical oxygen demand (BOD), tannins and lignins, and sulfate. A discussion of the results of each of these parameters follows.

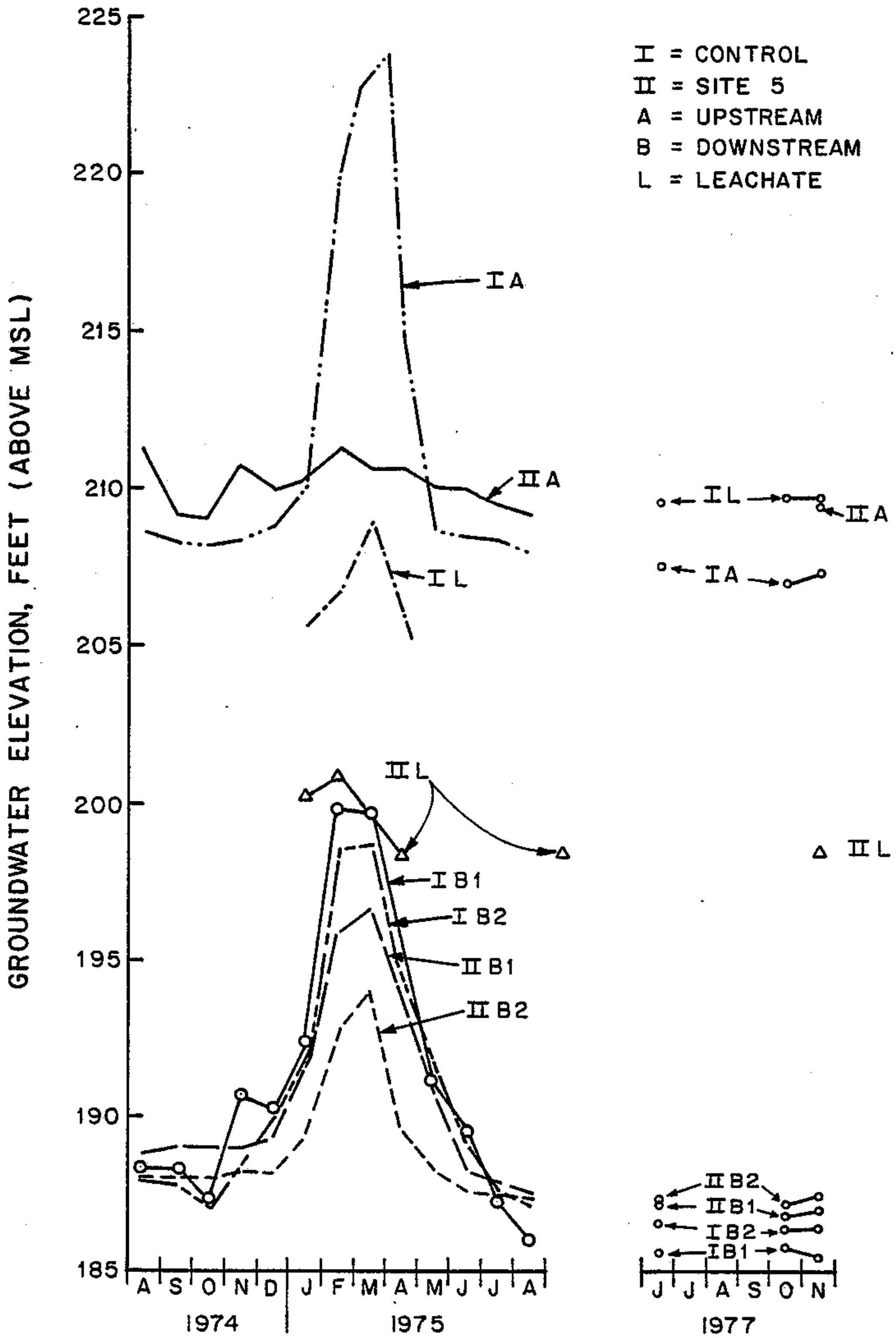
1) pH

The pH is a measure of the hydrogen ion activity and indicates an acidic condition for values less than 7 and a basic condition for values greater than 7.

Figure 14 shows the pH values obtained during this study. The results indicate that for Site 5, pH values were less acidic below the disposal location than those found in the groundwater entering the site.

The control site showed the values tended to fluctuate between upstream and downstream locations but in general the values were fairly consistent. The rate of groundwater's flow for the control site was about 98 days between the upstream well and downstream wells. Taking the lag time into account, the upstream and downstream values are very similar.

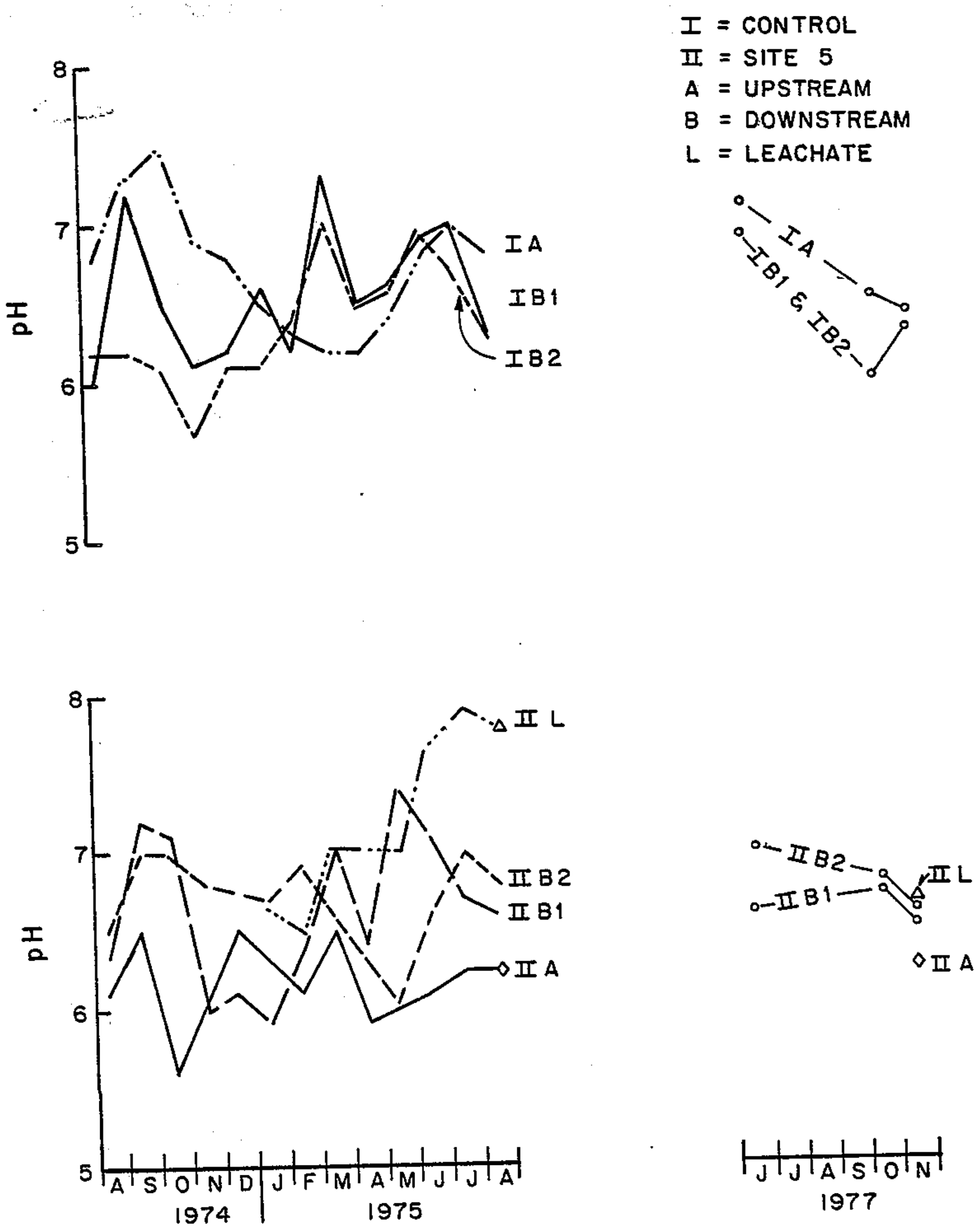
1 in. = 25.4 mm



1 ft = 0.305 m

GROUNDWATER ELEVATIONS

FIGURE 13



pH VALUES

FIGURE 14

The pH of the leachate from the vegetation's disposal was initially acidic (6.5-7.0) for 3 months and then became alkaline (7.0-7.9) for 6 months. A final reading taken 39 months after initial placement in the embankment showed a pH of 6.7.

2) Color

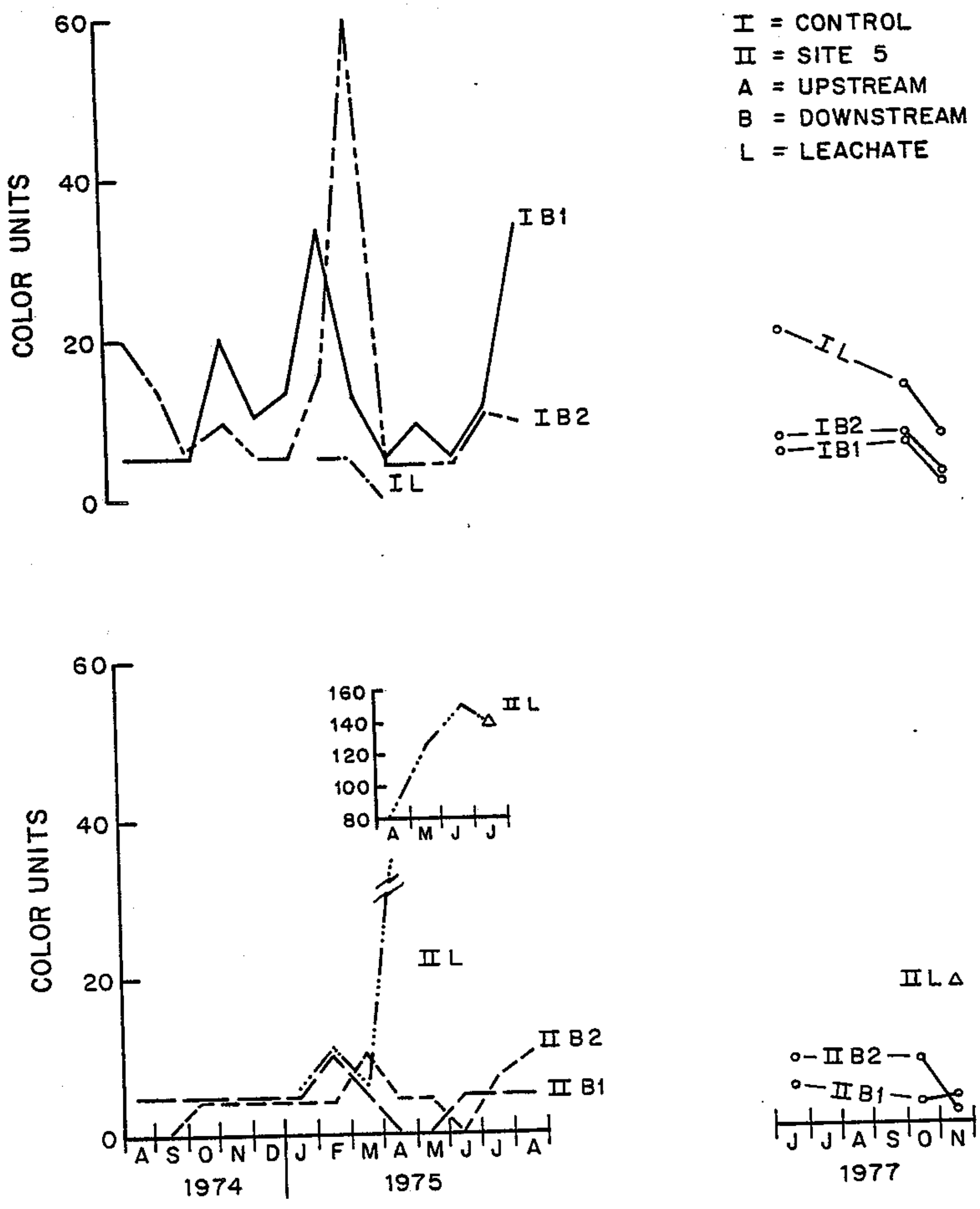
Water samples were tested for color by using Standard Methods* No. 204A. The color data recorded in the downstream wells at Site 5 do not show any significant color impartation to the groundwater (see Figure 15). In fact, the control site showed higher color readings than the disposal monitoring location.

The color recorded in the leachate at the Site 5 disposal area does show a significant color beginning in April of 1975. The color apparently is derived from the decaying organic material. It is evidently chemically removed, diluted, or filtered as the leachate percolates through ground since no change in color was recorded in the downstream wells.

*Standard Methods for the Examination of Water and Waste Water.

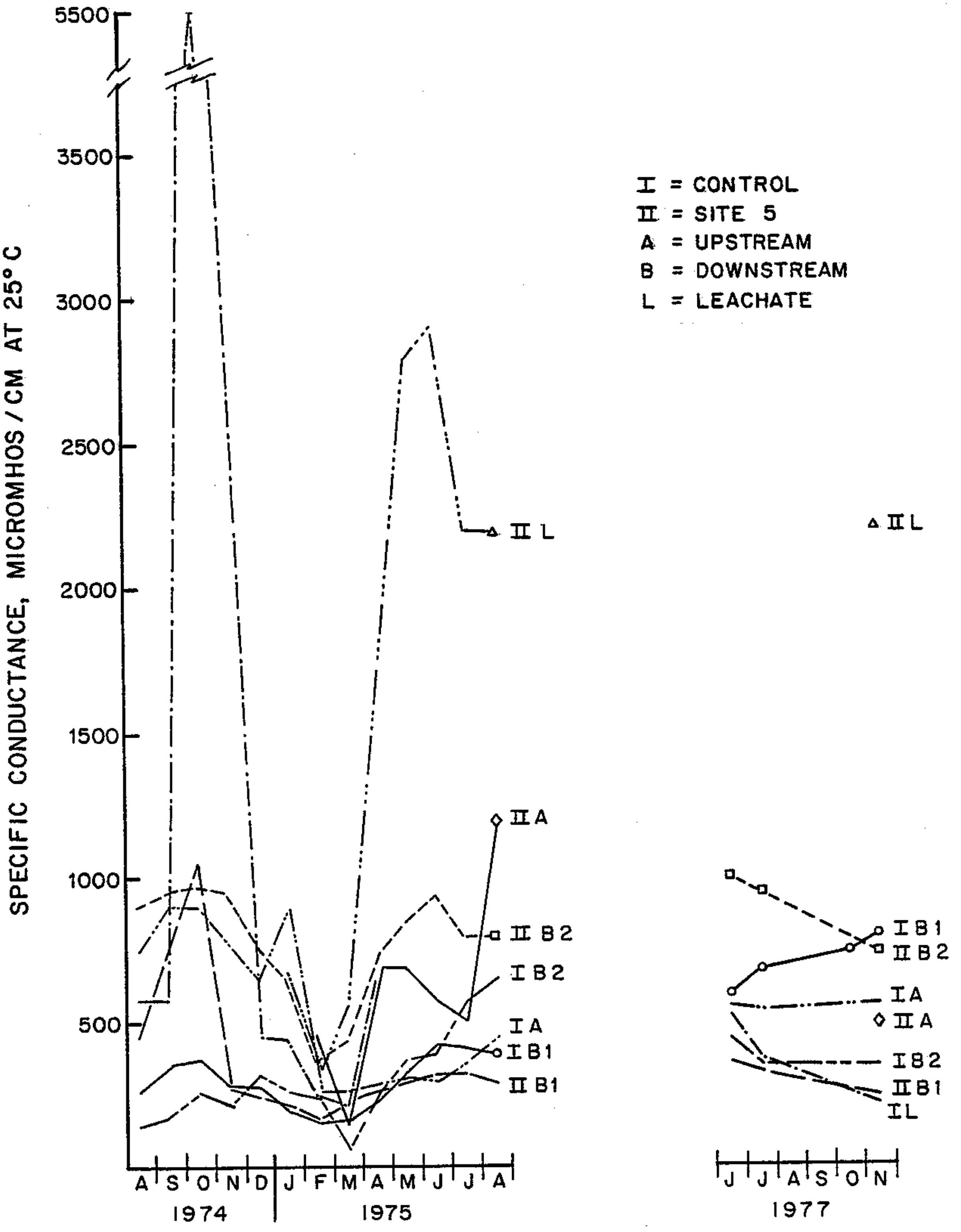
3) Specific Conductance

The specific conductance (EC) data recorded at Site 5 and the control site are shown in Figure 16. The EC is an indication of dissociated ions that are able to conduct an electric current in a solution. EC was determined using a Beckman RA-2A meter.



COLOR

FIGURE 15



SPECIFIC CONDUCTANCE

FIGURE 16

The data recorded at the downstream well (IIB2) show a higher level of specific conductance throughout the entire test period. The general fluctuations in EC for the upstream and downstream wells have a consistent pattern. This apparently reflects the leaching of electrolytes, probably salts, from the soil during the rainy season.

Several of the data show EC values over 500 micromhos/cm @ 25°C which indicates a marginal water for some agricultural crops. The highest values recorded were over 1,000 micromhos/cm and these were all for the downstream observation wells.

4) Chemical Oxygen Demand

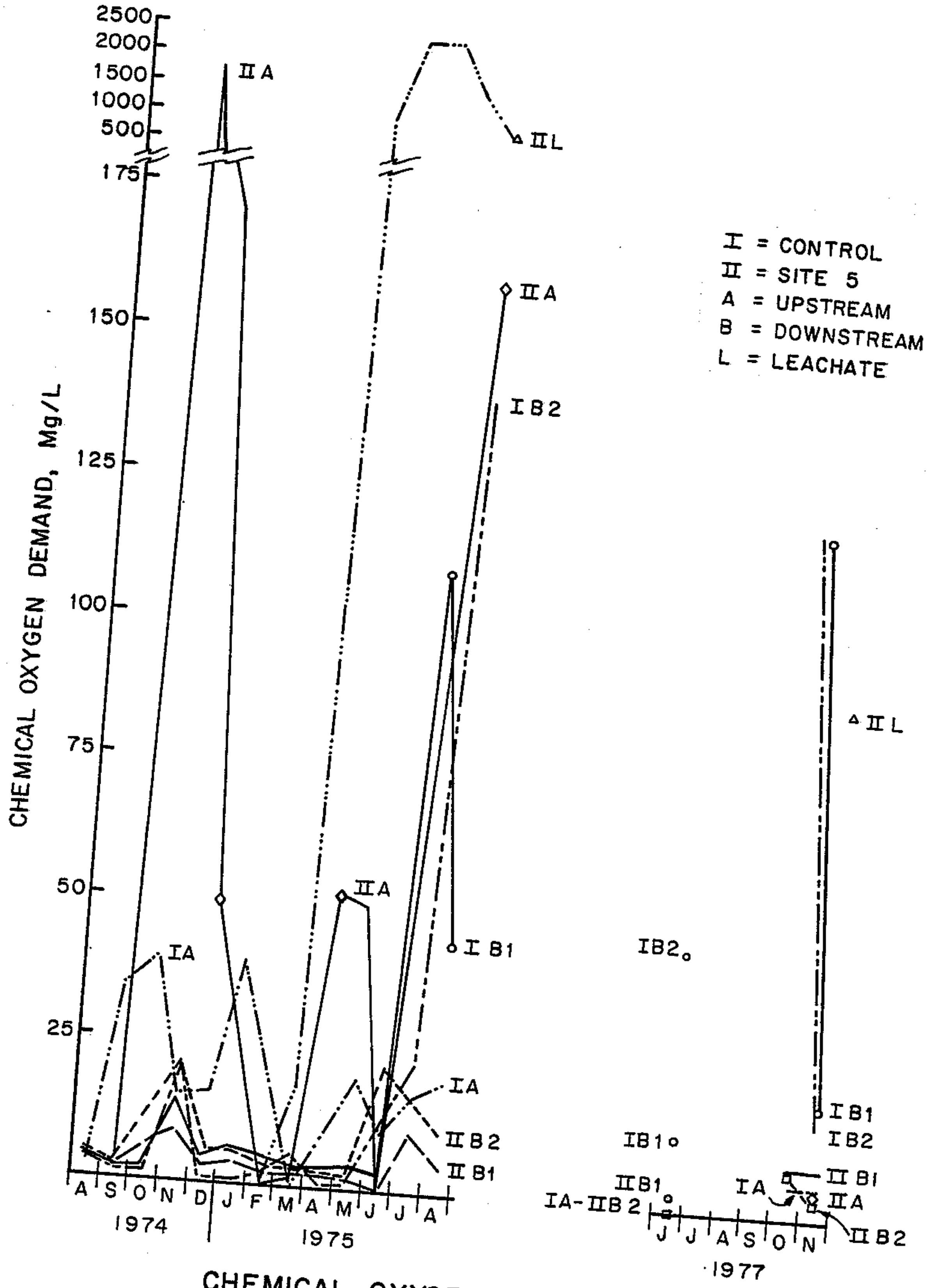
The Chemical Oxygen Demand (COD) was determined from water tests using Standard Methods No. 508. Results of tests performed on water samples from Site 5 and the control are shown in Figure 17.

There does not appear to be any change in COD from the disposal of vegetation at Site 5. In fact, the upstream well at Site 5 generally showed higher COD values than downstream wells.

Water samples from the leachate at Site 5 did show fairly high COD values. The maximum recorded was over 2,000 mg/l recorded in May-June of 1975, approximately one year following completion of the disposal. The last recorded values in 1977 showed results of 20-100 mg/l.

5) Biochemical Oxygen Demand

The 5-day Biochemical Oxygen Demand (BOD) was determined by the Califoria Department of Health. Results of the



CHEMICAL OXYGEN DEMAND

FIGURE 17

tests at Site 5 and the control are shown in Figure 18. There was minimal difference between results obtained from the upstream and downstream observation wells. Values were typically less than 10 mg/l.

Results of samples taken from the leachate at the Site 5 disposal area were considerably higher during the May-June period of 1975. The highest recorded value was 800 mg/l. This did not appear to influence BOD readings obtained in the downstream wells.

6) Tannin and Lignin

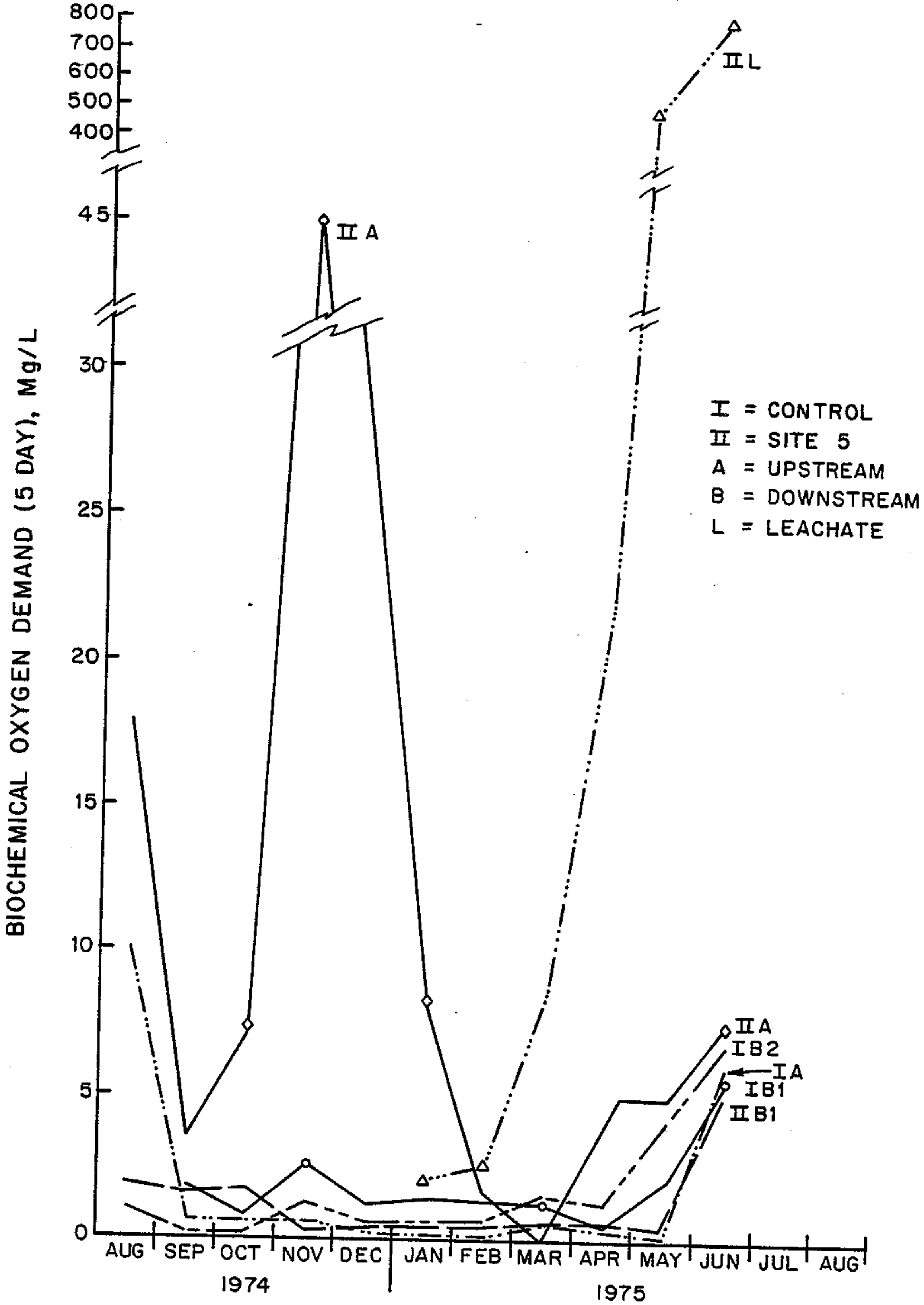
Tannin and lignin are chemicals commonly associated with the decomposition of vegetation. Water samples were tested for these chemicals according to Standard Methods No. 513. Results of the tests are shown in Figure 19.

There was no apparent difference between values obtained in upstream and downstream samples. Test results typically ran below 1 mg/l except for two upstream readings at Site 5 which read over 7 mg/l and almost 5 mg/l in October-November of 1974.

The tannin and lignin values obtained from the leachate tests at Site 5 began to steadily increase from less than 0.1 mg/l in February of 1975 to 10 mg/l by June of 1975. A final test result of 1.4 mg/l was recorded in November of 1977. There did not appear to be any influence on readings in downstream wells, however.

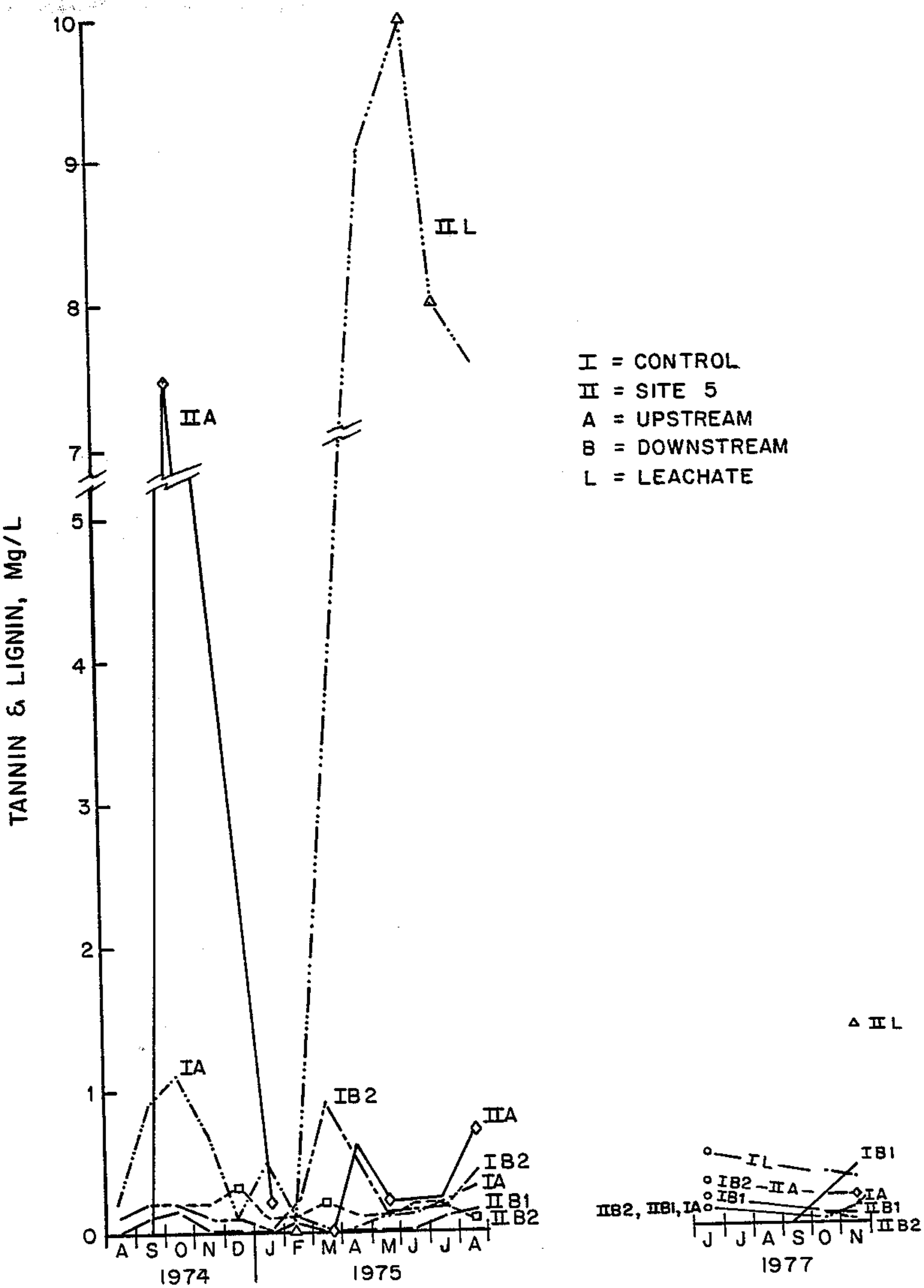
7) Sulfate

Sulfate was analyzed according to Standard Methods No. 427C. The results of the sulfate tests are shown in Figure 20.



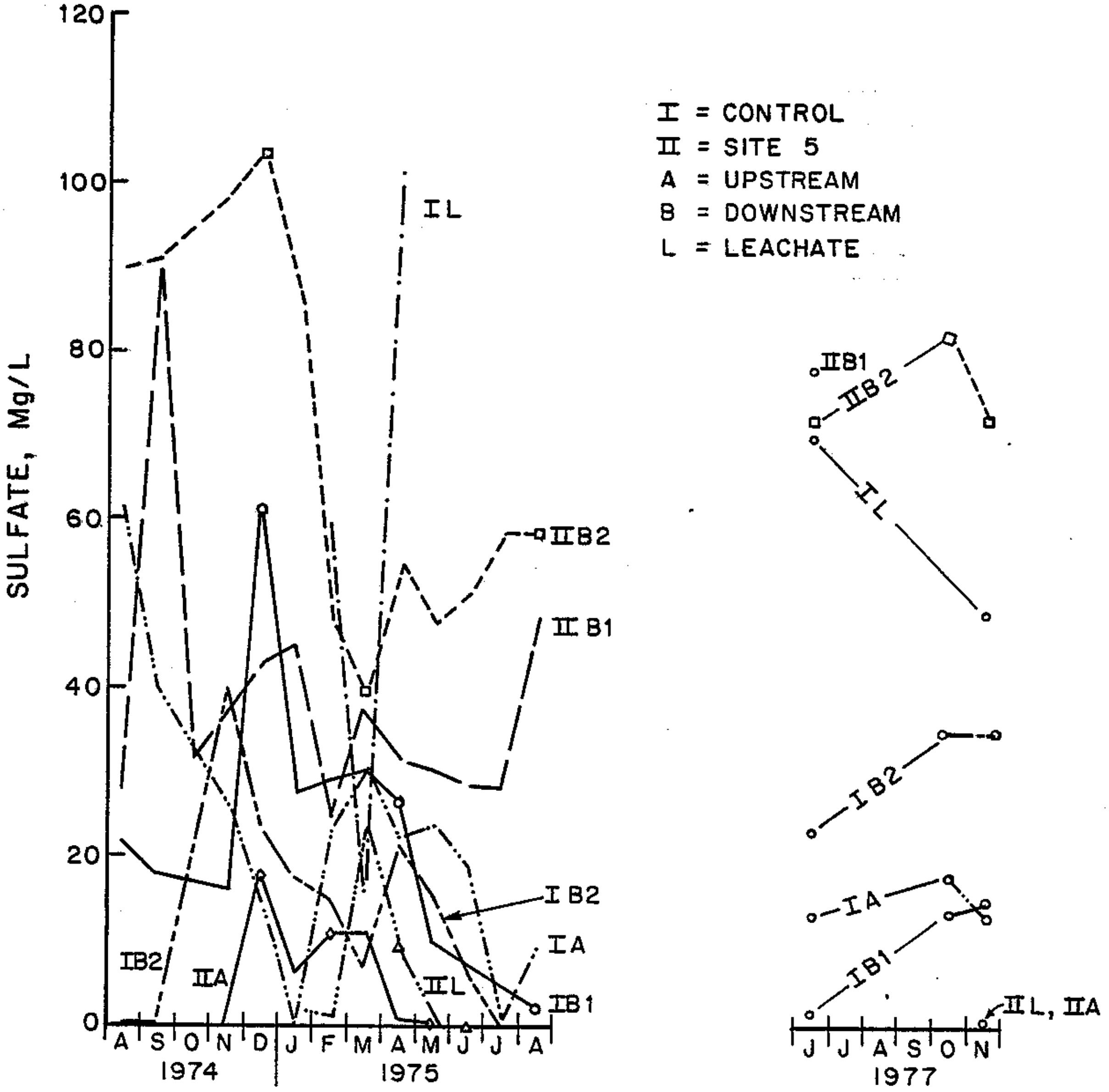
BIOCHEMICAL OXYGEN DEMAND

FIGURE 18



TANNIN & LIGNIN

FIGURE 19



SULFATE

FIGURE 20

There was a significant difference between upstream and downstream values. Values typically averaged around 10 mg/l for upstream samples and varied between 40 and 100 mg/l for downstream samples. The control section showed sulfate values were about the same for upstream and downstream samples. The sulfate values recorded for the leachate were similar to those at the control site and were lower than readings at the downstream wells.

In summary, the test data do not indicate any adverse effects on groundwater at the vegetation disposal Site 5 for the period of observation. The results show that the leachate from the disposal location contains higher levels of Chemical Oxygen Demand, Biochemical Oxygen Demand (5-day) and Color Units, and contains more Tannin and Lignin than the groundwater. The filtering action of the soil, additional chemical reactions, or dilution, apparently reduced the effects of the leachate on groundwater as observed in downstream wells. Before definite conclusions can be formulated concerning the net effect of leachate from the vegetal disposal on groundwater, replicate tests should be run on several sites to confirm the data.

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APPENDIX

Estimated Annual Average Maintenance Waste Quantities (July 1972 to June 1974)

Maintenance Program Activity	District 01	02	03	04	05	06	07	08	09	10	11	Statewide
Mechancial Sweeping, CY	800	800	5,500	13,000	2,800	2,800	20,000	3,000	400	1,900	4,700	53,000
Manual Litter Pickup, CY	650	700	2,600	12,000	1,800	2,500	27,000	3,500	200	1,500	1,000	53,000
Litter/Freeway Patrol, Man-miles	6,800	51,000	71,000	314,000	49,000	58,000	38,000	127,000	10,100	34,000	33,000	792,000
Animal Disposal, Ea.	260	970	590	2,100	250	320	1,100	270	40	750	300	7,000
Digout Pavement Base, CY (flexible)	10,000	21,000	10,000	40,000	13,000	10,000	10,000	5,000	2,500	11,000	6,000	160,000
(rigid)	0	25	2,400	5,100	120	150	960	5	0	20	1,700	10,500
Drainage Structure Cleaning, CY	700	500	1,500	4,500	700	1,100	4,300	700	200	1,200	800	16,000
Ditch Cleaning (invert < 10') 1000 LF	1,530	1,940	1,150	1,670	480	830	1,030	460	94	1,150	870	11,300
Channel Cleaning (invert > 10') CY	17,000	5,400	7,900	8,900	11,000	11,000	36,000	30,000	7,000	2,600	7,900	145,000
Drift or storm Mat'l Removal, CY	40,000	32,000	25,000	23,000	28,000	17,000	62,000	61,000	28,000	11,000	20,000	350,000
Small Slide Removal, CY	66,000	26,000	15,000	34,000	39,000	6,200	58,000	30,000	5,600	4,700	2,600	634,000
Roadside Section Restoration (Bench Cleaning, etc) CY	1,800	4,000	6,300	3,800	20,000	14,000	8,000	13,000	26,000	2,700	2,600	102,000
Chipping Shrubs or Brush cuttings, CY	100	30	100	9,000	1,700	400	12,000	1,800		900	1,100	27,000
Tree Trimming (includes chipping), Each	700	4,200	5,200	18,000	5,200	5,000	10,000	5,600	100	5,800	1,900	62,000
Tree Removal (includes chipping, Each	500	1,000	1,300	4,600	900	800	4,200	900	100	1,300	400	16,000
Mulching Plants, CF	18,000	800	7,000	97,000	116,000	71,000	77,000	20 000	-	10,000	42,000	460,000
Slope Protection, SF	1,800	600	13,000	15,000	6,500	6,700	21,000	200	60	13,000	1,400	80,000

1 CY = 0.76 m^3
1 ft = 0.305 m

1 mi. = 1609 m
1 CF = 0.028 m^3

1 SF = 0.093 m^2

MAINTENANCE QUANTITIES (1974-75)

County	Rainfall In.	Bench Cleaning CY/mi	Remove small Slides CY/mi	Ditch Cleaning CY/mi	Remove drift or storm deposited material CY/mi	Drainage Str. cleaning CY/mi
District 01						
Del Norte	85	-	135.4	2702	39	30.0
Lake	31	8.6	6.8	8519	14	7.6
Mendocino	48	4.4	56.2	1876	37	7.0
Siskiyou	60	11.1	88.9	1853	34	8.5
District 02						
Lassen	13	0.1	-	72	2	1.0
Modoc	14	-	0.5	195	22	10.5
Plumas	27	4.0	17.1	771	19	11.2
Shasta	43	4.7	16.8	746	12	10.0
Siskiyou(SW)	30	1.2	48.9	644	23	8.6
Tehama	34	5.0	1.5	272	34	12.1
Trinity	43	2.0	9.3	679	4	2.4
District 03						
Butte	26	2.6	30.8	1384	52	6.6
Colusa	14.5	-	22.5	5495	24	10.2
El Dorado	35	8.7	14.6	967	18	14.1
Glenn	18		-	55	-	8.8
Nevada	52	1.7	2.2	348	10	11.8
Placer	37	0.2	2.9	879	29	12.7
Sacramento	18	0.2	-	334	0.3	8.4
Sierra	48	0.1	16.3	1892	63	29.1
Sutter	22	-	-	307	-	2.1
Yolo	18.5	-	3.6	392	3	9.9
Yuba	22.5	-	-	682	-	2.9
District 04						
Alameda	16	1.7	1.2	696	1	11.5
Contra Costa	16	39.3*	5.0	1219	8	36.1
Marin	34	1.3	4.6	1915	9	9.5
Napa	28	15.8	21.0	1043	50	12.4
San Francisco	16	6.1	-	721	-	2.1
San Mateo	16	7.6*	14.0	2103	10	21.0
Santa Clara	12.5	1.1	9.0	1678	7	19.3

MAINTENANCE QUANTITIES (1974-75)

County	Rainfall In.	Bench Cleaning CY/mi	Remove small Slides CY/mi	Ditch Cleaning CY/mi	Remove drift or storm deposited material CY/mi	Drainage Str.Cl... CY/mi
Santa Cruz	20	426.6*	33.5	1870	14	12.9
Sonoma	28	6.1	8.7	1617	12	14.9
			District 05			
Monterey	14.5	52*	60.1	722	37	9.4
San Benito	17	10.4	-	404	13	13.7
San Luis Obispo	24	21.7*	1.5	475	8	10.2
Santa Barbara	18	16.8	3.7	742	28	11.4
			District 06			
Fresno	9	4.1	4.3	771	16	7.7
Kern	7	9.9	0.1	426	7	9.3
King	5	3.1	-	49	0.6	3.4
Madera	9	65.5*	16.8	583	0.6	9.5
Tulare	8.5	12.9	-	319	9	7.4
			District 07			
Los Angeles	14	50.0*	36.5	818	14	15.2
Orange	12	90.2*	2.6	681	12	4.8
Ventura	14	31.8*	8.8	668	14	9.2
			District 08			
Riverside	9.5	12.9	5.1	256	31	14.
San Bernardino	8	8.0	5.0	335	40	6.
			District 09			
Inyo	10	1.8	7.9	77	9	1.
Kern	9	2.9	-	198	36	3.
Mono	12	374.5*	3.3	56	53	2
			District 10			
Alpine	30	-	4.7	1095	7	5
Amador	30	13.7	3.4	2405	1	[illegible]
Calaveras	31	6.0	2.2	1359	12	[illegible]
Mariposa	33	4.5	4.2	3567	30	[illegible]
Merced	9	9.3	-	78	-	
Sacramento	16.5	1.4	-	243	-	
San Joaquin	11.5	3.3	-	143	-	
Solano	19	25.7	2.3	659	3	
Stanislaus	11.5	-	-	35	-	
Tuolumne	34.5	1.2	0.7	2395	4	
			76			

MAINTENANCE QUANTITIES (1974-75)

County	Rainfall In.	Bench Cleaning CY/mi	Remove small Slides CY/mi	Ditch Cleaning CY/mi	Remove Drift or storm deposited material CY/mi	Drainage Str. Cleaning CY/mi
			District 11			
Imperial	2	0.8	-	460	28	3.5
Riverside(s)	2	-	-	113	13	6.2
San Diego	12.5	3.1	1.1	783	14	9.8

* Exceeds normal annual quantity

1 CY = 0.76 m^3

1 mi. = 1609 m

Garbage at Roadside Rests (1977)

District	Roadside Rest	Rte.	Garbage CY/YR	Ave. Annual Daily Traffic AADT
01	Irving Lodge	101	730	4,500
	Moss Cove	101	730	4,500
	Empire Camp	101	550	4,100
	Trinidad	101	1,200	5,600
	Collier Tunnel	199	730	5,200
02	Corning	I-5	3,600	13,400
	Red Bluff	I-5	918*	7,550*
	O'Brien	I-5	730	10,400
	Lakehead	I-5	720	9,900
	Grass Lake	97	550*	2,100*
	Weed Airport	I-5	234*	6,900*
	Randolph Collier	I-5	918*	7,550*
	Hillcrest	299	545	2,200
	Honey Lake	395	725	3,600
	Secret Valley	395	182	900
	Shingletown	44	78	800
	Bogard	44	104	1,100
	Massack	70	156	2,200
03	West Branch	70	550	1,950
	Alpha Omega	20	550	1,600
	Dunnigan	I-5	1,100	13,400
	Willows	I-5	2,200	12,100
	Elkhorn	I-5	550	18,000
	Donner Summit	I-80	1,100	19,100
	Gold Run	I-80	1,100	16,300
04	Crystal Springs	I-280	128*	42,250*
05	Gaviota	101	702*	15,800*
	Buttonwillow	I-5	180	37,000
06	Tipton	99	900	26,500
	C. H. Warlow	99	900	24,500
	Coalinga Avenal	I-5	1,440	8,000
07	Gavin Canyon	I-5	300	55,000

08	Desert Oasis	I-40	2,555	6,400
	Halloran	I-15	2,555	11,600
	Wheaton Springs	I-15	1,095	11,500
	Midway	I-15	1,550	12,400
	Fontana	I-10	1,080	54,000
	Wildwood	I-10	1,500	29,000
	Brookside	I-10	1,620	25,000
	Whitewater	I-10	2,160	22,400
09	Crestview	395	126*	2,150*
	Division Creek	395	126*	3,950*
	Haiwee	395	144*	1,400*
10	Los Banos	I-5	1,460	10,600
	Hunter Hill	I-80	302*	42,500*
	Mountain Springs	88	46*	2,850*
	San Domingo	49	62*	4,550*
	Carson Hill	49	77*	1,300*
	Midpines	140	54*	2,400*
11	Sunbeam	I-8	297*	4,650*
	Cactus City	I-10	515*	6,900*
	Wiley's Well	I-10	189*	6,700*
	Two Rivers	111	162*	4,000*
	Aliso Creek	I-5	129*	23,700*
	Sand Hills	I-8	39*	4,900*

*1973 data   1 CY = 0.75 m^3