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Disposal of an Integrated Pulp-Paper Mill Effluent by Irrigation

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January 1979

DISPOSAL OF AN INTEGRATED PULP-PAPER MILL EFFLUENT BY IRRIGATION

by

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory-Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

Kraft pulp mills generally discharge large quantities of wastewaters to the receiving waters near where they are located. Biological treatment of wastewaters is normally effective only to 85 or 90% of the oxidizable organics. This report describes how one mill dramatically reduced their BOD, Suspended Solids and other pollutants discharged to the receiving water by disposing of approximately 1/2 of the treated waste volume on a special flood irrigation agricultural field. The effluent percolate, which eventually enters the Sacramento River, is essentially devoid of organic material. Other mills should find the material contained in this report useful for consideration of possible application if land is available and their discharge limits are severely restricted.

Appendix H, 'Analysis of Groundwater Flow Regimen', was authored by Clinton Parker, US-EPA, from data supplied by Simpson Paper Company. Its content is the opinion of Dr. Parker and not necessarily that of the company.

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ABSTRACT

In January, 1974, the Simpson Paper Company decided to enlarge its recently acquired, integrated bleached kraft pulp-fine paper mill, near Anderson, California, (Shasta Mill). The company concluded that conventional liquid waste treatment methods would not assure compliance with the revised Waste Discharge Permit issued by a State Agency. For five day bio-chemical oxygen demand (BOD-5), and total suspended solids (TSS), this permit prescribed limits which were substantially lower than the guidelines published in December, 1976, by the U.S. Environmental Protection Agency.

In anticipation of these events, Simpson initiated a research program in 1973, to explore the use of the fully-treated secondary effluent from its Shasta Mill for beneficial crop irrigation. This program included the operation of laboratory soil columns and field test plots, plus hydrological studies. Potential problems were identified, and remedies for those problems were developed.

After obtaining the necessary permits, construction of a 162 hectare irrigation project began in early 1975, with the first effluent irrigation taking place in January, 1976. During the next 20 months, over 5.3 million cubic meters (about 1.41 billion U.S. gallons) of effluent were applied to the carefully prepared fields, using an innovative, highly automated, flood irrigation system.

Several crops have been grown, including wheat, oats, corn, alfalfa and beans. In most cases, the yields were equal to, or better than, the California averages for those crops.

The effluent percolate, which eventually enters the Sacramento River, is essentially devoid of suspended solids, BOD-5, chemical oxygen demand (COD), color, and toxicity components. Both the indirect percolate discharge and the direct secondary-treatment effluent discharge to the river meet all of the requirements of the Waste Discharge Permit.

The main problem, which was anticipated, is the control of the composition and movement of groundwater, relative to local Use Permit requirements. This has required the implementation of a complex monitoring program, plus some revisions to the original project design.

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LIST OF ABBREVIATIONS AND SYMBOLS

ABBREVIATIONS

ACID	--	Anderson-Cottonwood Irrigation District, a local public utility
BD	--	"bone dry" (moisture free)
BOD	--	biochemical oxygen demand, usually after five days of incubation (BOD-5)
BV	--	bed volumes (the quantity of liquid equal to the volume of media, such as ion exchange media or sand or soil, in a reaction column or tube)
CEC	--	cationic exchange capacity
cfs	--	cubic feet per second
COD	--	chemical oxygen demand
DFG	--	Department of Fish and Game, State of California
DO	--	dissolved oxygen
DWR	--	Department of Water Resources, State of California
EC	--	electrical conductivity (of a water sample)
FTU	--	formazin turbidity unit
gpam	--	gallons per acre per month
gpd	--	gallons per day
gpd/ac	--	gallons per day per acre
gpm	--	gallons per month
ha	--	hectare, 10000 square meters (approx. 2.47 acres)
kg	--	kilogram
kg/ha	--	kilogram per hectare
km	--	kilometer
lb	--	pound
m	--	meter
me/l	--	milliequivalent per liter
mg/l	--	milligrams per liter
MGD	--	million gallons per day
MPN	--	most probable number
NPDES	--	National Pollution Discharge Elimnation System (Resulted from Federal Water Pollution Control Act, 1972 Amendments)
ppm	--	parts per million
PVC	--	polyvinyl chloride (a plastic used for construction material, including piping)
RWQCB	--	Regional Water Resources Control Board, State of California, Central Valley Region
SAR	--	sodium absorption ratio
SMAD	--	Shasta Mosquito Abatement District
SPC	--	Simpson Paper Company

SWRCB -- State Water Resources Control Board, State of California (parent of the nine RWQCBs)
TAC -- Technical Advisory Committee
TCU -- true color units (in water)
TDS -- total dissolved solids (in water)
TER -- toxicity emission rate (in a liquid effluent discharged to a public waterway)
TLm -- median tolerance limit, or the concentration of the tested material in a suitable diluent at which just 50% of the test animals are able to survive for a specific period of exposure (in this report, the tested material is the Shasta Mill effluent, the test animals are salmonoid species of fish of fingerling size, and the exposure time is 144 hours.)
tu- MGD -- toxicity concentration, or 100/(TL-50)where TL-50 is median lethal dose with an empirical formula to adjust for the condition where less than 50% of the test fish are lost in undiluted effluent. The tu value is multiplied by the discharge in millions of gallons per day to get TER.
TL-50 -- same as TLm
TSS -- total suspended solids (in a water sample)
WAR -- water acceptance rate (of soils)

SYMBOLS

B -- boron (as a discharge constituent)
Se -- selenium (as a discharge constituent)
Cl -- chlorides (as a discharge constituent)
K -- potassium (as a plant nutrient in soils or water)
N -- nitrogen (as a plant nutrient in soils or water)
P -- phosphorous (as a plant nutrient in soils or water)

CONVERSION FACTORS AND METRIC PREFIXES[a]

CONVERSIONS TABLES

To convert from	to	Multiply by
acre (ac)	hectare (ha)	4.047×10^{-1}
acre feet (ac ft)	metre^3 (m^3)	1.335×10^{3}
feet^3 per second (ft^3/sec, cfs)	metre^3/second (m^3/sec)	2.832×10^{-2}
foot (ft)	metre (m)	3.048×10^{-1}
gallon (gal)	metre^3 (m^3)	3.785×10^{-3}
gallon/acre/month (gal/ac/month,gpam)	metre^3/hectare/month (m^3/ha/month)	9.348×10^{-3}
gallon/day (gal/day)	metre^3/day (m^3/day)	3.785×10^{-3}
inch (in)	metre (m)	2.54×10^{-2}
pound (lb)	kilogram (kg)	4.536×10^{-1}
pounds/day (lb/day)	kilograms/day (kg/day)	4.536×10^{-1}
million gallon/day (mgd)	metre^3/day (m^3/day)	3.785×10^{3}
ton (t)	kilokilogram (kkg)	9.0718×10^{-1}
ton/acre (t/ac)	kilokilogram/hectare (kkg/ha)	2.242

METRIC PREFIXES

Prefix	Symbol	Multiplication factor	Example
kilo	k	10^3	2 kg = 2 x 10^3 g
centi	c	10^{-2}	2 cm = 2 x 10^{-2} m

[a]Standard for Metric Practice. ANSI/ASTM Designtion: E380-76$^{\varepsilon}$, IEEE Std 268-1976, American Society for Testing and Materials, Philadelphia, Pennsylvania, February 1976. 37 pp.

ACKNOWLEDGMENTS

The credit for the success of Simpson Paper Company's effluent irrigation project at its Shasta Mill can be attributed to a wide range of company people - from the Chairman of the Board of Directors to the Waste Treatment Plant Operators - and to several outside consultants and advisors.

The authors wish to recognize the contributions of the Redding, California, office staff of the Cooperative Extension Service, University of California (Farm Advisory), and the Simpson-Shasta Ranch contractor, the Pacific Farms, of Gerber, California.

Simpson Paper Company thanks the U.S. Environmental Protection Agency for its recognition of the Company's project, and for its support of certain portions of the monitoring programs in the form of a Demonstration Grant. The cooperation of Dr. H. Kirk Willard (Project Officer, Cincinnati, Ohio), Mr. Ralph H. Scott (formerly EPA-Corvallis, Oregon), and Jim Fedders, (EPA - Cincinnati, Ohio), was greatly appreciated.

SECTION 1

INTRODUCTION

Simpson Paper Company, with headquarters in San Francisco, California, operates an integrated, bleached kraft pulp plus fine paper mill, near Anderson-Redding, California. For almost 13 years, this mill has discharged a secondary-treated effluent to the Sacramento River. The upper reach of this river includes several salmon spawning grounds, and also supports a popular recreation industry. For these and other reasons, the Central Valley Regional Water Quality Control Board (RWQCB) has routinely imposed very stringent limits on municipal and industrial discharges to the river.

In January, 1974, the company announced an expansion at this mill (henceforth, the Shasta Mill), including the installation of a second paper machine. In October of that year, the RWQCB issued a revised Waste Discharge Permit for the enlarged mill. Portions of this permit are shown in Appendix A.

The revised permit prescribed limits on BOD-5 and TSS discharges which were well below the latest U.S. Environmental Protection Agency (U. S.-EPA) recommendations for equivalent manufacturing operations. (Development Document, BPCTCA, EPA 440/1-76/047b, Table I, p. 4, December 1976). After a detailed study, Simpson concluded that the new conditions - and especially the TSS requirement - could not be met on a sustained basis by conventional primary and secondary treatment methods.

In mid-1972, being aware of the trends in water quality regulation, and recognizing the unique attributes of the Sacramento River, Simpson began to evaluate the use of the Shasta Mill's treated effluent for irrigation. By the summer of 1974, the company's studies of this alternative had reached the point where a decision could be made with minimum risk.

Fortunately, the Shasta Mill already owned a 430 ha. (1100 acre) "ranch", about 5 km. from the mill site. This property had about 4200 m. frontage on the Sacramento River, was reasonably level, and a major portion had high permeability soil. About 162 ha. of this property was selected for a full-scale effluent irrigation project. It was believed that the revised Waste Discharge Permit conditions could be met by diverting up to 40% of of the secondary effluent onto this land.

The Shasta Mill expansion project required an Environmental Impact Report (EIR), as a result of which four Use Permits were granted by the Shasta County Planning Commission, in November, 1974. Because some local and state officials expressed apprehensions about the effluent irrigation project, one of the Use Permits included an unusual number of constraints on this activity. A portion of this Use Permit is shown in appendix B.

The application of treated and untreated waste waters to land is not new technology. In 1973, US-EPA published a comprehensive survey of this practice (1), and a pulp-paper research group had also studied the subject in 1965 (2). However, the Shasta Mill irrigation project was somewhat unusual in several respects:

- The possible need to irrigate on a 365 day/year basis.
- The hydraulic loading on the soil, which was expected to be as high as 0.3m./month equivalent precipitation. (Actual average has been 1.96 m./year).
- Presence of up to 70 mg/l. of TSS in the treated effluent. (Actual average has been about 30 mg./l.)
- Presence of color bodies, equivalent to as much as 900 Pt-Co color units, a major portion of which was known to be slowly biodegradable.
- From a crop irrigation standpoint, the treated effluent had relatively high TDS (up to 1300 mg./l.) and relatively high sodium ion concentration (up to 200 mg./l, mostly as sodium chloride).
- The need for effective control of groundwater level, movement and composition.
- Possibility of odor emissions from the irrigated fields.

During the period, 1972-1974, the company carried out a research program oriented at these and other potential complications. This included the operation of laboratory soil columns and field test plots, and advice from several consultants. Based on this research, the company concluded that all problems which might be associated with the full-scale project were manageable. Subsequent events have verified this.

Simpson Paper Company realized that a key to the success of the irrigation project was the achievement of a high qualtiy effluent. Accordingly, the original primary treatment facilities were upgraded, and an all-new secondary treatment facility was installed at the Shasta Mill. The original secondary system was the high-rate, contact-stabilization version of the activated sludge process. The new system consisted of two,low-rate, aerated stabilization basins. (A complete description of the primary and secondary treatment facilities is given in reference (3). This also includes a general description of the irrigation system).

In most respects, the climate in north Central California is favorable to an irrigation project such as that carried out by Simpson's Shasta Mill. In fact, the very hot, dry, summers make intensive agriculture virtually impossible without some form of irrigation. The winters are cool and rainy. Snowfall is rare, and while freezing temperatures are experienced, they are not severe enough or of sufficient duration to cause the ground to freeze. In most years, surface evaporation exceeds total natural precipitation.

Table 1 summarizes typical weather data for the area.

TABLE 1. TYPICAL WEATHER DATA, REDDING, CALIFORNIA

	Temperature F° Min.	Temperature F° Max.	Rainfall Inches	Relative Humidity 4:00 pm	Relative Humidity 4:00 am	Relative Humidity 10:00 am
Jan.	35.6	44.8	6.72	76%	61%	65%
April	47.6	73.3	3.05	66%	39%	44%
July	65.8	98.8	0.08	46%	19%	26%
Oct.	51.1	78.9	2.10	58%	32%	39%
Year	49.7	75.6	37.76	60%	37%	43%

The data in Table 1 are monthly or annual means. In July and August, daytime temperatures in the range 100° -105° F. are common, with R. H. around 10%. In midwinter, temperatures seldom drop below 30°F. Over a 10 year period, annual average natural precipitation has ranged from 20 inches to 60 inches. Calendar years 1976 and 1977 were drought periods in north central California, with 22 to 25 inches of precipitation in Redding.

The Shasta Mill discharges its treated effluent to the Sacramento River. Upstream of the discharge is a large, man-made reservoir (Shasta Lake), which is operated by the U.S. Bureau of Reclamation. Like all of the major fresh surface waters of California, the flow from Shasta Lake is fully allocated for specific beneficial uses. The largest use is for irrigated agriculture in central California.

One consequence of this intensive water management program is that river flows tend to be high during the normal crop season, and low during the winters, allowing the reservoir to refill. Typically, summer flows are in the range of 340 cu. meters

/sec., and winter flows of about 200 cu. m/sec. (up to 800 in the late part of the wetter winters, and up to 1900 in flood years). During the drought years of 1976-1977, summer flows were curtailed somewhat (to about 280) while winter flows were reduced to the uncommonly low levels of 75 to 100 cu. m/sec.

As can be seen in Appendix A, portions of the Shasta Mill's Waste Discharge Permit are based on Sacramento River flow, with the most stringent conditions applying when the flow is less than 142 cu m/sec. Since the low flows occur during the winter, when irrigation is more difficult to carry out, the Shasta Mill faces an unusual challenge in the management of its liquid effluent discharge.

RECEIVING WATER QUALITY

For water quality management, the entire Sacramento River watershed is under the jurisdiction of the California Regional Water Quality Control Board (RWQCB), Central Valley Region. In June, 1971, this agency issued a management (control) plan (4) for the area, to satisfy federal and state requirements for the construction grant program, and to meet the requirements of the California Porter-Cologne Water Quality Control Act of 1970. The plan defined water quality objectives for different reaches of the Sacramento River (sub-basins), in terms of turbidity, bottom deposits, floatables, oil and grease, odors, pesticides, pH, biostimulants, bacteria, temperature, dissolved oxygen, specific conductivity, total dissolved solids, chloride ion, and trace constituents (heavy metals plus chlorine, carbon-chloroform extract, and methylene blue active substances). Based on these criteria, and inputs from other agencies (e.g. California Dept. of Fish and game (DFG), U.S. EPA, and others) the RWQCB issues "Waste Discharge Permits". In this respect, the RWQCB has an agreement with the U.S. EPA wherein RWQCB administers the National Pollution Discharge Elimination System (NPDES) within its geographical area. Thus, State Waste Discharge Permits are also NPDES Permits, under the conditions of Public Law 92-500 and its amendments.

In April, 1975, the California State Water Resources Control Board (SWRCB), parent of the Regional Boards, published a "Program for Water Quality Surveillance and Monitoring in CA." In addition to the State and Regional Boards, this program is carried out jointly with other agencies, including the State Department of Health, DFG, and the California Department of Water Resources (DWR). According to the Redding, CA, office of RWQCB, the upper reach of the Sacramento River is not water quality limited, and is in compliance with all water quality criteria to the extent that these are affected by the activities of man.

Annual macro-benthos studies of the Sacramento River by the

Institute of Paper Chemistry, Appleton, Wisconsin (under cont-tract with Simpson Paper Company) have shown that receiving water quality above and below the discharge is "excellent" and not adversely affected by the discharge from the Shasta Mill.

Shasta Mill's Environmental Laboratory also carries out a regular receiving water quality monitoring program. Free-flowing Sacramento River water is tested several times a month at five stations, one above and four below the point of discharge (i.e.- effluent diffuser). Testing includes dissolved oxygen (DO), temperature, pH, color, and turbidity. In addition, interstitial gravel waters - sampled at two or more stations along the westerly shore of the river - are tested weekly for DO, temperature, pH, color, and monthly for fish toxicity. Subjective observations (for foam, oil slicks, discoloration, floating solids, changes in animal and plant life in and near the river, etc.) are included with the objective data in the monthly reports to the RWQCB. In over ten years of intensive monitoring under this or similar programs, there is no evidence that the Shasta Mill discharge has had a significant adverse impact on receiving water quality, or that the discharge has resulted in a condition where river quality does not meet or exceed the standards of the RWQCB.

SECTION 2

CONCLUSIONS and RECOMMENDATIONS

Treated secondary effluent from the Shasta Mill can be used in the place of "fresh water" for cash crop production on irrigated fields which are properly prepared and managed. To the extent that this effluent is 99.75% to 99.80% water by weight, versus 99.90% to 99.95% for "fresh water", most of the considerations related to fresh water irrigation also apply to the effluent. For example, the irrigation rate can exceed evapo-transpiration rate without adverse effects on soil quality (physical and chemical characteristics) or crop production if:

- The surface infiltration (water acceptance) rate of the soil is high enough to prevent ponding of water for more than about four hours after water application has stopped.
- The subsurface permeability of the soil exceeds the total liquid application rate, such that the root zone is not flooded.

Since the climate in the project area is "mild" (i.e. soil does not freeze in winter), soil quality and surface run-off can be managed on a year-around basis. Therefore, effluent can be applied to the fields all year, with or without vegetative cover. However, the presence of vegetation, even if dormant or in the form of non-viable stubble, helps maintain the water acceptance rate and minimizes erosion.

From an agricultural standpoint, the differences between the Shasta Mill effluent and "fresh water" fall into three classes, based on the presence of:

- Total suspended soils (TSS). For the project period, the 10 to 70 mg/l. of TSS in the effluent did not appear to cause any unmanageable problems. However, there may be some long-term complications.
- Soluble inorganic components. The effluent contains exchangeable sodium which was found to displace calcium and magnesium from the soil. Both laboratory and field tests by Simpson Paper Company suggest that this can be compensated by addition to the soil of low-solubility compounds containing calcium or magnesium. However, the possibility of long-term adverse effects may exist. The effluent also contains chloride and sulfate ions, which

were not found to cause any agricultural problems in the prevailing concentrations. Because of the language of the County Use Permit, chloride ion posed a regulatory problem which was only partially resolved. (Natural precipitation, and standard "fresh water" irrigation, appear to be effective in correcting most if not all of the identified unfavorable effects of effluent irrigation in this particular project, except when the additional water results in hydraulic overloading of the soil).

- Soluble organic components. Upon passage of the effluent through the soil, essentially all of the BOD and COD matter (including color bodies) was removed and most likely destroyed (oxidized to simpler forms). The acute fish toxicity of the effluent percolate was unmeasureably low (nil), but bioassays with the undiluted secondary effluent itself showed 95% or greater survival of king salmon fingerlings after 144 hours of exposure, continuous flow basis.

Based on extensive pre-project studies, control of ground water level and movement beneath some of the effluent-irrigated fields was expected to be difficult, and this was the case. This was largely the result of pre-existing conditions, aggravated by the occasional need to apply relatively large amounts of effluent to those fields. For this and other reasons, the application of treated industrial effluents to land is not something that can be done anywhere or under any circumstances. Therefore such projects will usually require extensive and costly groundwater monitoring programs, such as the one developed and carried out by the Shasta Mill.

RECOMMENDATIONS

The "disposal" of industrial liquid effluents to land can have some long-term consequences (measured in decades rather than months or years) which are not necessarily apparent in a relatively short-term project, let alone quantifiable. If, despite the already known limitations of this activity, it is believed that more "land disposal" projects should or will be put into operation, an effort should be made to evaluate any such long-term effects. To assure that this information is properly derived and gets the widest distribution, the US-EPA might consider the development and support of specific research projects. Based on the Shasta Mill experience, these are suggested:

- An investigation of the long-term effects of low micron and submicron sizes of inorganic particle filtration at soil surfaces.

- Investigation of ion exchange mechanisms within different soils. (The Shasta project indicated that sodium - calcium exchange did not necessarily take place according to textbook descriptions).

- Investigate the physical and/or chemical reactions involving semi-refractory BOD and chemical oxygen demand (COD) components of an effluent in different soils.

SECTION 3

PRE-OPERATIONAL RESEARCH PROGRAM

FIELD TEST PLOTS

In the summer of 1973, twelve small test plots (total of about 0.8 hectare) were established on an unused portion of the Simpson-Shasta Ranch. Three of these plots were leveled, cultivated, and seeded, whereas the others were left in a natural state, with mixed vegetative cover.

Garden-type "Rain Bird" sprinklers were used initially to achieve uniform effluent application on all plots.

At this time it was believed that grass crops would be the best choice. Accordingly, the early plantings on the tilled plots were such crops as clover, alfalfa, fescue, orchard grass, etc. Since soil chemistry was to be studied, no fertilizers or chemical soil amendments were used in the early stages of the project.

The effluent was applied at unusually heavy rates, corresponding to about 2 cm./day, to accentuate any adverse effects that might appear. When rainy winter weather arrived, the topsoil became very wet, with occasional ponding in low areas. Despite this, and the lack of fertilizers, the vegetation on all effluent-irrigated plots developed reasonably well.

The following spring, upon advice of our consultant agronomist, the existing tilled plots were redeveloped, and new plots established. By this time it was apparent that not even the legumes could fix nitrogen rapidly enough to compensate for the high soil leaching rate, so a fertilizer program was developed. Later, the cropping plan was enlarged to include field corn.

Simpson technicians had attempted to collect and test the effluent percolate at various depths beneath the cultivated test plots. This was not entirely successful, but in the meantime the company had begun the operation of laboratory soil columns, which provided the needed information. However, soil and tissue (leaf) samplings were done at the test plots, with analyses by outside laboratories.

By late 1974, the company had decided that the full-scale effluent irrigation project would not include sprinklers. Accordingly, the plots seeded to field corn were irrigated by the furrow method. Also the irrigation rates, which had been as high as 200,000 liters/ha./day, were reduced to rates which were anticipated in the full-scale system (70,000 to 110,000 liters/ha./day average).

Overall, the test plots gave the company confidence that the treated effluent was not toxic to common commercial crops, even at relatively high hydraulic loadings. For example. the corn yields were equal to that achieved with river water irrigation. (Table 2). Likewise, plant tissue analyses showed that the test crops had normal levels of basic elements and macro- and micro-nutrients. (Table 3).

TABLE 2. CORN YIELD IN EXPERIMENTAL TEST PLOTS, 1975

	Fertilizer, Lbs./Acre			Yield
Irrigated With	N	P	K	BD Tons/Acre
Effluent (1)	198	18	18	2.6
Effluent (2)	190	0	0	2.2
Effluent	0	0	0	1.3
River Water	0	0	0	2.5
River Water (1)	198	18	18	2.0
FULL SCALE SYSTEM, 1976				
Effluent (3)	303	53	53	3.4

(1): 860 Lbs./Acre ammonium sulfate (21% N)
220 Lbs./Acre 8 - 8 - 8 (%N - %P - % K)
(2): 860 Lbs./Acre ammonium sulfate
(3): 120 Gallons/Acre aqua ammonia (32% N)
263 Lbs./Acre 6 - 20 - 20

Note: One lb./acre equals 1.12 kg./ha.
One ton/acre equals 2240 kg./ha.

LABORATORY SOIL COLUMNS

These were set up principally to evaluate the effect of the treated effluent on soil chemistry. Simpson also wanted information on the composition of the leachate to the sub-soil.

Three fiberglass columns, 30.5 cm. diameter, were filled with 180 cm. of Shasta Ranch soil. Treated effluent was applied at rates of 0.93 , 1.86, and 3.72 cm./day. The columns were operated for over a year. (See Table 4)

TABLE 3. TISSUE ANALYSIS - CORN*

Parameter	Units	GREEN CHOP Irrigated with Effluent	GREEN CHOP Irrigated with River Water	KERNELS Irrigated with Effluent	KERNELS Irrigated with River Water
TOTAL N	%	3.34	3.00	1.65	1.74
NO_3	ppm	200	200	100	100
S	%	.23	.22	.16	.16
P	%	.25	.29	.08	.11
K	%	2.0	2.2	.33	.33
Mg	%	.14	.16	.14	.17
Ca	%	.68	.85	.02	.01
Na	%	.02	.01	.03	.01
Fe	ppm	180	225	40	35
Mn	ppm	59	49	9	9
NH_4	ppm	1660	1750	.10	.14
B	ppm	17	15	5.5	5.3
Cu	ppm	7	9	2	3
Zn	ppm	115	78	29	33

*All data reported on a dry basis

A more complete report of this activity is given in Appendix C, and the results may be summarized as follows:

In the absence of vegetation, and without the use of soil additives, typical ranch soil becomes saturated with sodium ion after 2.5 to 3.2 bed volumes of effluent have been applied, assuming a sodium ion concentration of 300 to 400 mg./l. (This is about twice the sodium concentration in the Shasta Mill effluent, since February, 1976). Exchangeable calcium and magnesium are depleted at about the same (stoichiometric) rate. Dolomitic limestone addition to the soil was found to be effective in reversing the sodium-calcium ion exchange reaction. Substituting river water (low sodium, low salinity) for effluent leached out the salts which had accumulated in the soil. Without tilling and in absence of vegetation, soil permeability decreased 60 - 80%, depending upon effluent application rate. BOD-5 removal was essentially complete. At the 0.93 cm./day effluent irrigation rate, or 10,000 gal./acre/day, the COD and color removal were 80% and 83%, respectively. At the 3.72 cm./day rate, the removals were 52% and 46%, with the same 180 cm. soil depth. Chloride ion was found to be a suitable tracer for effluent percolate, since it is non-reactive and is not absorbed in the soil.

TABLE 4. SOIL COLUMN PERFORMANCE DATA

Parameter	Units	Col. 1	Col. 2	Col. 3
Application rate	gpd/ac.	10,000	20,000	40,000
BOD-5 reduction	%	90	90	90
TSS reduction	%	90	90	90
COD reduction	%	80	75	52
Color reduction	%	83	*	46

*Equilibrium not reached when river water leaching experiment initiated.

NOTE: 10,000 gpd/ac. equals 93,455 liters per day per hectare, or 0.93 cm./day.

GRAVEL-BAR DEMONSTRATION PROJECT

When Simpson was attempting to obtain the several permits required for the effluent irrigation project, questions were raised about the impact of the effluent percolate on the Sacramento River, which bordered the Company's Ranch on the generally east side. Hydrological studies by a company consultant had already shown that this percolate would ultimately enter the river, and the laboratory soil columns had shown that the percolate would be innocuous. Nevertheless, the company established a 2.5 ha. sprinkler irrigation project adjacent to the river shoreline, where the treated effluent was applied at rates up to 7.9 cm./day. This was at least 5.6 x the maximum rate expected in the full-scale project.

Another purpose of this project was to evaluate odors resulting from sprinkler operation, since some ranch neighbors had expressed concern about this. (Kraft pulp mill effluents, even after high-efficiency biological treatment, have a characteristic odor some-times described as medicinal or earthy or mildewy).

There was no intent to develop vegetation on the gravel bar, and the cobbly, gravelly soil was generally unsuitable for this purpose. However, some grasses did emerge during the experiment, indicating that hydroponic gardening might have been possible.

A detailed report of this experiment is attached as Appendix D.

While operational problems were experienced and not all of the project objectives were fully achieved, the overall conclusion was that the Sacramento River would not be adversely affected by the full-scale effluent irrigation project.

While this project was underway, and partly as a result of it, the company decided that the full-scale effluent irrigation system would not include sprinklers. This was based in part on concerns about odor releases from the sprinklered effluent and possible fog generation during the winter months. Therefore, the full-scale system was designed for flood irrigation (checks or borders) and later modified for row crops (furrow irrigation).

GROUND-WATER MOVEMENT STUDY

In 1974, the company engaged a professional ground-water hydrologist to ascertain soil permeabilities and ground-water movement beneath those portions of the Shasta Ranch that were to be irrigated with the treated mill effluent. In addition to several existing wells on or surrounding the ranch, the hydrologist drilled more than 20 additional wells. The general conclusion was that with one exception, the mass movement of ground-water was easterly toward the Sacramento River. In the central portion of the ranch, the hydrophiles were essentially perpendicular to the river bank, the most desirable condition. However, at both the northern and the southern ends of the 4500 meter frontage, the hydrophiles shifted, including a small vector parallel with the river bank. This is shown in Fig. 1.

Since there was serious concern by some of the adjoining private property owners that the sub-surface effluent percolate might flow beneath their property with possible harmful effect on their crops (including fruit and nut orchards), or might affect their private wells, the company established "buffer zones" at both the northerly and southerly portions of the ranch. These zones were not to receive effluent until the actual ground-water movement of the full scale project was confirmed.

In addition, the consulting hydrologist identified a "ground-water divide" on the south-westerly side of the ranch, also shown in Fig. 1. On the westerly side of this divide, some ground-water appeared to flow toward a small stream (Anderson Creek) bordering company owned land. Therefore, it was recommended that no effluent be applied to lands subject to this questionable ground-water movement until further information was obtained.

As a result of the hydrological studies, about 162 ha. of the Simpson Ranch were identified for receiving the treated effluent. This area was divided into fourteen, letter-coded fields, depending on grade (slope) and soil characteristics. These are shown in Fig. 2, Fields C, D, E, F, I, J, K, L, M, N, O, P, Q, and R. It was indicated that some of the other fields such as B, and G, might receive effluent at a later time, based on experience with the initially-designated fields.

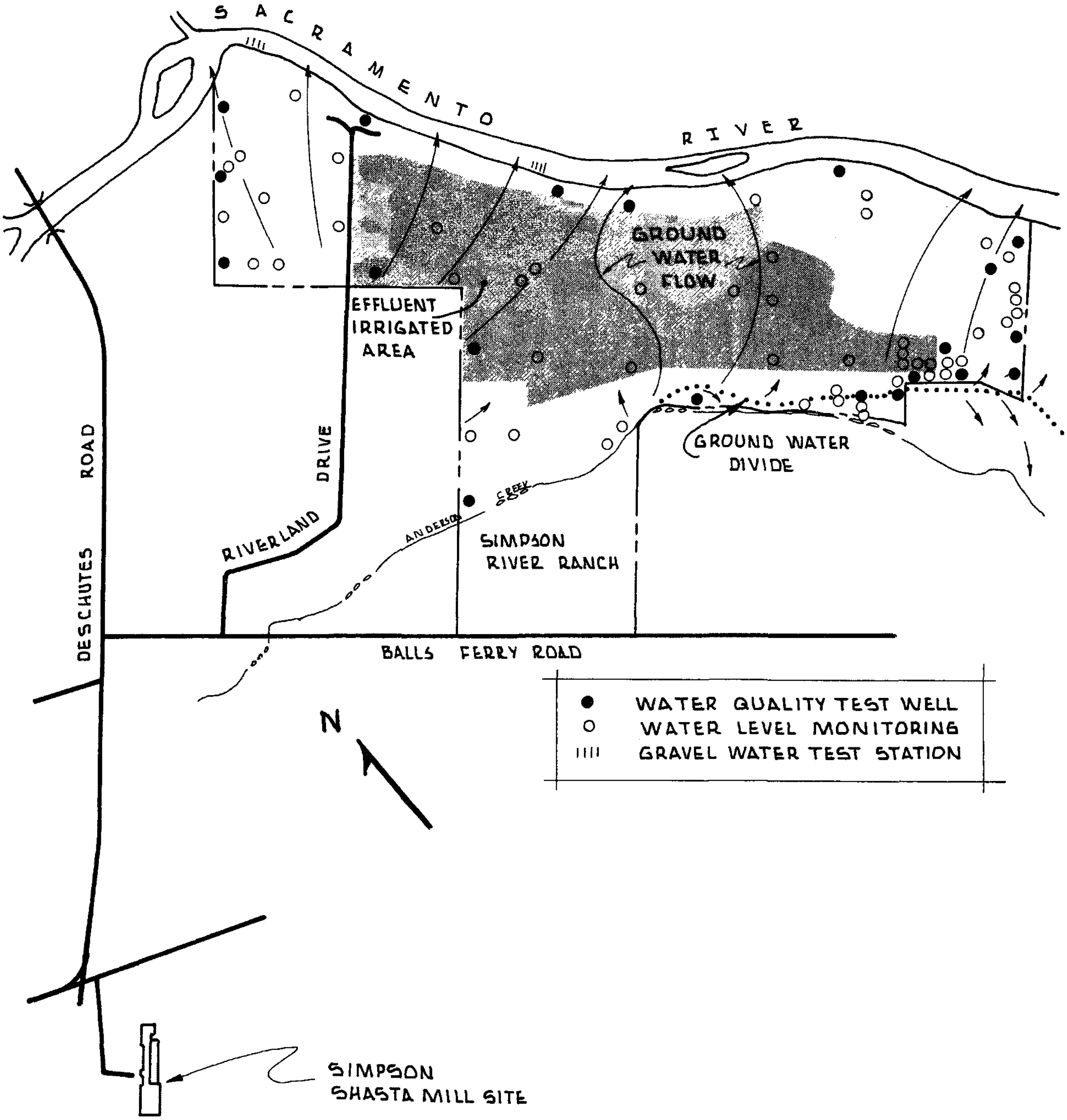

Figure 1. Simpson-Shasta River Ranch, general groundwater movement.

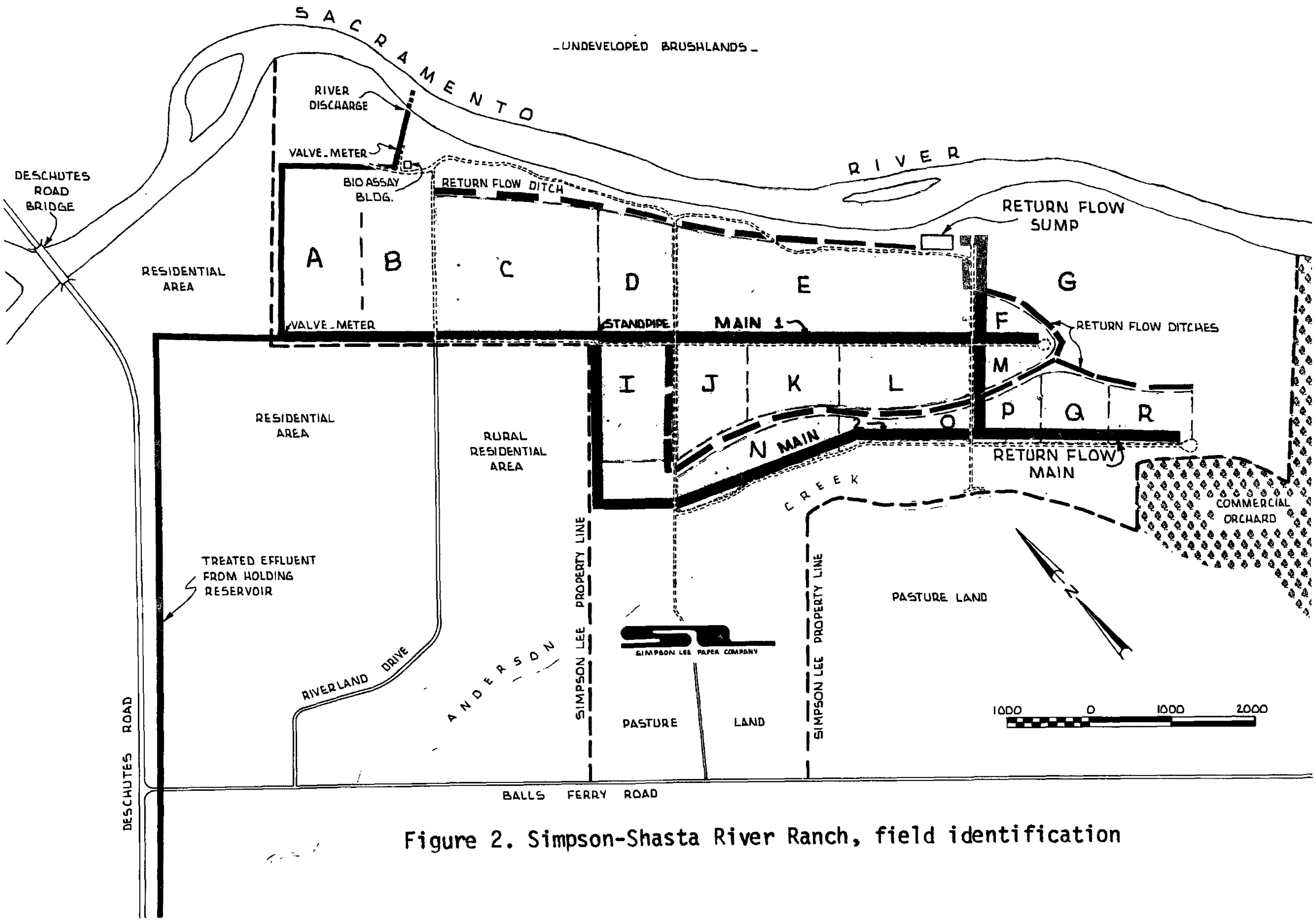

Figure 2. Simpson-Shasta River Ranch, field identification

Other findings of the hydrologist included:

- On most of the fields to be irrigated with effluent, depth to ground-water ranged from 2.5 to 7 meters (relatively high water table). Among other things, this was influenced by absolute river level and irrigation of adjoining properties.
- The slopes of the hydrophiles (gradient of ground-water elevations) were generally small, ranging from 0.6% to 1%. (Note: Most of the fields were graded to slopes of 0.3% to 0.8%, but these did not necessarily correspond to ground-water gradients).
- The permeability of the soils which were to receive the treated effluent were unusually high, ranging from 20,000 to 100,000 liters/sq.m./day. (20-100 m./day). Earlier tests by Simpson technicians and others had indicated that the water infiltration (acceptance) rates at soil surfaces devoid of vegetation were as high as 2 m./day.

On the basis of this information, it was believed that fields with vegetative cover could be irrigated for short periods of time at rates up to 500,000 liters/ ha/hr, without excessive run-off (return flows). However, sustained irrigation at such a rate might result in localized ground-water "mounds", in which case the effluent percolate could move in directions not expected from the general hydrophiles. Therefore, the irrigation schedule was an important aspect of the project, especially where flood irrigation was to be practiced.

SECTION 4

PHYSICAL FEATURES OF PROJECT AREA

LANDFORM - SIMPSON SHASTA RANCH

Geographically, the project area lies in the upper extremity of the Sacramento River Valley, about 8 km. east of Anderson, CA, and adjoining the river shoreline for a distance of about 4.2 km. The terrain in this area is essentially flat, with the fields designated to receive mill effluent having slopes of less than 1%. In general, this land slopes gently toward the river, although there are some natural drainages which are parallel with the river shoreline. In a 75 km. portion of the river between Redding and Red Bluff, CA, the average hydraulic gradient is 0.083%. In this area, the valley is about 40 km. wide, with the Cascade Mountains to the east, the Klamath Mountains and Modoc Plateau to the north, and the Coast Range to the west. Ranch Field E is about 115 meters above sea level.

SOILS

The soils found in the Sacramento River Basin are generally sedimentary deposits known as alluvium. These soils have been deposited by periodic flooding of the river and the erosive actions of its upper tributaries. In the local area, soil of this kind is known as "river bottom sandy loam", and is often mined for use as top dressing in residential areas. From a technical standpoint, these soils are known as "Reiff" and "Columbia", with U. S. Soil Conservation Service codes typically 1 M4-1C/1A1 and 1 L5-1C/2A1. These soils are suited to cultivation of many agricultural crops with minor limitations, and capable of high productions if sufficient water and nutrients are provided. These soils have moderate to moderately rapid permeabilities.

SUBSURFACE - GEOLOGY

The geology in the project area indicates that the flood plain deposits are composed of three distinct formations. The uppermost is the "recent alluvium", with a thickness of 3 to 6 meters. The materials consist of unconsolidated gravel, sand, silt, and clay. As previously indicated, the permeability is typically 50 m. per day or higher.

The second layer is the "Tehama Formation", which ranges to a depth of 300 m. or more. This formation consists of semi-consolidated mixtures of clay, silt, sand, and gravel. Most of the fresh ground-water in the basin is drawn from the Tehama Formation, which is stratified with poor vertical permeability. Water moving to the ground-water will not move to any significant extent into this formation, below the recent alluvium. Thus, water moving vertically below the root zone will enter the shallow ground-water and then flow laterally toward the Sacramento River.

The deepest geologic layer is the "Chico Formation", which is composed of consolidated sedimentary rocks, including sandstone, shale, and conglomerate. Saline water predominates in this formation.

SECTION 5

CONCEPTUAL AND FINAL DESIGN OF FULL-SCALE EFFLUENT-IRRIGATION PROJECT

PRELIMINARY AND FINAL PLANS

To assist in the design of the effluent-irrigation project, Simpson Paper Company engaged a consulting firm, CH2M Hill and Associates, Redding, California. Other consultants were engaged directly by the company for specific purposes, such as the development of cropping plans.

In June, 1974, CH2M-Hill submitted a "Conceptual Design", which was based on a combination of sprinkler plus surface (border-strip) irrigation. At this time, the plan was to apply 26,530 cu.m. of effluent per day to 282 ha. of prepared fields. In the next five months the operating parameters were re-defined to suit a two-phase mill expansion program, the second phase of which was deferred.

The first phase included provisions for a new paper machine plus an upgrading of the original paper machine and other minor changes within the Shasta Mill, to be completed by January 1, 1976. On this basis, the final plans for the effluent-irrigation project were prepared, with contract documents published in February, 1975. As previously indicated, the company elected not to install sprinklers. About 162 ha. of land area were designated to receive up to 455,000 cu. m. per month of the treated effluent. The border-strip irrigation system and the return flow systems were to be highly automated to assure uniform effluent application and to minimize operating labor.

It was the company's intention to engage a local, qualified, contractor to carry out the agricultural management, based on established guidelines. To assist in this, CH2M-Hill prepared an "Operation and Management Plan for the Simpson Ranch", dated January, 1975. A copy of this plan is attached as Appendix E. By the late summer of 1975, the company had made several changes to the plan, one of the major ones being a decision to make the initial field plantings with the oats and wheat instead of grass (hay) crops.

It should be pointed out here that both the Conceptual and the Final Plans for effluent irrigation were based on the development of "random-seeded-crops," as contrasted to row crops, with the so-called hay or grass crops pre-dominating. The slopes of the fields, the original checks or borders, and the placing of the automated irrigation valves were all based on this thinking. However, starting in the spring of 1976, and again in 1977, row crops (corn, beans, onions) were planted with good results. Among the reasons for the change in cropping plan in 1975-76 were:

- Questions as to the marketability of the hay crops. Most likely, a major portion of the crop would have had to be sold fresh (as "green chop") within a 10 km. radius of the ranch, or cubed (pelletized), or ensiled. Neither the company nor the ranch contractor had the equipment to carry out such activities at the time the project began, and there was concern that not enough customers could be found for the product.

- Hay crops are usually allowed to field dry after mowing, for as long as 3 weeks. During this period, it would not be possible to apply effluent. On the other hand, effluent could be applied to such crops as wheat and corn during the final curing, just prior to harvest.

- The last stages of test plot operation in 1975 showed that field corn did very well when irrigated with effluent.

- The cereal grains, including corn, were much more attractive as cash crops in 1975-76 than were hay crops. (This situation reversed in 1977).

EFFLUENT APPLICATION, GROUND-WATER MONITORING.

On a weekly basis, a Shasta Mill representative would inform the ranch contractor of the volume of effluent which had to be applied to the fields over the next seven day period. It was expected that this would be based on the difference between the total suspended solids in the effluent from the secondary treatment system vs. the allowable discharge of TSS to the Sacramento River (NPDES Permit Conditions). However, the contractor could use a greater volume of effluent, at his discretion.

Since two of the major concerns were groundwater composition and movement (including the effluent percolate), several additional test wells were drilled. About 17 of the total number were designated as "water quality test wells", while these and more than 50 other wells were used to monitor the absolute elevation of the ground-water. The locations of some of those drilled during the research phase (Sec. 3), are shown in Fig. 3 and Fig. 1.

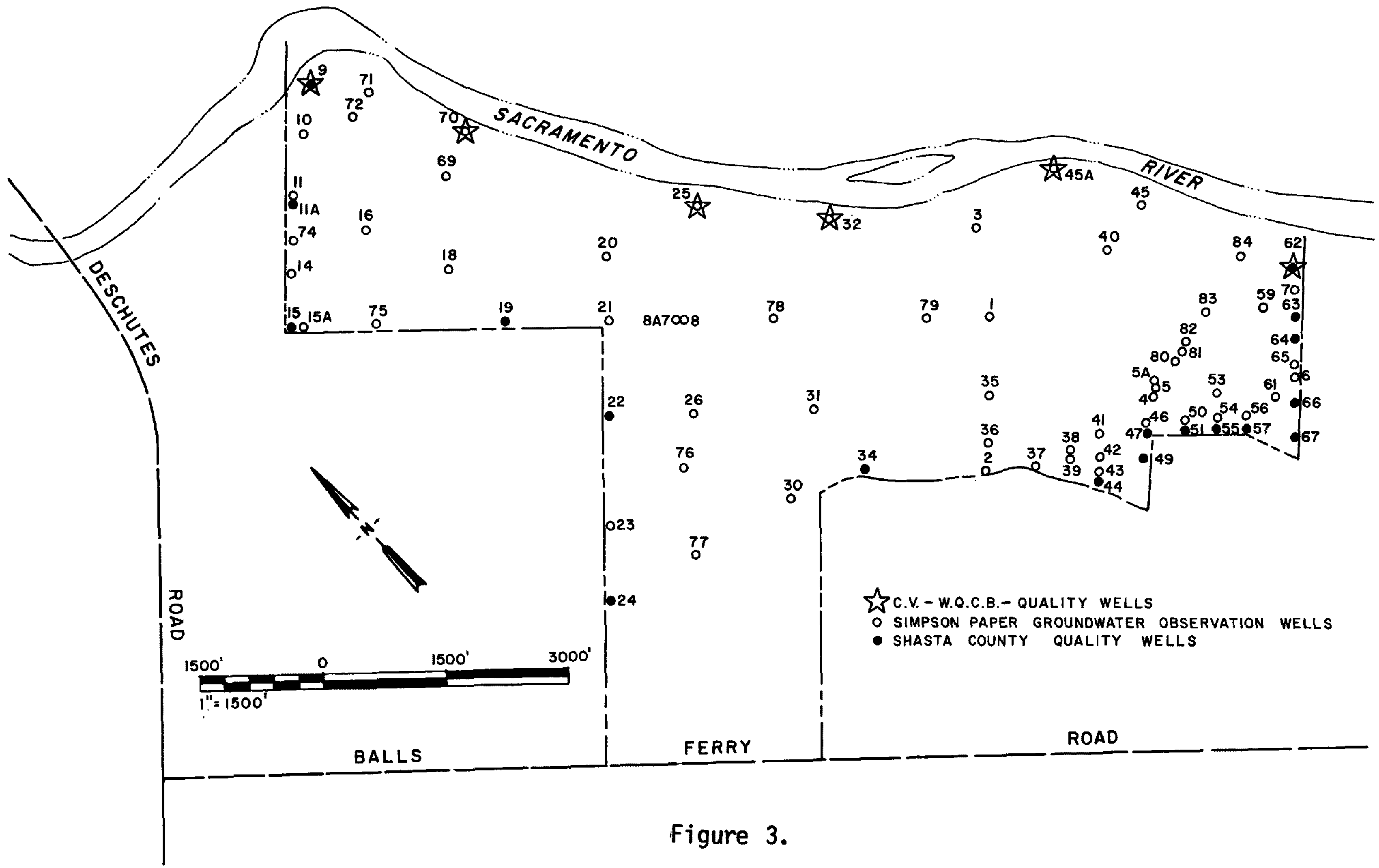

Figure 3.

SIMPSON GROUNDWATER MONITORING WELLS

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SECTION 6

PHYSICAL DESCRIPTION OF EFFLUENT IRRIGATION SYSTEM

CONSTRUCTION

Construction began in January 1975 as initial clearing and grubbing got underway. A minor portion of the area to be developed for fields was covered with oak trees, brush and berry vines, all of which had to be removed in time for the heavy land-leveling equipment which was to begin work in early April. The larger portions of the Oak trees were chipped and sold for conversion into wood pulp. The smaller limbs were cut and sold locally as firewood.

The heavy equipment arrived in April on schedule and undertook the enormous task of moving the more than 335,000 cubic meters of earth required to produce the desired slopes and cross-slopes on the irrigated fields. Depending upon soil characteristics, length of fields, valve spacing and natural terrain, the slopes were precisely established in the range of 0.2% to 0.8% fall.

In general, the system consists of over 6100 meters of buried, gasket-jointed, reinforced-concrete pipe, with outlets at center-to-center spacings of 7 to 14 meters along the length of the fields. A total of 470 automatic irrigation valves are utilized, one for each outlet on the irrigation mains. These automatic irrigation valves were developed by Paul Fischbach of the University of Nebraska and are currently being distributed by the Econogation Valve Company of Humboldt, Nebraska. The bodies are constructed of a polyolefin resin, with opening and closing being controlled by the admission of low pressure air to a rubber bladder within each valve body.

The Fischbach valves are controlled by automatic, multiple-port controllers distributed by the Toro Research and Development Center, San Marcos, California. Each controller is equipped with a timing mechanism, and an eleven-port valve. Each port of the valve is connected, via buried PVC airlines, to up to four Fischbach valves. More than 38,000 meters of PVC airlines were installed.

The general location of the irrigation lines is shown in figure 4. The effluent from the secondary treatment system is transported to the Simpson Ranch via an existing 0.76 meter-

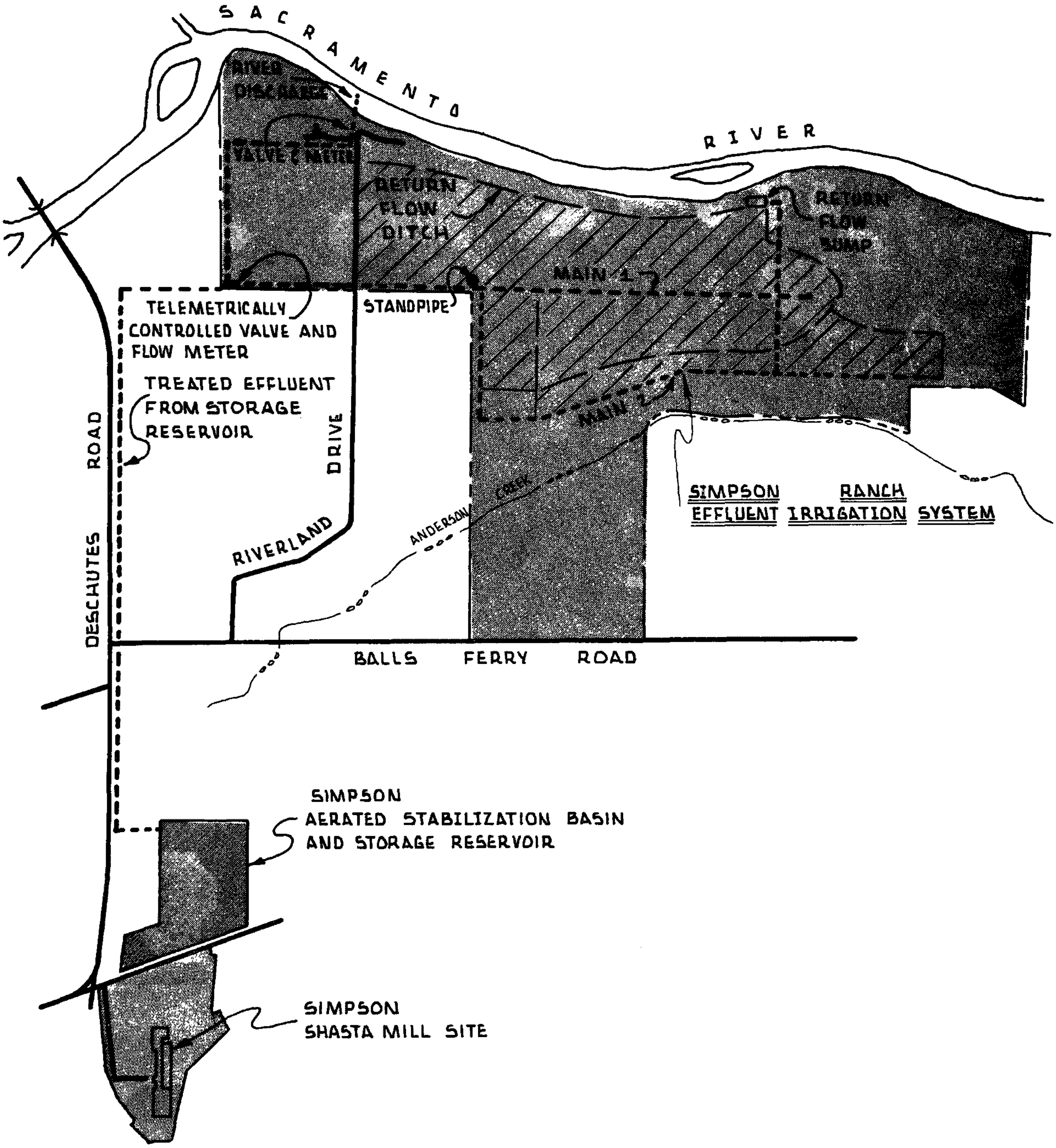

Figure 4. Simpson-Shasta River Ranch, effluent distribution lines.

dia. buried concrete pipe. At the generally northwest corner of the ranch, a tee was installed with the branch supplying Main 1. At the upstream end, Main 1 is also 0.76 m. dia., decreasing in steps over its 2800 meter length. The flow into Main 1 is regulated by a motor-operated (automatic) butterfly valve, 0.61 m. dia., with a propellor-type flowmeter and integrator. Main 1 serves eight of the letter-coded fields (C, D, E, F, J, K, L, M), with the Fischbach valves being operated in a multiple of four per controller signal.

About 1140 meters downstream of the tee is a sub-branch line known as Main 2, which is laid generally west toward Anderson Creek and then southward, somewhat parallel with Main 1. This Main is 1460 m. long and starts out at a diameter of 0.46 m. It serves three letter-coded fields (I,N,O). On Main 2, each controller signal controls just one Fischbach valve.

The run-off from the effluent-irrigated fields flows through a 7630 meter long network of earthen ditches, terminating at an east-central "Return Flow Sump". This is an earthen basin of about 7,600 cu.m. capacity, equipped with level transmitters and controllers. A 5,700 liter/min. Return Flow Pump delivers this water to a buried Return Flow Main, which serves three fields (P, Q, R) at the generally southwest end of the ranch. The Return Flow Main is about 1900 m. long, and starts out at 0.46 m. dia. A separate, manually-valved, branch line was run from Main 1 to the Return Flow Sump, so that "first use" effluent could be supplied should the need arise. Also, by manual valve arrangement, Return Flow can be sent in reverse flow through Main 2, or vice versa. On the Return Flow Main, each controller signal controls just one Fischbach valve.

SYSTEM BASIC OPERATION

The Fischbach valves open as the timing mechanism vents each of the individual eleven ports to the atmosphere, allowing the water pressure in the irrigation main to push the air out of the Fischbach valve bladder, thus opening an orifice allowing discharge of water to the field. Each of the eleven ports on the Toro timer is time-adjustable from 0 to 9 hours, the actual field-selectable time setting being a function of field slope and length, type of crop, maturity of crop, season and soil permeability.

On command from a central control station, a 110V electrical pulse activates the first of the irrigation controllers that has been preset for automatic control. The pulse starts the timing mechanism which rotates the multiport valve, allowing the first set of Fischbach valves to discharge water for the pre-set time interval. At the end of that time interval, the timing mechanism automatically shuts the first set of valves and opens the second set of valves, this process continuing until each of the 11 positions at that particular controller has been satisfied. This controller then releases an electrical pulse which is then picked up by the next successive controller, perhaps 300 meters down the pipeline. The second controller then cycles through the 11 positions and eventually sends a pulse to the next controller, the cycle repeating until all controllers on that main have been satisfied.

SAFETY CONTROLS

Significant design effort was spent in allowing the system to operate with infrequent attention while at the same time providing adequate protection against washouts, flooding or water spills off the irrigated fields. The motor-operated flow control valve, which regulates the amount of water released to the irrigation system, is equipped with three interlocks designed to curtail the basic irrigation rate in the event potential problems should arise. A high-level switch is located in a large concrete stand-pipe on irrigation Main 1. Should the water be discharged into the field at a rate less than the rate water is entering the irrigation main, the level in the standpipe will rise, the switch closes and the valve is closed after an adjustable timer period of 0-15 minutes. The valve reopens automatically once the level in the standpipe has dropped below the level switch. If the water level in the Return Flow Water Sump rises above a predetermined maximum level, indicating near-overflow conditions, a level switch closes and a telemetry signal closes the irrigation main flow control valve until such time as the level in the return flow sump is below the maximum level. Once the level has dropped sufficiently, the main flow control valve opens automatically and irrigation resumes. Finally, if the level in the No. 2 Aerated Stabilization Basin (feeding the irrigation main from the pulp-paper mill site) drops below a predetermined level, the irrigation main flow control valve closes via a telemetry signal until such time the Basin rises to the proper level. Each of these basic pieces of information are telemetered back to a control panel at the Shasta Pulp Mill, some 8 kilometers away.

SECTION 7

CROP EXPERIENCE

FIRST SEASON

By the summer of 1975, Simpson people were confident that almost any crop traditionally grown in the upper Sacramento River Valley could be grown with the treated Shasta Mill effluent. This was based on the company's earlier research (particularly the test plot studies of 1973-1975) and information from several consultants and other sources. Accordingly, in the late fall of 1975, about 57 ha. were seeded to Montezuma red oats and 105 ha. to Anza hybrid wheat.

The first effluent irrigation took place on January 7,1976. Soon after, some portions of the juvenile crops showed an abnormal yellowing, with some wilting immediately after irrigation. Naturally this was of great concern, and several specialists were brought in to identify the problem. Extensive tissue analysis did not reveal any diseases or toxicants. The cause was never fully explained, but it appears that temperature shock, similar to frost damage, occurred when the warm effluent contacted plants acclimated to colder ambient temperatures. (About 15 months later, a similar phenomenon occurred with a bean crop. This time, an investigation resulted in the conclusion that two factors were involved:

- Insufficient amounts of micro-nutrients were present in the soil, specifically zinc, sulfur and possibly iron. This was corrected.
- In leveling the fields in early 1975, some cuts of over one meter were made, whereas other areas were filled to an equal or greater depth. The yellowing of vegetation was much more evident in the cut areas, due to:
  - Removal of original organic matter (humus) and topsoil nutrients, and
  - Greater soil compaction, resulting from heavy machine traffic not fully corrected by subsequent cultivation.

It is now believed that these conditions were the main cause or certainly contributed to, the abnormal yellowing of the oat and wheat crops in February, 1976).

The yields on the first two crops turned out quite satisfactory, oats (as hay) at 8800 kg./ha. and wheat (as grain) at 4400 kg./ha. In the spring of 1976, field corn (Asgrow RX-70) and some sweet corn were seeded to some of the recently-harvested fields. These crops also did well, with the field corn taken as grain in October, 1976, at about 7600 kg./ha. The company's consulting agronomist indicated that these yields of oats, wheat, and corn were equal to or better than that achieved on comparable fields irrigated with fresh water.

SECOND SEASON

During the winter of 1976-77, a major portion of the Simpson Ranch was left fallow. Previously-planted fields were given a very light discing, and effluent was applied as necessary to assure compliance with the NPDES Permit requirements. While the fallow fields accepted the effluent without major problems, the company concluded that it would have been better to have live vegetation, even if dormant. The future cropping plan was modified accordingly.

The 1977 crops included kidney beans, field corn and wheat, plus experimental crops including barley, seed onions and alfalfa. Only a small portion of the seed onions was irrigated with the mill effluent, but that portion did as well as the rows irrigated with PUD water originating from the Sacramento River.

The first two cuttings of alfalfa averaged about 2350 kg./ha. per cutting, a satisfactory yield. On the basis of this success, plus other reasons, the company decided to enlarge the alfalfa fields to a total of about 43 ha., beginning in September, 1977.

The kidney beans were adversely affected by a combination of problems not necessarily related to the use of mill effluent for irrigation. The bean crop was being harvested at the time this report was being prepared, and no yield data were available. However, the company's consultants indicated that kidney beans are among the least salt-tolerant crops, and that the mill effluent did not meet the usual standards for this crop.

FUTURE PLANS

As previously indicated (Section 5), the original cropping plan did not include row crops. While the ranch contractor devised ways to irrigate such crops, and the yields were fair-to-excellent, the slopes or grades of some of the fields were too steep, and erosion occurred in some areas. Further, furrow irrigation resulted in larger amounts of field run-off than with the border-strip (broad-flood) methods, taxing the Return Flow System. In 1976, these disadvantages were more than offset by the favorable market price for field corn.

By early 1977, the market prices of corn and wheat had dropped to less than 50% of the 1975 levels. This, plus the fact that most row crops were not suitable for winter growth, resulted in a company decision in mid-1977 to shift back to more fodder-type crops such as alfalfa and oat hay.

It has become obvious to Simpson Paper Company that it must maintain a high degree of flexibility in its cropping plan. While a principal objective of the ranch effluent irrigation project is to assure compliance with the Shasta Mill's Waste Discharge Permit, the company also has to reckon with the well-known vagaries of the agricultural marketplace.

Simpson's investment in its Shasta Mill effluent irrigation project exceeds $10,000 per hectare, excluding land costs. With such high fixed costs, the only way the effluent-irrigated portion of the ranch could be made profitable, in the normal sense, would be by the planting of high-risk crops or labor-intensive crops (such as tomatoes or other "truck-garden" produce). At the present time, these are not consistent with company objectives.

SECTION 8

COMPLIANCE WITH WASTE DISCHARGE PERMIT

For the past 20 months, the Shasta Mill has operated in full compliance* with its unusually stringent Waste Discharge Permit (Appendix A). Part of this is due to the exceptional quality of the secondary effluent itself. However, for 8 of those months, compliance was made possible only by the use of this effluent for irrigation, in amounts up to 45% of the monthly flow from the secondary treatment system. As anticipated, the principal compliance difficulty during those eight months was meeting the TSS criterion. This occurs mostly during the winter months, when Sacramento River flows are normally the lowest, and is compounded by the observation that TSS concentration in the secondary effluent (mostly residual biofloc) is higher during the colder months. Obviously, this need to irrigate during the winter months is not consistent with usual agricultural practices. While this poses some ideological problems in dealing with otherwise successful, conventional, agriculturists, Simpson and its consultants and contractors have demonstrated that a common ground can be found, and that effluent irrigation projects such as this can be managed successfully.

For the other 12 months, effluent was used by the ranch contractor at his discretion. For all practical purposes, this was the only kind of water available to the contractor for the support of the crops, a condition which was recognized as being undesirable from a ground water management standpoint (See Sec. 9). Consequently, in the summer of 1977, the company began a project which would make other (non-effluent) water available to the contractor. It is expected that this alternative water supply will be used at certain times, and especially during the months of April through August, using components of the distribution system originally provided for the effluent.

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* This statement is limited to the physical and biochemical properties of the effluent itself, as discharged to the Sacramento River directly or indirectly (as effluent percolate through the ranch soil).

Table 5 shows effluent application to the Simpson Ranch, by quarters. For the total period, it may be assumed that the average effluent flow from the secondary treatment system was in the range of 3.7 to 4.2 million cubic meters per quarter (11.0 to 12.5 million gallons per typical operating day).

TABLE 5. EFFLUENT APPLICATION TO SIMPSON SHASTA RANCH

PERIOD	QUANTITY, thousands	
	Cu. Meters	Gallons U. S.
1976		
1st Quarter	970	256,000
2nd Quarter	481	127,000
3rd Quarter	720	190,000
4th Quarter	1,452	383,000
1977		
1st Quarter	534	141,000
2nd Quarter	697	184,000
July Only	303	80,000
August Only	125	33,000
TWENTY MONTH TOTAL	5,282	1,394,000

Approximate percentage of total secondary effluent diverted to irrigation system for 20 month period, average - 20.1%.

Highest Quarter (1976 - 4th) - 37.6%

Highest Month (December 1976) - 46.5%

A typical Shasta Mill monthly report to the Central Valley Regional Water Quality Control Board is included in Appendix H, Exhibit 1. Following that, as Exhibit 2, is an example of a mill worksheet, showing the distribution of the secondary effluent between direct discharge to the river and irrigation. This worksheet also contains the data on the two key effluent quality parameters, BOD-5 and TSS.

FISH TOXICITY

Since the upper reach of the Sacramento River is a natural spawning ground for king salmon and "steelhead" trout, there was great concern on the part of the State regulatory agencies about the impact of the Shasta Mill discharge on the fishery. Among other precautions, the mill is required to perform 144 hour, continuous-flow, bioassays on a regular basis. Fingerling-size king salmon or rainbow trout are used in these tests.

Results for the period March-November, 1977 are summarized in Table 6.

TABLE 6. FISH BIOASSAY RESULTS

Condition	Ave. Percent survival*
Control	99.82
100% effluent	94.82
75% effluent	99.46
56% effluent	99.64

*Twenty eight bioassays

Using California Fish and Game Department's reporting technique, the average "toxicity emission rate" (TER) for the stated period was 0.94 tu-MGD, versus a permit limit of 10.0 tu-MGD (Toxicity concentration, tu, is 100/(TL-50), where TL-50 is the median lethal dose, with an empirical formula to adjust for the condition where less than 50% of the test fish are lost in undiluted effluent. The tu value is multiplied by the discharge in millions of gallons per day to get TER. While TL-50 (or TLm) may be scientifically sound criterion for toxicity characterization, Simpson Paper Company has serious reservations about the calculated tu values when fish survival exceeds 50% in an undiluted effluent sample).

The Shasta Mill also performs bioassays on the mixture of ground-water and effluent percolate taken from test wells on the effluent-irrigated fields. In all cases, fish survival has been 100%.

On the basis of these data, and the results of several additional test programs carried out at the request of the state regulatory agencies, Simpson Paper Company contends that its Shasta Mill effluent is harmless to the Sacramento River fishery.

SECTION 9

GROUND-WATER MANAGEMENT

BACKGROUND

Even in the conceptual stage of the effluent irrigation project, Simpson Paper Company recognized that effective ground-water management was a key to the success of the activity. Later, when the permits were being developed, it became apparent that this was a matter of great concern for some of the neighboring property owners and for the agencies charged with protecting their interests. At times, some of these concerns threatened to result in regulatory actions which would have made it extremely difficult, if not impossible, to carry out or continue the project.

Part of this reaction might be attributed to basic "fear of the unknown", relative to the use of a treated industrial effluent for irrigation. Tending to enhance this were such circumstances as the proposed, relatively high, irrigation rate and the unconventional practice of year-around irrigation in an area where ground-water levels were known to be high (i.e. relatively close to the land surface).

The resources to be protected included:

- Potable ground-water supplies on properties adjoining the Simpson Shasta Ranch.
- Non-potable ground-water beneath properties adjoining the ranch (specifically because of fruit and nut orchards on some of those properties).
- The Sacramento River, especially the ecology of the western shoreline, adjoining the ranch.

Two regulatory agencies, the California Regional Water Quality Control Board (RWQCB), and the Shasta County Planning Commission, exercised overlapping jurisdictional rights in these matters, and their requirements are shown in Appendices A and B.

Compliance with the RWQCB standards has not been a problem for either party, and, in fact, that agency has made complimentary statements about Simpson's entire water quality protection program.

In late 1976, almost a year after the Shasta Mill treated effluent irrigation project began, a conflict arose with the County Planning Commission over the interpretation of the Use Permit condition. An account of this matter is given in Appendix F. The conflict, which has been only partially resolved as of this writing, could have handicapped the project to the point where the company could not meet its Waste Discharge Permit conditions.

The company did experience some operating difficulties during 1976, especially during the months of October through December. At no time did this result in any threat to the three resources previously identified for protection. However, as a result of the experience gained, Simpson modified certain aspects of its management plan (Appendix F, Part 3), and is now confident that the irrigation project can be controlled satisfactorily.

An analysis of the groundwater response to irrigation practice is contained in Appendix H.

SPECIFIC DIFFICULTIES ENCOUNTERED

First Situation

In 1974, the company's consultant hydrologist identified some anomalies in ground-water hydrophiles at the generally south-western portion of the ranch (see Sect. 3), including a "ground-water divide". Having thus been alerted to a potential problem, the company was especially watchful of the test wells in and surrounding Fields Q and R. (See fig. 2).

Soon after effluent irrigation of these fields began, there was some evidence that effluent percolate was moving in an undesired westerly direction, this being a function of the rate of irrigation. While investigating the causes of this, the company voluntarily ceased effluent application to Field R and a portion of Field Q.

After considerable study, the company concluded that there were three inter-related causes for this condition:

- Very shallow slope to the ground-water hydrophile, thus making the area susceptible to "water mounding" and temporary reversal of this slope.
- Portions of Fields Q and R are underlain by a seam of extremely permeable soil (approaching coarse gravel), which can conduct the effluent percolate along a horizontal plane at an unusually high rate.
- There was an impediment to ground-water movement toward the easterly side of those fields. Working with its consultant hydrologist, the company has undertaken a remedy

in the form of a ground-water interceptor ditch on the easterly side of the fields in question. By pumping water from this ditch, it is believed that the slope of the hydrophile toward the east will be increased sufficiently to permit effluent application to the fields. At the time of this writing, pumping had not yet begun.

Second Situation

In the last quarter of 1976, the Shasta Mill had to apply 25% to 45% of its secondary effluent to the ranch to assure compliance with its Waste Discharge Permit. This occurred at the time when a major portion of the ranch was fallow, and the evapotranspiration rate for the three month period was less than 11.4 cm. (4.5 inches). (The corresponding effluent application rate for that period was about 89 cm. or 35 in.).

This resulted in an undesirable degree of soil saturation, with occasional, short-term, "ground-water mounding" in some areas. The remedies for this area were:

- Maintain vegetative cover over a larger fraction of the ranch during the winter months.
- Provide better control of amount of effluent applied to any given field or portion thereof, to avoid localized hydraulic overloading. (See Appendix F, Part 3).
- Intensify test-well monitoring at times when large amounts of effluent must be applied to the fields to anticipate and mitigate potential ground-water problems.

All three remedial actions were adopted in the summer of 1977. In addition, the mill was encouraged to make further reductions in fresh water usage, thus reducing the amount of treated effluent which would have to be applied to the fields during the winter.

Third Situation

A few of the water quality test wells showed chloride ion concentrations which approached the limits prescribed by the County Use Permit. (See Appendix F, Part 1. The original limit was about 123 mg./l. of chloride ion, this being changed to 200 mg./l. in July, 1977. The chloride ion concentration in the effluent ranges from 180 to 270 mg./l., but it is not uncommon to find effluent percolate constituting up to 80% of the groundwater in the vicinity of some of the ranch interior test wells, as well as those near the river shoreline).

The company believes that one of the better remedies for this condition is a reduction in the amount of effluent (hence chloride ion) applied to the ranch fields during an entire calendar year. Accordingly, Simpson is installing new facilities which will provide another, low-chloride, water source for irrigating the ranch during those times (especially the summer months) when permit conditions can be met without effluent irrigation.

A typical chemical analysis of the Shasta Mill's secondary effluent is shown in Appendix G, Exhibit 2.

Some examples of test well data from the Simpson-Shasta Ranch are given in Appendix G, Exhibit 3.

SECTION 10

SOIL MANAGEMENT

Beginning with its initial research program in 1972-74, Simpson recognized three potential soil conditions which might result from effluent irrigation:

- Accumulation of suspended solids in the topsoil, as the result of filtration.
- Depletion of calcium and magnesium from the soil as the result of exchange with sodium ions in the effluent.
- Depletion of soluble nutrients, especially nitrogen (N) compounds, due to high leaching rates.

The pre-operational studies described in Section 3, were intended to find ways of coping with these conditions, and those findings were put into practice in the full-scale system.

SUSPENDED SOLIDS

The Shasta Mill secondary effluent contains from 10 to 60 mg./l. of TSS, with the long-term average being about 30 mg./l. A major portion of this is biofloc residual from the biological waste treatment process itself. The remainder is mainly calcium carbonate and inorganic paper additives such as kaolin, alumina, and titanium dioxide.

The biofloc, with its high organic fraction and low nutrient content (N,P,K, and many micro-nutrients), is, if anything, beneficial to the soil. It is analgous to a balanced compost and not considered to be detrimental.

The other suspended solids are filtered out in the topsoil and in some cases a whitish mineral residual is seen in areas where vegetation is sparse or when there had been temporary ponding of the effluent. While these insoluble minerals are not necessarily incompatible with agricultural soils, the particle size is quite small, generally less than 20 microns. Thus, where they are allowed to accumulate in discrete, continuous layers, one possible result is a marked decrease in the water infiltration rate. A slight manifestation of this has been seen where furrow irrigation of row crops was practiced.

It has been found that the conventional tilling and soil preparation associated with intensive agriculture is sufficient to prevent a water-infiltration - rate problem due to the inorganic suspended solids. Further, growing vegetation causes minute movements or "disturbances" at the soil-air interface, tending to prevent any "layering effect". In the case of perennial crops, such as alfalfa or clover, this "disturbance" effect at the soil surface is seen to be sufficient, thus not requiring that the established stand be sacrificed prematurely for mechanical tilling.

On a long-term basis, it may become necessary to do some severe mechanical tilling, such as ripping or deep-plowing, to blend the filtered mineral matter with the topsoil. Based on experience to date, it appears that such treatment would not have to be done at less than five year intervals, if at all.

CALCIUM-MAGNESIUM DEPLETION

The soil-column experiments (See Section 3) indicated that this condition could be managed by the periodic addition to the top-soil of limestone, gypsum, or dolomite, with the dolomite having some advantages. Accordingly, full field-scale experiments with these materials were carried out in 1976. This included the application of a by-product of the local sugar beet processors, which consisted mostly of calcium carbonate. The application rate was about 4500 kg./ha. (2 tons/acre), based on earlier soil analyses and other information.

In the late summer of 1977, as a part of the establishment of the winter crops, all fields subject to effluent irrigation received similar heavy applications of the several "soil sweeteners" (a term sometimes used by gardeners in reference to neutral calcium and magnesium compounds), and this program will continue on an "as needed" basis.

It should be pointed out again that one component of the suspended solids in the effluent is calcium carbonate (with a small amount of magnesium carbonate), and that both calcium and magnesium ions are also present in soluble form in the effluent. While these are not sufficient to balance the sodium ions also contained in the effluent, their presence does reduce the amount which has to be applied in dry form to the top-soil, via broadcasting.

The company's program to monitor the results of the field applications of calcium and magnesium has revealed some anomalies. While these suggest that the mechanism of ion exchange in the soil may not be as straight-forward as was originally believed, no changes to the program are planned at this time. However, the company is intensifying its studies in this area.

DEPLETION OF SOLUBLE NUTRIENTS

Simpson expected that the fields subject to relatively heavy effluent irrigation would require somewhat higher applications of fertilizers than for the same crops grown with "conventional"irrigation. While the logic is reasonable, the company has not yet been able to quantify the difference.

In the local area, the most common method of adding nitrogen to the soil is via aqua ammonia or ammonia (gas). While this is advantageous with acidic soils, it is known that the ammonia must be converted to the nitrate form before it can be utilized by the vegetation. Since this conversion requires some unknown period of time, there was concern that too much of the N would be lost to the sub-soil by leaching, or volatilization.

While the application of "slow-release" forms of nitrogen (such as urea formaldehyde) would be highly desirable, the cost is prohibitive . The company is investigating the several other forms of nitrogen used in intensive agriculture, to see if there is a better choice than ammonia.

The soils on the Simpson-Shasta Ranch were inherently deficient in phosphorous (P), so this nutrient has been added. The phosphorous compounds have a built-in "slow release" characteristic, so there is no concern about abnormal leaching rate. In the original ranch top-soil, potassium (K), was present in sufficient amounts. While the retention mechanism is different from the phosphates, potassium leaching is not a matter of concern.

As indicated in Section 7, it has been seen that the extensive earth moving in 1974 resulted in the "scalping" of topsoils in some areas. While the mechanical or structural characteristic of the exposed sub-soils in those areas was satisfactory for agriculture, there is an apparent deficiency of humus and the major nutrients, as well as some micro-nutrients such as sulfur, zinc, and possibly iron. The humus (organic matter) will build up slowly in the normal course of events, and the other deficiencies, once detected, were remedied by specific soil supplements.

SECTION 11

VECTOR (NUISANCE INSECT) MANAGEMENT

Simpson's Ranch is included in the Shasta Mosquito Abatement District, a local public utilities district (PUD). Their field crews have indicated to the company that due to the modern irrigation practices carried out at the ranch, including good water run-off management, the vectors are few in number and easily controlled.

Those insects known to be harmful to agriculture are controlled by the ranch contractor, using standard methods approved by the State Health Department.

SECTION 12

PROJECT STAFFING - MANPOWER AND SERVICES

The Shasta Mill effluent irrigation project is managed jointly by Shasta Mill and Corporate personnel.

The mill has responsibility for assuring compliance with all permits. With regard to the Waste Discharge Permit, mill people inform the ranch contractor as to the quantity of effluent that has to be diverted to the ranch fields on a weekly basis. With regard to County Use Permit, the mill staff carries out the ground-water monitoring program. The mill staff also does soil and tissue samplings, with testing done in its own or outside laboratories, and carries out an extensive receiving water quality monitoring program. (This last program was described in Section 1).

Corporate personnel develop the contracts with the ranch contractor and coordinate some of the relationships with the mill. In addition, the corporate staff develops and/or carries out the engineering projects (including engagement of contractors and other special services), cropping plans, and long-range ranch management plans.

The mill staff includes the Technical Director, an Environmental Control Engineer, a salaried assistant to the Environmental Control Engineer, and three technicians. Other technicians from the Technical Department are utilized when necessary.

The corporate staff includes the Vice President-Administration, and his field deputy, the Environmental Projects Engineer. Available for consultation are the Corporation Director of Engineering and the Corporation Director of Environmental Protection. Extensive use has been made of outside consultants in specialized fields including water science, agronomy, horticulture, geology, pomology, and ground-water hydrology.

The ranch contractor includes a General Manager, a part-time Field Foreman, a full-time Irrigation Tender, and field laborers as needed. The ranch contractor also retains an independent agricultural consultant on a part-time basis.

For assistance in the basic design of the Shasta Mill efluent irrigation project, including most of the detailed engineering and preparation of equipment specifications, Simpson engaged the general consulting firm, CH2M-Hill and Associates, of Redding, California.

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3. Narum, Q. A., and Moeller, D. J. "Water Quality Protection at the Shasta Mill." Tappi 60 (11): 137-141, 1977.

4. Anon. Interim Water Quality Control Plan, Central Valley Basin, Volume One. California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA., 1971.

APPENDICES

APPENDIX A. PORTIONS OF LIQUID WASTE DISCHARGE PERMIT FOR THE SHASTA MILL

California Regional Water Quality Control Board, Central Valley Region, Sacramento, CA.

Order No. 74-468, NPDES No. CA0004065, amended May 19, 1977. (Excerpts)

* * * * * * * * * * * * * * * *

Background Information

a. Simpson Paper Company discharges an average of 10 MGD and proposes to discharge up to 17.8 MGD of treated process and domestic wastewater from its integrated pulp and paper mill and an undetermined quantity of excess groundwater, effluent percolate, and irrigation sump water (from a land disposal operation) into the Sacramento River, a water of the United States, at a point 4000 feet downstream from the Deschutes Road Bridge. (Discharge 001).

b. Flow in the Sacramento River, in the vicinity of the discharge, varies from approximately 3000 cfs to over 100,000 cfs. At approximately 28,000 cfs the river overflows its banks.

c. Simpson Paper Company proposes to discharge up to 7.0 MGD of treated process and domestic wastes to a large parcel of land adjacent to the Sacramento River. (Discharge 002).

d. Simpson Paper Company, as part of a demonstration project, proposes to discharge 0.06 MGD of treated process and domestic wastewater to river gravels within the flood plain of the Sacramento River just upstream from the existing outfall. (Discharge 003).

e. Simpson Paper Company discharges an undetermined volume of storm water runoff into a drainage course tributary to Anderson Creek. (Discharge 004).

f. Simpson Paper Company proposes to dispose of sludge from the extended aeration lagoon on a 20-acre parcel just south of the pulp and paper mill. (Discharge 005).

* * * * * * * * * * * * * * * *

Order

IT IS HEREBY ORDERED, Simpson Paper Company, in order to meet the provisions contained in Division 7 of the California Water Code and regulations adopted thereunder and the provisions of the Federal Water Pollution Control Act and regulations and guidelines adopted thereunder, shall comply with the following:

A. Effluent Limitations: (Discharge 001)

1. The discharge shall not have a pH less than 6.5 nor greater than 8.5.

2. The discharge from the domestic sewage treatment plant shall not contain a median most probable number (MPN) of total coliform organisms in excess of 23 per 100 ml nor a maximum MPN of 500 per 100 ml.

3. Bypass or overflow of untreated or partially treated waste is prohibited.

4. The discharger shall use the best practicable cost effective control technique currently available to limit mineralization to no more than a reasonable increment.

5. The discharger shall use the best practicable cost effective control technique currently available to limit the discharge of nutrients.

6. The maximum daily discharge rate shall not exceed 17.8 MGD

7. The toxicity emission rate (TER) of the discharge shall not exceed a monthly mean of 10 tu-MGD nor a maximum of 20 tu-MGD for any one bioassay or when river flow past the point of discharge is greater than 28,000 cfs.

8. The discharge of an effluent in excess of the following limits is prohibited when river flow past the point of discharge is less than 5000 cfs:

Constituent	Units	30-day Average	Daily Maximum
BOD-5	lbs/day	2130	4260
	mg/l	--	50
Suspended Solids	lbs/day	2130	4260
		--	120
Settleable Solids	ml/l	--	0.1

9. The discharge of an effluent in excess of the following limits is prohibited when river flow past the point of discharge is in the range of 5000 cfs to 10,000 cfs:

Constituent	Units	30-day Average	Daily Maximum
BOD-5	lbs/day	3320	6640
	mg/l	--	50
Suspended Solids	lbs/day	3720	7440
	mg/l	--	120
Settleable Matter	ml/l	--	0.1

10. The discharge of an effluent in excess of the following limits is prohibited when river flow past the point of discharge is in the range of 10,000 cfs to 28,000 cfs:

Constituents	Units	30-day Average	Daily Maximum
BOD-5	lbs/day	4500	9,000
	mg/l	--	50
Suspended Solids	lbs/day	5300	10,600
	mg/l	--	120
Settleable Solids	ml/l		0.1

11. The discharge of an effluent in excess of the "daily maximum" limits shown in A. 10, above, is prohibited when river flow past the point of discharge is 28,000 cfs or greater.

B. Discharge Specifications: (Discharges 002 and 003)

1. The discharges shall not cause concentrations of constituents in excess of the following limits in groundwater leaving or adjacent to Simpson property, excluding the shoreline of the Sacramento River:

Constituents	Units	Maximum
Specific Conductance	Micromhos/cm	1000
Sodium Adsorption Ratio	Number	6.0
Boron	mg/l	0.5
Selenium	mg/l	0.02
Chlorides	mg/l	200

2. The discharges to land shall not cause measurable 5-day Biochemical Oxygen Demand and suspended solids in groundwater entering the Sacramento River.

3. The survival of salmonoid test fishes in 96-hour bioassays in groundwater percolating into the Sacramento River shall not be less than:

   Minimum for any one bioassay 70%
   Median of any three or more bioassays. . . 90%

4. Discharge of runoff from land irrigation to the Sacramento River, Anderson Creek, or tributaries thereof is prohibited.

5. Sediment from erosion of irrigated land or from construction activities shall not enter the Sacramento River, Anderson Creek or tributaries thereof.

6. The discharges shall not cause concentrations of materials in groundwater leaving or adjacent to Simpson property that would adversely affect beneficial uses.

7. The discharges shall not cause taste and odors in any domestic water supply.

C. Discharge Specifications, Storm Water: (Discharge 004)

   1. Storm water runoff to surface waters or surface water drainage courses shall contain no process wastes or sewage.

D. Discharge Specifications, Sludges: (Discharge 005)

   1. The discharge of sludge or runoff from the sludge disposal site to surface waters or surface water drainage courses is prohibited.

E. Receiving Water Limitations: (Discharges 001, 002, 003, 004)

1. The discharges shall not cause the dissolved oxygen concentration in the Sacramento River to fall below 9.0 mg/l, nor fall below 7.0 mg/l in the interstitial gravel waters.

2. The discharges shall not decrease the concentration of dissolved oxygen in the Sacramento River by more than 0.5 mg/l.

3. The discharges shall not cause visible oil, grease, scum, or foam in the receiving waters or watercourses.

4. The discharges shall not cause concentrations of any materials in the receiving waters which are deleterious to human, animal, aquatic, or plant life.

5. The discharges shall not cause esthetically undesirable discoloration of the receiving waters.

6. The discharges shall not cause fungus, slimes, or other objectionable growths in the receiving waters.

7. The discharges shall not cause bottom deposits in the receiving waters.

8. The discharges shall not alter the abundance of diversity of bottom dwelling macroscopic fauna in the Sacramento River.

9. The discharges shall not increase the turbidity of the receiving waters by more than 10% over background levels.

10. The discharges shall not cause concentrations of constituents in the Sacramento River below the Simpson Paper Company outfall in excess of the following limits:

Constituents	Units	Maximum
Mercaptans	mg/l	0.05
Crude Sulfate Soap	mg/l	1.0
Fatty Acids	mg/l	1.0
Resin Acids	mg/l	0.2

11. The discharges shall not cause the surface water temperature of the Sacramento River to increase more than 1^{o}C.

12. The discharges shall not cause taste or odor in any domestic water supply.

13. The discharges shall not cause a violation of any

applicable water quality standard for receiving waters adopted by the Board or the State Water Resources Control Board as required by the Federal Water Pollution Control Act and regulations adopted thereunder. If more stringent applicable water quality standards are approved pursuant to Section 303 of the Federal Water Pollution Control Act, or amendments thereto, the Board will revise and modify this Order in accordance with such more stringent standards.

F. Provisions:

1. The existing diffuser in the Sacramento River shall be periodically inspected and maintained to insure maximum initial dilution of wastewater.

2. Neither the discharge nor its treatment shall create a nuisance as defined in the California Water Code.

3. The requirements prescribed by this Order amend the requirements prescribed by Order No. 73-172, NPDES No. CA0004065, adopted by the Board on 23 February 1973 which shall remain in effect until production is increased by 10 percent or more.

4. This Order includes items 1, 3, 5, 6, and 7 of the attached "Reporting Requirements".

5. This Order includes items 1, 2, 4, 5, 6, 7, 8, 9, 10, and 11 of the attached "Standard Provisions".

6. The discharger shall comply with the Monitoring and Reporting Program No. 74-468 and the General Provisions for Monitoring and Reporting as specified by the Executive Officer.

7. This Order expires on 1 September 1979 and the Simpson Paper Company must file a Report of Waste Discharge in accordance with Title 23, California Administrative Code, not later than 180 days in advance of such date as application for issuance of new waste discharge requirements.

8. For the purpose of determining compliance with Effluent Limitations A. 7 through A. 11, the discharger shall install a gauging station within 1000 feet of the point of discharge. Calibration shall be performed with the assistance of the California Department of Water Resources. A continuous flow recorder shall be provided.

APPENDICES

APPENDIX B. PORTIONS OF USE PERMIT FOR EFFLUENT IRRIGATION PROJECT

Shasta County, California, Planning Commission and Board of Supervisors.

Use Permit #90-74, September 26, 1974. (Excerpts)

* * * * * * * * * * * * * * * *

STANDARD CONDITIONS

1. Permits and/or requirements of all concerned governmental agencies are to be met.

2. Construction shall be substantially in accordance with plans and statements submitted. (E.I.R., Part G, pp. 28-37)

3. Current air pollution control requirements, or as they may be revised, shall be met.

SPECIAL CONDITIONS

Construction

4. All temporary parking areas shall be watered or oiled to prevent dust.

5. Dust created during construction shall be controlled by sprinkling or other suitable method.

6. Sanitary facilities in accordance with Department of Public Health requirements, shall be established for construction workers.

7. Construction on earth moving activity•shall be limited to hours of 7:00 a.m. to 7:00 p.m., Monday through Saturday.

Operational

8. A Site Location and Effluent Discharge Plan at an appropriate scale shall be submitted to and approved by the

Technical Advisory Committee prior to commencement of land disposal activity. Said plan shall indicate as a minimum the following:

a. The specific area(s) proposed for spray and for flood irrigation.

b. The areas proposed to be leveled, contoured, or sloped.

c. Vegetation which will be removed.

d. Vegetation which will be retained.

e. Existing and proposed pipelines and/or irrigation channels.

f. Location and depth of monitoring wells. Also, an Interior Area Irrigation Plan, the purpose of which shall be to determine groundwater migration direction and quality, shall be submitted.

g. Location and extent of interceptor drains, or plans to achieve the same objective.

h. Location of access roads.

i. Adjoining property boundaries and ownerships.

9. Vegetation adjacent to and along the Sacramento River is not to be altered in any manner which would reduce the screening effect now provided.

10. No effluent disposal activity shall be conducted within 75 feet of the primary river channel, except as set forth in Use Permit #6-75.

11. Spray or flood irrigation discharge shall be limited to secondary effluent only.

12. There shall be no surface runoff of effluent to adjoining properties.

13. A buffer strip along the property line to mitigate adverse visual effects, which specific locational and dimensional characteristics shall be determined in conjunction with and approval by the Technical Advisory Committee upon submittal of the Site Location and Effluent Discharge Plan, is to be provided and maintained in a natural state. Supportive vegetation may be required to further the buffering effect in areas of critical concern.

14. Regional Water Quality Control Board standards shall be met.

15. Monitoring wells shall be established on the periphery of the disposal site. The total number and location shall be in accordance with Department of Public Health recommendations. Monitoring activity shall be conducted under auspices of Department of Public Health. Analysis records shall be maintained and shall be made available for jurisdictional agency review. Minimum acceptable limits of effect, as caused by the Simpson Lee Project, are listed as follows:

   a. No rise in the existing groundwater table at any point along the Simpson Lee property line, based on historical data.

   b. Water samples from these test wells shall not show a change in the chloride and/or sulfate ion which exceeds 50% of the difference between pre-operational background levels and those prescribed by the United States Public Health Service, nor shall the color exceed 50 platinum cobalt units above background levels.

   c. Water samples from the test wells shall not exceed the upper ranges of the quality criteria for Class I irrigation waters, as shown in Table 5-8, pp. 109, "Water Quality Criteria", 2nd Edition, Publication No. 3A, State Water Quality Control Board, 1963. If background or pre-operational quality levels are already within 25% of, or already exceed one or more of these criteria, the permissable change shall not exceed 25% of the background level, nor in any case shall this result in a water quality beyond the Class II limits.

   d. An increase of no more than 0.5 p.p.m. of boron over existing levels. If water quality indicators are exceeded, permittee shall within 30 days provide plans for the remedy of this condition, and within 90 days shall have implemented corrective measures. A contingency plan for remedy of excessive concentrations of boron, chloride and solium, shall be submitted to and approved by the Technical Advisory Committee, prior to initiation of land disposal activity.

16. Permission to inspect the site shall be given to all Local, State and Federal Governmental agencies having permit, and/or review authority at any time during the term of the permit.

17. Noxious insects shall not be allowed to develop in any manner, which may prove to be a nuisance to adjoining property owners. Permittee shall take all steps necessary to annex the subject property to the Shasta Mosquito Abatement District (S.M.A.D.). Until such time as

annexation is complete, permittee may either contract with S.M.A.D. for mosquito control, or conduct their own program. Such program or contract to be approved by the Technical Advisory Committee prior to initiation of land disposal activity. The T.A.C. shall secure advice of S.M.A.D. on any such program or contract.

18. Lone Tree Road and Riverland Drive shall not be used by permittee for purposes of entrance or exit of heavy equipment, except during construction phase Riverland Drive may be so used. A transportation permit shall be obtained from the Department of Public Works for overweight loads.

19. The permittee shall notify the State Archaeological Clearinghouse of the intent to disturb identified sites of potential archaeological value, and shall permit qualified archaeologists to conduct field investigations of those sites listed in the State Archaeological Clearinghouse comments, contained within Part A of the Final Environmental Impact Report, for a period of six (6) months from the date of notice. Copy of such notice to be furnished to the Technical Advisory Committee.

20. All natural drainage courses through the company's property are to be retained or else re-routed to the same equivalent receiver.

21. The permittee's "effluent disposal" operation shall not cause an offensive odor level, measured at the dwelling on the affected property, in excess of four (4) times the threshold level, as determined by a method approved by the Air and Industrial Hygiene Laboratory of the Shasta County Department of Health. Such determination, as well as any suggested remedies shall be made by the Shasta County Dept. of Public Health.

22. All effluent irrigation to be no less than 100 feet from the nearest property line.

23. Prior to installation of the number three paper machine, the Technical Advisory Committee shall review all conditions of the use permit and report to the Planning Commission.

APPENDICES

APPENDIX C. RESULTS OF SOIL COLUMN EXPERIMENTS

Report by Shasta Mill Technical Department, Environmental Control Group, December, 1975. (Excerpts)

Objectives

1. To evaluate typical ion exchange capacity of Simpson Ranch soil under fully controlled conditions.

2. To determine effect of dissolved and suspended solids on soil permeability, in the absence of chlorophyll-containing plants.

3. To evaluate the ability of the soil to remove BOD, COD and color from the effluent.

4. To discover ways of counter-acting any negative effects of loading soil with effluent at high rates.

Summary

Simpson Ranch soil becomes saturated with sodium after 2.5-3.2 bed volumes (BV) of effluent has been applied, assuming a sodium concentration of 300-400 mg/l. Exchangeable calcium and magnesium are depleted at the same rate. Chloride was found to be a suitable tracer of effluent percolate, since it is not adsorbed as it passes through the soil. Soil permeability decreased from 57% to 84%, depending on effluent application rate. BOD removal was essentially complete. COD and color removal efficiencies are inversely proportional to the effluent application rate. At the lowest rate (10,000 gal/acre/day) the COD and color removal were 80% and 83% respectively. At the highest rate (40,000 gal/acre/day) the reductions were 52% and 46%. Dolemite lime addition was found to reverse the sodium-calcium ion exchange reaction. Substituting river water (ie. low sodium and salinity) for effluent showed that this would leach out sodium as well as reduce the salinity of the soil.

Introduction

Three fiberglass columns, each 12 inches in diameter and filled with 70 inches of ranch soil were used for the study. After automatic metering proved infeasible, effluent was added batchwise Monday through Friday at 7/5 the average daily rate to compensate for no additions on weekends. The leachates were collected five times per week and tested as two-week composites. The average addition rates for columns 1, 2, and 3 were 10,000, 20,000, and 40,000 gal/acre/day, respectively. The applied effluent and the leachates were analyzed for pH, alkalinity, electrical conductance, total and calcium hardness, sodium, chloride, color, BOD, and suspended solids by Simpson Technical personnel. COD, nitrate, ammonia and Kjeldahl nitrogen and phosphate were determined by Cook Laboratories, Menlo Park, California. The unit used to describe the amount of effluent applied to the soil in this study is Bed Volume (BV). The BV is the volume of effluent expressed as a fraction of the volume of the soil tested. Another way of looking at this parameter is that it expresses the inches of effluent applied as a fraction of the depth of the soil (in inches). Thus, a BV of 1.0 has been applied when a total of 70 inches of effluent has been added to a 70 inch column of soil. By comparing BV's required to bring about certain changes in leachate chemistry at different effluent application rates, reaction rates and equilibria can also be compared. Another important aspect of the study involved changing the effluent-soil relationship by calcium addition or leaching with irrigation water to make the soil more compatible with crop production.

Test Results

1. Ion exchange capacity of Simpson Ranch soil.

    a. Cationic Exchange

    The substitution of calcium and magnesium in the soil by sodium from the effluent is of particular interest since this can lead to a deterioration of soil permeability and also shift the osmotic equilibrium of vegetation growing in that soil. About 95% of the sodium in the effluent is removed until 0.8-1.0 BV have been applied. Then the adsorption rate decreases more or less linearly with the amount of effluent applied until the adsorption rate reaches zero. (i.e. sodium concentrations in leachate and effluent are identical). This occurred after 2.5 to 3.2 BV had been applied. Highly variable effluent sodium levels may be the cause of some apparent inconsistencies in the test data. For example, it was expected that due to a longer contact time, the column with the lowest addition rate would remove more of the sodium since the cationic exchange reaction should be more complete. The data we collected indicate the opposite. However, by considering the changing sodium content of the applied effluent and actual contact time (since it was batch rather than continuous addition) it appears that the ion exchange rate is independent of effluent addition rate in the range 10,000-40,000 gal/acre/day.

Initial total hardness levels in the leachates were quite high, indicating a rapid depletion rate for exchangeable calcium and magnesium in the soil. The level of activity decreases as the total hardness level approaches that of the effluent. The rate of depletion was found to be basically independent of the effluent application rate within the range investigated. Exhaustion of exchangeable calcium and magnesium occurred at 2.5-3.5 BV which corresponds to the volume of applied effluent at which the sodium ion adsorption capacity of the soil was depleted.

The amount of effluent required to reach an equilibrium in the cationic exchange reaction depends on the sodium concentration in the effluent as well as the cationic exchange capacity (CEC) of the soil. Saturation of the soil with sodium will occur more rapidly if the effluent sodium concentration is high and/or the soil CEC is low.

b. Other ion exchange, leaching, and bacterial activity.

(1) Chloride is not adsorbed by the soil and stays in the leachate as it passes through the soil. The chloride ion can therefore, be used as a tracer when investigating leachate distribution in groundwaters.

(2) Initially the application of effluent leached soluble salts from the soil (as measured by EC) faster than they were added by the effluent. After about 0.5 BV had been added to the column, the conductivity of the leachate had dropped to the level found for the effluent.

(3) As expected, no P- alkalinity existed for the effluent or the leachates. Total alkalinity was variable, but generally leachate levels were lower than those in the effluent.

(4) Initial concentrations of nitrate in the leachates were extremely high (up to 1300 mg/l). This caused some concern since high nitrogen concentrations in groundwaters entering the Sacramento

River could cause eutrophication problems. A second experiment was set up to specifically study the nitrate problem. Two soil columns were used, one was irrigated with effluent, the other with river water. The application rate for both columns was 20,000 gal/acre/day. Initial nitrate levels in the leachates were only slightly higher than those of the waters being added to the columns. obviously the original three soil columns had some peculiarity in their history to cause a buildup of nitrate nitrogen in the soil prior to the effluent application. An investigation of the history of the soil columns revealed that they were filled with soil in July 1973, but not put into use until December 1973. During the five months the columns were idle, protein from organic matter in the soil would decompose to ammonia, which then would be oxidized to nitrite which further oxidizes to nitrate. In addition, non-symbiotic bacteria in the soil may have fixed atmospheric nitrogen which also would add to the nitrate concentration in the soil. Since there were no chlorophyll-containing plants growing in the soil that would use nitrate nitrogen, the level in the soil would build up, resulting in a relatively high concentration after a period of five months. Since nitrates are very soluble in water, they were leached out quite rapidly when the experiment began.

(5) Leachate phosphate levels were much lower than those in the effluent. Since both acid and basic conditions in the soil can convert water-soluble phosphates to insoluble phosphates, this could explain the reduction in phosphate concentration.

2. Effect on soil water acceptance rate (W.A.R.).

The water acceptance rate was determined by measuring the rate at which a water column with an initial height of 8 inches would percolate into soil presaturated with water. Variability of this method is high, but there was a definite decrease in water acceptance rate as the study progressed.

TABLE C-1. W.A.R.* vs. EFFLUENT APPLICATION

Elapsed time, days	Col. 1		Col. 2		Col. 3	
	WAR	BV	WAR	BV	WAR	BV
0	135	0	126	0	81	0
137	22	0.72	23	1.44	71	2.88
601	58	3.16	24	6.33	13	12.65

*WAR is water acceptance rate of soil in U.S. gal./sq. ft./day.

The loss in W.A.R. is due to two factors. It is physically reduced by inorganic suspended solids accumulating in the surface of the soil by simple filtration. The layer involved is thin, less than 1/4 inch. A chemi-physical change occurs throughout the soil as a result of cation exchange, with the adsorbed sodium causing deflocculation of the soil. The relative influence of each factor on W.A.R. depends on the sodium and inorganic suspended solids concentrations of the effluent. The influence of the latter will be much less under actual irrigation because the root systems and plant growth would break up the surface of the soil.

3. BOD, COD and color removal.

a. BOD

To date, BOD removal for the effluent has been essentially complete after it has passed through the 70 inches of soil, ie., the test results are of the same magnitude as the variability of the BOD test.

b. COD

COD levels in the effluent were quite variable during the study, ranging from 170 mg/l to 985 mg/l. This makes it difficult to calculate COD removal efficiency, but based on average values after an equilibrium had been reached, the following conclusions were made:

	Col. 1	Col. 2	Col. 3
COD reduction,%	80	75	52

Since the COD level of the leachate increases or decreases with the COD of the effluent, and since an equilibrium was reached for each column, the conclusion is that the reduction is a biochemical process rather than physical adsorption, and that the COD reduction efficiency is a function of the effluent loading rate.

c. Color

The color of the effluent was also variable during the study, with a range of 1600-3600 TCU. Based on average equilibrium values, the color reductions were:

	Col. 1	Col. 2	Col. 3
Color reduction,%	83	*	46

*Equilibrium not reached when river water addition initiated.

It is interesting to note that for column 3 (the only column with long-term equilibrium data base) the reduction is relatively constant in magnitude, about 1000 TCU, rather than on a percentage basis. It appears that the micro-organisms that break down the color have a relatively constant capacity to oxidize or otherwise destroy color which is not dependent on the color concentration, but does vary with effluent addition rate.

4. Ways to counteract negative effects of loading soil with effluent at high rates.

The main negative effects are:

Reduced soil permeability

Increased soil alkalinity*

Increased soil salinity**

*Soil is considered alkali if Na > 2 meq/100g or exchangeable Na > 15% of cationic exchange capacity.
**Soil is saline if soluble salts (EC) > 4 mmho/cm.

The above phenomena can have a severe effect on crop production if not controlled, by disturbing the plant-soil osmosis equilibrium and internal plant physiology.

Two methods of controlling the above adverse effects were investigated: calcium replenishment and leaching the soil with river water. Only chemiphysically-induced reduction in permeability would be affected by these methods. The criterion for success would be a higher sodium level in the leachate than in the column influent indicating desorption of the sodium, and in the case of river water addition, EC levels in the leachate higher than in the river water, indicating removal of soluble salts (salinity).

a. Calcium replenishment

Columns 1 and 3 were used to study the effect of calcium addition.

(1) Calcium carbonate was added to column 3 at 2 tons/acre equivalent after 140 days (2.95 BV) of operation. No significant changes occurred in the leachate chemistry as a result of the $CaCO_3$ addition, probably because of the low solubility of that compound.

(2) Gypsum ($CaSO_4$) was added to columns 1 and 3 at a 2 tons/acre rate after 312 days of operation (1.64 and 6.57 BV respectively). Definite changes occurred in the leachate, but they were relatively shortlived. COD and color levels dropped temporarily, possibly due to the sulfate ion providing additional oxygen to anaerobic bacteria involved in the decomposition of those two parameters. The total hardness concentration of the leachates increased considerably while there was no noticeable effect on the sodium concentration, indicating that in this particular circumstance, gypsum may not be suitable for reversing the sodium-calcium ion exchange reaction.

(3) Dolemite lime.

Dolemite lime is a combination of calcium and magnesium carbonates. This mineral was added to column 3 after 404 days of operation (8.51 BV) at 2 tons/acre. After the addition, the sodium level of the leachate began deviating from the level in the effluent to a point where the sodium concentration in the leachate was over 100 mg/l higher than in the effluent. However, this could also be partially explained by a simultaneous drop in effluent sodium concentration which could have changed the soil-effluent sodium equilibrium. An unexpected change in the effluent-leachate calcium relationship occurred simultaneously. The total hardness of the leachate dropped considerably lower than that of the effluent, in spite of the dolemite addition. This would suggest that in addition to the calcium and magnesium from the dolemite lime, the soil adsorbed these ions from the effluent as well to replace the expelled sodium. In view of these findings, it appears that dolemite lime is quite suitable for reversing the sodium-calcium ion exchange.

It should be remembered however, that while not reversing the reaction, other types of calcium addition to the soil on a regular basis may control the adsorption of sodium by the soil to the point where it is not a problem.

b. Leaching the soil with river water.

After effluent had been applied to column 2 at 20,000 gal/acre/day for 228 days (2.4 BV), river water was substituted and added at the same rate for 240 days (2.53 BV) to study the effects of "normal" irrigation water. Then effluent was applied again to determine whether any regeneration of the soil had taken place.

Leachate sodium levels decreased sharply about 40 days (0.42 BV) after river water was substituted for effluent. Seventy days (0.74 BV) after the change was made, the sodium concentration began decreasing at a slower, but fairly constant rate until effluent addition was resumed. The sodium concentration then increased rapidly until it reached an equilibrium with the effluent.

River water addition did not have any noticeable effect on the leachate total hardness reduction rate until 70 days (0.74 BV) after the change was made. At that time, the rate of decrease lessened considerably and remained fairly constant until effluent addition began again. Then the total hardness concentration increased relatively rapidly until it was the same as when river water addition was initiated. After peaking, it decreased at a rate comparable to pre-river water conditions. At the time of this report there is not sufficient data to draw any conclusions about how COD and color removal rates are affected by leaching. EC levels in the leachate remained higher than levels in the river water during that part of the experiment, which shows that accumulated salinity (soluble salts including sodium) can be readily leached out by the addition of normal irrigation water.

To summarize, dolemite lime addition or leaching with low sodium water will remove soil alkalinity, and fresh water leaching will also decrease soil salinity.

APPENDICES

APPENDIX D. RESULTS OF GRAVEL-BAR SPRINKLER IRRIGATION PROJECT

Report by Shasta Mill Technical Department, Environmental Control Group, May 7, 1975. (Excerpts)

<u>Objectives</u>

1. To verify predicted direction of groundwater flow.

2. To determine if effluent percolate can cause a deterioration of Sacramento River gravel waters, making it unsuitable for salmon spawning.

3. To determine if aesthetically undesirable conditions result from spray irrigation with Shasta Mill effluent.

<u>Summary</u>

The project was started up on 10/7/74. Initial application rate was 42,100 gal/day/acre or about 1.5 inches/day. On 10/14/74, the application rate was doubled to 84,200 gal/day/acre. Effluent was applied at this rate until percolate infiltrated the Raney-type wells that supply river water to the bioassay facilities, and sprinkling was terminated on 11/12/74. Three wells, all located between the irrigated area and the Sacramento River, showed significant increases in electric conductivity (EC), chloride, sodium and color. None of the other seven wells showed significant changes in water chemistry. In the three affected wells, the effluent concentration in the groundwater began to decrease shortly after sprinkling was terminated, and after three months most parameters returned to pre-operational levels.

<u>Results</u>

1. A total of 14,880,000 gallons of effluent was applied over a 36 day period. This corresponds to an average of 72,510 gallons/day/acre.

2. About 5750 lbs. of suspended solids (1009 lbs. acre) were captured by the filtering action of the sand.

3. About 2700 lbs of BOD-5 (486 lbs/acre) were removed by soil bacteria in reactions similar to those in trickling filters.

4. No suspended solids were found in water drawn from any of the test wells. Results of BOD analyses were so low that they were within testing error.

5. The groundwater movement is essentially perpendicular to the river. Only wells 5, 6, and 7 showed any change (except well #2, but that was due to effluent from the bioassay facilities). Chloride levels at gravel stations B and C confirmed this as they increased significantly while levels at stations A and D remained constant.

6. Relatively little groundwater was available for dilution. Data from wells 5 and 6 indicate that a steady state condition would have been about 5 parts effluent percolate to 1 part groundwater (83%) assuming 84,200 gallons/day/acre effluent application and little or no precipitation or other irrigation which would increase the groundwater flowrate.

7. There was no indication of vertical stratification of effluent percolate in the groundwater table. Wells 5 and 6, with mean sampling depths of 6.5 ft. and 22.0 ft. respectively, had similar concentrations of chloride and other chemical parameters throughout the duration of the project.

8. The effluent sprinkling had no significant effect on the temperature and pH of the groundwater.

9. Work done to determine the impact on gravel waters was hampered by lack of suitable test locations. Heavy silting of the river bank prevented meaningful analysis for dissolved oxygen, the most important parameter of gravel water quality. Beginning on 10/15/74, gravel waters were also tested for chloride as an indicator of effluent percolate concentration.

10. A very light musky odor could be detected on daily startup. It was believed that this was caused by anaerobic conditions developing in the project pipelines when the sprinklers were idle overnight. The odor disappeared in less than five minutes.

11. The irrigation system did not increase the vector population in the vicinity of the project site.

12. No deleterious effects on vegetation were observed. In

fact, some grasses began to grown within the irrigated area.

Discussion

This project was scheduled to start up in July 1974, but various delays, including getting necessary permits, shifted the startup date to early October. The sprinkler area, Fig. D-1, is located on a gravel bar adjacent to the Sacramento River, and is subject to flooding during the winter months, usually beginning in December. The project would have to be shut down prior to flooding, and sprinkler heads and risers would be removed to prevent equipment damage. Therefore, a maximum of two months operation was expected for the project, and higher initial irrigation rates than planned had to be used in order to assure a significant change in groundwater chemistry in those areas affected by effluent percolate.

When background data were collected, it was discovered that there were no suitable locations for sampling interstitial gravel waters because the river bank was heavily silted. The dissolved oxygen content of the collected waters was lower than that of river water and higly variable. Later in the project these waters were also tested for chloride. The background chloride levels at the gravel waters test stations were estimated based on levels in nearby wells and general changes in chloride levels as the project progressed.

Test Wells 1-7 showed high chloride background levels, probably caused by percolates from the bioassay facilities and the nearby secondary sludge disposal system. Chloride is very useful as a tracer, as this ion is not significantly affected by ion exchange in most soils. Knowing background chloride levels of the groundwater and effluent, the effluent percolate concentration in the wells can be calculated. Assuming background levels of 50 mg/l and 400 mg/l respectively, and an ultimate chloride concentration of 340 mg/l in wells 5 and 6, the steady-state percolate concentration would be 83% assuming no changes in the groundwater flow rate or the effluent application rate of 84,200 gal/acre/day. Percolate concentration at gravel water test station C at the termination of sprinkling was 61% (assuming background and termination chloride levels of 20 mg/l and 250 mg/l respectively.) This shows that very little river water permeated the silted riverbank. Sample station B was somewhat better in this respect, but still far from ideal. Stations A and D showed little change from background levels. This, and the fact that only wells 5, 6, and 7 showed significant changes in water chemistry, leads to the conclusion that the ground-water movement

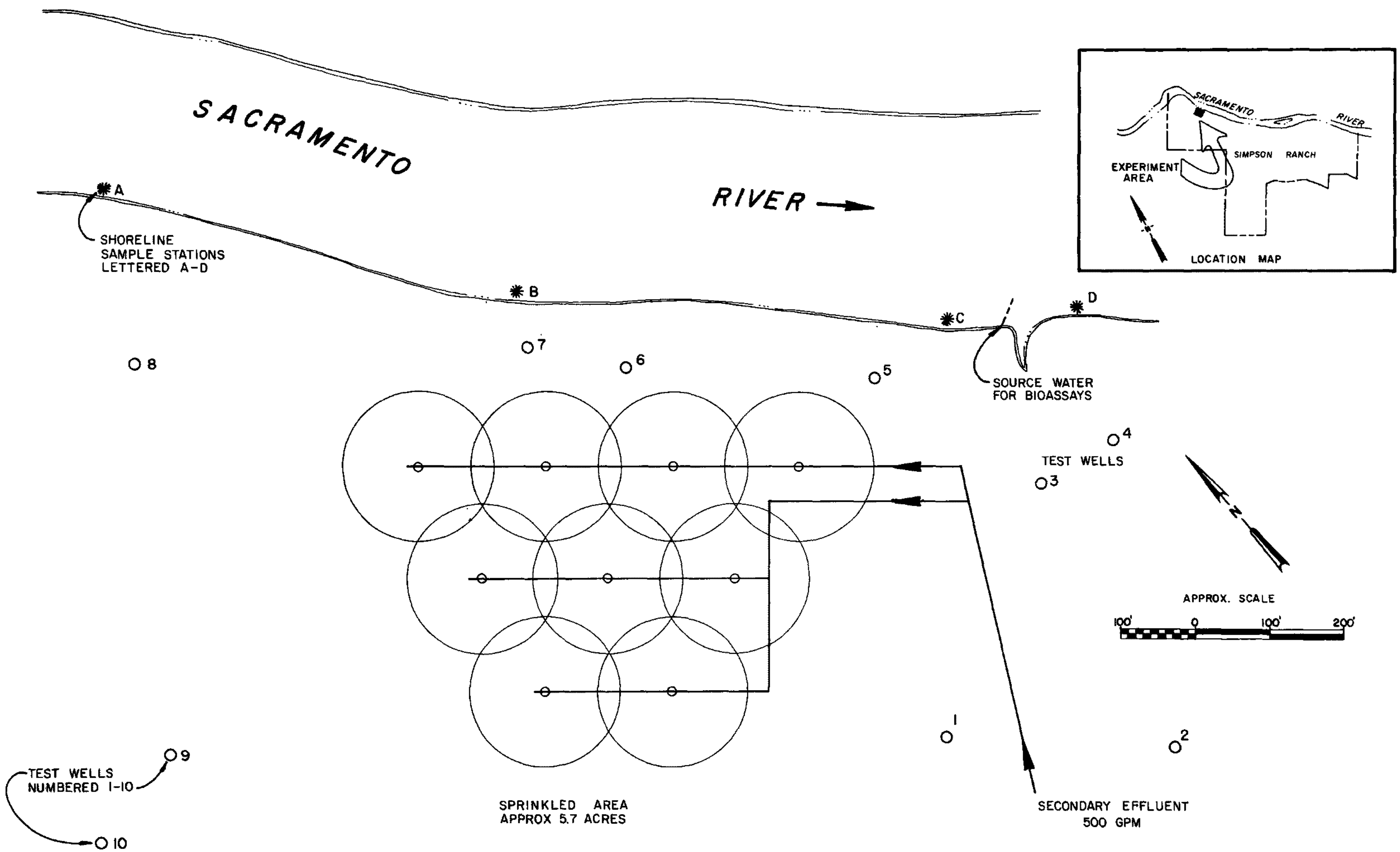

Figure D-1. GRAVEL BAR SPRINKLER IRRIGATION PROJECT pattern is basically perpendicular to the riverflow.

As mentioned above, the impact of effluent percolate on Sacramento River gravel waters is difficult to assess because of sampling problems. Nevertheless, some statements can be made based upon the results of the 1974 salmon egg bioassay. When it was initiated, it was discovered that the dilution water to the bioassay facilities contained high concentrations of chloride, indicating an influx of effluent percolate and groundwater to Raney wells that supply the dilution water. These wells were installed below the river bottom to supply river water which, by filtration through the sand and gravel, was essentially free of silt and turbidity. The river bottom above these well casings has become increasingly covered by silt in recent years as a result of an upstream snag and the percolation rate of river water to the wells has decreased considerably. Gradually, more and more groundwater entered the dilution water supply, and the problem became critical in early November, 1974, when the riverflow dropped as low as 6000 cfs and the groundwater flow in the area had increased by about 480,000 gpd as a result of the gravel bar demonstration project. As a result, the estimated effluent percolate concentration in the dilution water at times exceeded 30%, and the demonstration project was shut down. The egg bioassay proceeded as planned with effluent concentration up to 7.2% in spite of the above problem. This bioassay produced excellent results; the hatching rate in 7.2% effluent (98.6%) was as good as that for the control, (i.e., dilution water (97.5%). Both of these rates were better than any from previous egg bioassays performed at the Shasta Mill, even though the earlier tests had dilution water chemistry approaching 100% river water. In view of the above, it is unlikely that effluent percolate will have a negative effect on the hatching rate of future salmon eggs spawned in gravel waters adjacent to the Simpson Lee River Ranch.

Other than the slight musky odor on daily startup, there were no adverse environmental or aesthetic effects attributable to the project. As mentioned earlier, vegetation increased and no increase in the local vector population was determined. There has been some concern about increased mosquito generation as a result of irrigation with effluent, but it appears that at least the existing Shasta Mill effluent has repellant properties. In other studies conducted in 1974, mosquitoes did not lay eggs in effluent. The final polishing pond in the existing effluent treatment system, a quiescent basin with grass growing on the banks, would be considered an ideal location for mosquitoes. Yet, in all the years it has been in operation, not a single mosquito larva has been found there.

Although this study was considerably shorter than planned, it answered objectives No. 1 and 3 and partially answered No. 2. In view of this, it is recommended that this project be considered completed.

Testing Procedures

Sampling and testing procedures were audited by personnel from Shasta County Department of Health and found satisfactory. Samples from the wells were collected using a hand-operated diaphragm pump after it was found that vacuum pump arrangements were impractical. Water from the gravel test stations was sampled by a siphoning arrangements developed by Simpson Paper Co. personnel to eliminate entrainment of air which could cause high dissolved oxygen results.

Suspended solids and BOD removal figures of 5750 lbs and 2700 lbs respectively were calculated using the known daily effluent application rate and suspended solids and BOD concentrations as determined by the effluent operators. Since samples from the test wells did not contain any suspended solids of the type normally present in the mill effluent and the BOD results were so low that they fell within the precision range of the test, the above figures were based on 100% removal of the two components prior to the effluent percolate/groundwater mixture being collected in the test wells.

APPENDICES

APPENDIX E. OPERATION PLAN FOR THE SIMPSON-SHASTA RANCH

Report by a project consultant, CH_2M Hill and Associates, Redding, California, September, 1974.

Introduction

The operation of the River Ranch will involve two principal areas: the agricultural operation and the monitoring of conditions resulting from application of mill effluent. These areas will overlap to a degree since each affects the other. In both areas, a high degree of management is necessary. Since the mill is producing effluent almost continuously, the manager and lessee must have a well planned irrigation scheme that will provide for disposal of varying portions of the effluent as well as maximum utilization of the effluent for crop production. Prior planning is essential, and the following recommendations are intended to assist the manager in starting the operation. It is possible, if not probable, that any program will change as additional specific experience and information is developed and accumulated.

All recommendations reflect the two-phase development of the project, i.e., up to 4 MGD of effluent being available after installation of a second paper machine at the mill, and 7 MGD after installation of a third.

Cropping Plan

Under both initial and ultimate development conditions, a majority of the effluent irrigated area should be planted to a legume-grass forage mix. This is deemed to be the most likely crop to accomplish maximum evapotranspiration and to keep the surface open for fast water intake.

Although high value annual crops are more appealing from the standpoint of maximizing returns, especially considering the excellent soils at the ranch, it must be kept in mind that the success of the project will be dependent upon the infiltration rate of the soil during the winter months. Uptake of rainfall and effluent by crops during much of this period will be negligible. Therefore, the capacity of the soil to filtrate water through the surface will be at a minimum because of a high moisture content. Because of the nature of the effluent, the surface can also be sealed by accumulated organic solids and the associated overgrowth of bacteria. When vegetation is present, roots perforate the soil and maintain porosity, and surface litter is often present to support biological activity. Perennial forage crops are very effective because they cover much of the soil surface, and their roots underlie most of the cropped area.

Extensive application of effluent during the winter on bare soil, or even on soil covered by stubble or residue from a summer crop, should follow successful research conducted on a small acreage basis. The experience gained during the initial period of less than maximum effluent supply will establish the final pattern of crops and the rotation.

The initial development is designed to give a similar treatment to that expected under full development. To accomplish this, it is suggested that Fields C, D, E, F, K, L, and M along Main 1, and Fields O, P, and Q on the Return Flow Main be initially planted to a forage mix. It is likely that some of this acreage will have to be supplemented in the irrigation season by the Anderson-Cottonwood Irrigation District (ACID) Canal water. The remainder of the ranch should be cropped and irrigated from the ACID Canal.

A specific forage mix has been suggested by Milton D. Miller, Consulting Agronomist, in his report dated 16 October 1974. In addition to this mix, there are others that may be tried in order to obtain additional experience that may lead to an ideally adapted mix, or pure stand, for the conditions of high water applications during the winter and maximum production in the normal production season. All of the mixes would be appropriate for harvesting with animals or as hay or greenchop. Each of the mixes can be altered individually to achieve a particular purpose. Each variety has growing characteristics that achieve specific objectives.

The suggested mixes are on the following table. The quantities indicated are pounds per acre.

SUGGESTED FORAGE MIXES, LB. PER ACRE.

1.	Alfalfa (DeKalb 167)	20
	Alta Tall Fescue	10
2.	Alsike Clover	3
	Broadleaf Trefoil	2
	Salina Strawberry Clover	3
	Meadow Fescue	6
	Reed Canary Grass	5
	Akaroa Orchard Grass	6
	Red Top	5
3.	Salina Strawberry Clover	6
	Fawn Tall Fescue	10
	Akaroa Orchard Grass	4
	Ariki Rye Grass	10
4.	Ladino Clover	5
	Broadleaf Trefoil	3
	Akaroa Orchard Grass	6
	Ariki Rye Grass	8
	Alta Tall Fescue	8

The first mix is suggested by Milton D. Miller. A measure of the practicability of a pure stand of alfalfa can be obtained from this. Mix No. 2 is one suggested by a seed company with local experience. The third mix is one that has been successful in the high rainfall area on the North Coast of California. Mix No. 4 is suggested to get a measure, principally, of how Ladino clover will do under project conditions in the event Ladino seed production is desired, as suggested by Milton D. Miller.

The remaining fields not required for effluent disposal during the initial period can be used for annual crop production with irrigation from the ACID Canal when required. These crops could be wheat, milo, corn (grain or silage), or beans. Double-cropping in these areas would be a possibility. It is suggested that Field R be planted to wheat, also, and irrigated with effluent during the winter to see if, in these light soils, it will stand such treatment. If it will, a crop of wheat could be grown during the winter and then a double-cropped summer annual could be grown in the summer. This knowledge could be important for future planning.

Irrigation System

The method of application to be used for the effluent disposal areas initially will be the strip check or border method of surface irrigation. This is the best method for the close-growing forages planned for use. The factors considered in design of the border widths are valve discharge, lengths of run, irrigation slope, cross slope, and width of machinery to be used. The lengths of run of the borders are determined by local geography of the fields and economical land development. One automatically operated valve in each border will deliver effluent to the border. The furrow method will be used in the fields where annual crops are grown.

For the initial development, when up to 4 MGD of effluent will be available, the effluent disposal will occur along Main 1, and the runoff will be utilized on the Return Flow Main. Approximately 290 acres will be required on Main 1, and 60 acres on the Return Flow Main. Those fields to be irrigated with effluent initially from Main 1 are C, D, E, F, K, L, and M. The fields on the Return Flow Main to be irrigated are O, P, and Q. This will result in an average effluent application rate of approximately 0.43 inch per day, which is the same as the expected application rate after complete development when up to 7 MGD are available.

The exact timing of the irrigation sets will be determined after installation in the field. However, it is estimated that the cycle will be completed in 10-14 days.

Four valves operating at one time, each discharging 1,200 gpm, will be operating on Main 1, and one valve with the same unit discharge will be operating on the Return Flow Main. Since this flow represents the full 7-MGD delivery, it is planned to irrigate for only about 60 percent of the time during the initial development period and to utilize pond storage for the remaining time. This method will give a greater application efficiency because the borders were designed for a flow rate of 1,200 gpm. If effluent were applied at a lower rate for 24 hours per day, the upper ends of the borders would be greatly overirrigated.

This application program, coupled with the irrigation of the other cropped areas, will allow a representative picture, through the complete monitoring program, of the affects on the ground water level. The monitoring of the ground water will indicate the need, if any, for corrective supplemental subsurface drainage. The corrective measure can then be instituted prior to full development.

Surface Drainage System

It is planned that all surface runoff of applied effluent will be held on the project site and not allowed to flow into natural surface channels or the river. This runoff will be reapplied on the site. Surface drain ditches at the bottom of each field receiving effluent will collect the runoff and convey it to a sump from which it will be reapplied through the Return Flow Main.

The surface drain ditches, the culverts under the roads, and the flume, are designed to take emergency flows approximately equal to the 7 mgd irrigation discharge. If such an emergency situation happened to occur, the ditches would utilize the bottom portion of the fields as temporary storage to accommodate the flow. Because of the very flat slope across the bottom of most of the fields, it will be essential that these drain ditches be maintained as free of vegetative growth as possible. This can be accomplished by a regular spray program of herbicides or soil sterilants along the ditches or by mechanically cleaning and regrading the ditches regularly.

General System Management

Special management techniques will have to be developed to obtain the maximum benefits from the project. Regular irrigation and crop monitoring should continue until the optimum management combinations of water use and cropping patterns are determined. Complete familiarity with the operation of the automatic features of the project must be obtained.

Initially, the correct time settings for the automatic valves at each location will have to be determined. This will require watching the flow down each border and setting the automatic timer in accordance with the advance of the water. The rate of advance will vary from field to field in relation to the slope and border width as well as the soils. The initial setting may have to be adjusted during later irrigations until an average or optimum setting is determined.

Infiltration rates and depth of wetting of the soil at several locations down the border should be determined initially, and periodically thereafter, in order to determine the affect of the effluent on soil properties. These measurements will be used in conjunction with the ground water data to determine optimum management of the effluent disposal.

A determination of the stand of individual plant varieties in each forage mix seeded should be made as soon as the stand is established and about every 3-4 months thereafter. This will be the measure of the most desirable plant types to use in the permanent rotation to be established. Also, tissue analysis of the plants should be made periodically to determine the uptake of nutrients from the effluent. This can also be used for fertilizer application requirements. Records of effluent quality can be correlated with the data from the ground water sampling analysis to determine the effect that the land disposal procedures has on the effluent. It would also be appropriate to periodically sample and analyze the surface runoff at the sump to determine any effect that overland flow might have had on the effluent.

The operation of the complete system, as described previously, involves a rather rigid schedule for irrigation. Because of this, it will be necessary that the cutting, baling, and hauling of the hay, if that is the way the crop is to be harvested, be done within this rigid schedule. As pointed out by Milton D. Miller, the necessary machinery will have to be available at the specific time and in sufficient amount. Complete mechanization will be necessary to accomplish this. Or, if animals are to be used for harvesting, adequate fencing will have to be installed to handle the appropriate number of animals to use up the forage between the irrigations Even with this method, some degree of mechanization will be necessary to clip and otherwise manage the pasture.

APPENDICES

APPENDIX F. GROUNDWATER MANAGEMENT COMPLICATIONS AT THE SIMPSON-SHASTA RANCH

DISAGREEMENT WITH SHASTA COUNTY PLANNING COMMISSION

Part 1. History of Disagreement

In February, 1977, more than a year after the Shasta effluent irrigation project began, a disagreement arose with the Shasta County Planning Commission over the meaning of Use Permit Condition 15, the key being the first sentence: "Monitoring wells shall be established on the periphery of the disposal site". Those Company officials and Company consultants who participated in the development of the Use Permit Conditions in the summer of 1974, understood that the concern was for private agricultural properties adjoining Simpson's Ranch, and specifically those owned by two persons who also attended the Use Permit negotiating sessions. Therefore the Company interpreted "periphery" as referring to the land boundaries of the Ranch. On this basis, the Company identified for County officials seventeen water quality test wells near the land boundaries, to be monitored by both parties for the purpose of satisfying Condition 15. This went unchallenged until Feb. 17, 1977, at which time the Planning Commission ruled, in effect, that Condition 15 was applicable to any and all test wells on the Company's Ranch, irregardless of location or purpose. For Simpson Paper Co., this created an extremely difficult situation. Consequently, the Company asked the Commission to reconsider the decision.

Part of the difficulty involved several test wells along the Sacramento River shoreline, drilled to monitor compliance with the NPDES Permit. During the project design stage, the Company recognized that essentially all of the effluent percolate would migrate slowly toward, and become a part of, the River. Because of the nature of the groundwater gradient and other factors, it was also recognized that beneath some portions of the Ranch - and especially the easterly portion (nearest the River) - effluent percolate could at times comprise as much as 80% of the groundwater. However, based on the consultant hydrologist's studies, it was considered most unlikely that such conditions could exist at the land boundaries.

In a June 30, 1977, letter to the Planning Commission, a Central Valley Regional Water Quality Control Board representative wrote, "Our Board did not include limits on concentrations of salt-related constituents in groundwater percolating to the river, because evidence indicated downstream beneficial uses would not be adversely affected under proposed discharge rates. Prior to implementation of the land disposal project, all salt associated with the mill effluent was discharged directly to the Sacramento River with no documented adverse effect". In view of this, the Company assumed that the Planning Commission's concerns about the composition of water from the River shoreline test wells, and other interior Ranch test wells, were related to agriculture. Accordingly, another consulting firm was engaged to study this matter in some detail, and their report (Appendix F, Part 2) was presented to the Commission. The essence of this report is that the effluent-groundwater mixture, as sampled at test wells along the land boundaries of the Ranch represents a water whose concentration of crop-sensitive constituents is less than half of that generally accepted as safe for the crops grown on adjoining properties (i.e. - a safety factor greater than 2 prevails at the property line).

Concurrently, the Company revised its management plan for the effluent irrigation project, including, among other things, additional safeguards for neighboring agricultural activities (Appendix F, Part 3). This was also presented to the County Planning Commission, along with other written and oral testimony.

On July 14, 1977, the Commission modified its February decision, voting to apply a 200 mg./l. limit on chloride ion concentration in test wells other than those at the land boundaries of the Simpson Shasta Ranch, for which the original Use Permit Condition No. 15 would still apply. In reaching this decision, the Commission also took into account the latest State of California "Drinking Water Standards", wherein the maximum chloride ion concentration is shown as 500 mg./l. While still disputing the Commission's decision, the Company believes that it can comply with that limit, and all other rules and regulations currently applicable to the Simpson Shasta Ranch effluent irrigation project.

Part 2. Summary of Reports by Consultants

All consultants are members of Baier Agronomy, Inc., Woodland, CA.

Dwight C. Baier, President of Baier Agronomy, Inc. and formerly Agricultural Water Quality Specialist, Division of Planning and Research, California State Water Resources Control Board.

J. L. Meyer, Area Soil & Water Spec. Member of the Advisory Committee to the National Commission on Water Quality. Member of the UC Committee of Consultants which prepared the below reference, which has been accepted as agricultural water guidelines by California, the U.S. and FAO, Rome.

Milton D. Miller, Agricultural Consultant and Agriculturalist Emeritus, University of California. After serving the University of California for 40 years, he retired to private consulting practice. During his career he has also served as an agricultural consultant to Australia, Thailand and to the World Bank in Eastern Europe.

"Soils and Hydrology," by Dwight C. Baier.

Using reliable data collected by competent independent and Simpson Paper Co. technicians, 1977 hydrologic studies of the Simpson Paper Co. (SPC) Ranch property have been compared with similar studies that were conducted before a 400 acre block on the Ranch was developed for stop check irrigation. Using Simpson Paper Co. plant treated effluent, irrigation of the new area was begun in January 1976, continuing to the present. In the first 13 months of operation the new fields received a total of 3162 acre feet (3.9 million cubic meters) of effluent plus approximately 2.2 acre feet of rainfall per acre. This totals to about 10.74 acre feet to each of the 300 acres used to receive the effluent. These studies indicate the following:

1. There has been no significant change in water table elevations on the Ranch.

2. There has been no significant change in the direction of water movement due to SPC Ranch irrigation.

3. Groundwater under fields R and S is now and has always been flowing under the neighboring property to the south.

4. It is unlikely that any leachates from SPC irrigation will flow under neighboring properties, so long as effluent is not used for irrigation on field S and part of Field R. (Note by Company reviewer of consultants' reports: There never has been any intent by the Company to apply effluent to Field S. The groundwater condition at Field R is under continuing study.)

5. As proposed in the original development plans, it is possible to construct a hydraulic barrier to prevent water from flowing under neighboring properties.

6. As originally thought, the soils on the Simpson Ranch have proven to be unusually permeable and have readily accepted the applied effluent. During the last quarter of 1976 the fields received a total of 1175 acre feet of effluent plus rainfall. Each irrigated acre received about 3.9 acre feet of effluent plus the rainfall.

7. There has been no apparent change in the permeability of the Ranch soils due to application of large amounts of effluent. The soil monitoring program has shown no significant change in the salt balance. Some areas in some fields are showing a slight decrease in calcium and magnesium. This can economically be corrected when needed by application of Gypsum.

"Irrigation Water Quality with Respect to Deciduous Trees," by Jewell L. Meyer.

The Simpson Paper Co. (SPC) effluent irrigation project, as planned and implemented under Shasta Co. User Permit # 90-74 (Nov. 12, 1974) and the original Simpson Lee (Shasta Mill) Expansion Program Environmental Impact Report is an outstanding example of good waste water management and conservation of a very valuable natural resource, water. This has been accomplished since 1974 through the implementation of up-to-date Technology by Simpson engineers within the paper plant and in new field-related facilities. Collectively, these new practices and facilities are conserving water and have improved the quality of and reduced the quantity of plant effluent originally targeted. The company has upgraded the original primary waste treatment facility and installed a new secondary treatment, low-rate biological system for better suspended solids (TSS) management. All of these steps have resulted in a significantly reduced volume of improved quality effluent beyond that as originally provided in the EIR. Conclusions enumerated below are based on records supplied by Simpson Paper Co. personnel and on a trip to the Plant facilities and the Ranch.

1. Water Quality Guidelines, (University of California, Jan. 1977) and Water Quality for Agriculture (FAO Bulletin 29, Dec. 1976) establish salinity and chloride tolerance levels for the above listed crops considerably higher than records show us as those characterizing the SPC effluent.

2. Provided essential leaching requirements are met, current SPC effluent quality parameters including those of EC 1.0 to 1.5 and chlorides of 4.8 me/l (180 mg/l) to 7.6 me/l (270 mg/l), will not harm deciduous orchards or tolerant field and vegetable crops on or adjacent to the SPC Ranch, even if applied directly as effluent in surface irrigation for long-term periods.

3. The potentially phytotoxic substances boron and selenium in the effluent are far below established critical levels for these crops. Similarly, sodium is also below troublesome concentrations in the effluent.

4. With the improved effluent treatment system now used by SPC, the suspended solids content of the effluent reaching the Ranch for irrigation is very low, and has proven to be no problem from the standpoint of impeding water penetration.

5. Numerous examples in the San Joaquin Valley have been studied by the authors. They have found numerous cases where water of poorer quality than the present SPC effluent is regularly used for agricultural purposes. Using gravity irrigation or under-tree sprinklers, these poorer quality waters have been used successfully over long periods on walnuts, pears, plums and prunes with no damage to trees or yield.

6. The good field crop yields achieved in 1976 and those projected for 1977 by SPC Ranch management are proof that the effluent is very satisfactory for their irrigation purposes.

"An Agronomic Appraisal of Progress on Simpson Ranch Development", by Milton D. Miller.

Excellent progress has been made by The Simpson Paper Company (SPC) since 1974 in developing 500 acres of their Ranch for the production of crops, using paper plant effluent. That property is now efficiently using about 2 MGD. For short periods of time it could utilize up to 4 MGD. (Note by company reviewer of consultants' reports: The project was designed for effluent application up to 4 MGD. on a sustained basis. However, the actual average irrigation rate for the first 20 months of operation was about 2.3 MGD.) As contrasted with just serving as an effluent disposal site, the property in 1976 contributed to Shasta Co. agricultural income crops having a gross value in excess of $100,000. In future years, as the project development continues, the value will be much greater. The exceptional progress which has been achieved is due to the close cooperative working relationships which have been nurtured between SPC personnel and the thoroughly experienced,competent rancher selected to farm the property.

As originally expected, Ranch soils, after development for irrigation, have proven very productive. In the first year after leveling, the fields in 1976 per acre produced 3.9 tons of oat hay, 3,925 pounds of wheat and 6,760 pounds of corn. In 1977 additional crops have been added to the system including alfalfa, seed onions and red kidney beans. Beans are being used to test the reaction of a known salinity-sensitive crop to the qualities of the effluent water.

Four major changes have been made by Simpson officials in the original CH_2M Hill conceptual plan for developing the Ranch for effluent irrigation: (1) The proposed Return Flow Main in Field Q was relocated to avoid possible ground water contour problems. (2) The land grading, irrigation and drainage designs were changed to better accommodate row crop production. (3) In response to concerns of neighbors, no sprinkler irrigated area was developed. (4) The return flow system capacity was approximately doubled to maximize the capture and reuse of irrigation tail water. None of these changes have resulted in any adverse effects on the agricultural potential of the property. Rather, the results have been to economically improve the project.

Considering the natural slope of the terrain towards the Sacramento River and the predominance of very permeable soil types, the SPC Ranch has been proven to be especially well suited as a site for an effluent utilization project. In 1976 a total of 10.74 acre feet of water per acre (including rainfall) was easily absorbed into the 300 acres on which the effluent was applied. Through proper monitoring of the soil salt balance and use of corrective measures, which are economically available if needed, there is no reason to believe the area presently developed could not indefinitely continue to receive the average daily projected volume of 2 MGD.

Planning should begin soon for continued development of the property to enhance its agricultural productivity. Such planning should include: (1) Early development of supplemental sources of water for irrigation. (2) Releveling of portions of some fields to reduce soil erosion problems and to fill in areas of subsidence. (3) Provision of additional irrigation water lines so that excessively long runs can be reduced. (4) Development of suitable portions of remaining undeveloped arable land for surface irrigation.

Part 3. Revised Plan for Management of the Effluent Irrigation Project at the Simpson-Shasta Ranch

A report submitted to the Shasta County Planning Commission, Technical Advisory Committee, dated June 16, 1977. Prepared by Simpson Paper Company.

This report, based on the first 17 months of actual operation, modifies the original "conceptual plan" for the Ranch as developed by Simpson's consultants. (See Appendix E.) There is a new section on project staffing, the section on groundwater management has been expanded and reconciled with actual experience and the sections on soil management and cropping have been revised slightly.

Organization

A. For overall management purposes, Simpson's Shasta Ranch is under the Vice President, Administration, K. A. Perkins.

1. His on-site field agent (project coordinator), on special assignment from the Corporate Engineering Dept., is the Environmental Project Engineer, D. P. Mickelson.

2. The principal contractor for Ranch operations is Pacific Farms, Gerber, CA (Mr. Vincent Flynn, President, who, besides his own services, provides a field foreman and a full-time, on-site, irrigation tender. Mr. Flynn also retains Agricultural Advisers, Inc. of Yuba City, CA, as a consultant).

3. Recognizing that the principal objective of the effluent irrigation system is water quality management, the Shasta Mill indicates its needs directly to the Pacific Farms field foreman. This is coordinated by the Mill Environmental Control Engineer, Nils Roehne, a member of the Mill Technical Dept.

4. The Environmental Control Engineer also manages the several monitoring programs, which include the testing of water, soil, seed and leaf.

5. Simpson Paper Co. also engages its own consultants, independently of the principal contractor. In the past three years, these have included an agronomist, a pomologist, a water scientist, and a hydrologist.

6. The Corporate staff also provides consulting services to the Environmental Project Engineer and the Environmental Control Engineer. This includes the Director of Engineering, Dave Moeller, and the Director of Environmental Protection, Quintin Narum.

B. To carry out the extensive environmental quality assurance programs, the Mill Environmental Control Engineer has a salaried Laboratory Supervisor and three full-time Technicians. Two modern and well-equipped laboratories are located at the Simpson Shasta Ranch.

a. A Biological-Chemical Laboratory, which among other things, is used to carry out bioassays with fish and fish eggs.

b. A new Soils and Water Laboratory.

These laboratories are certified by the California Health Dept., and are inspected regularly by that authority and also by the U. S. Environmental Protection Agency.

To supplement the in-house testing, soil and biomass (leaf) samples are also sent to two independent laboratories for special tests. Agricultural Advisers, Inc., the Ranch contractor's agent, also performs certain laboratory functions.

In 1975, Simpson's effluent-irrigation project attracted the attention of the U. S. Environmental Protection Agency. Subsequently, this agency awarded the Company a special Research and Development Grant of $142,000 to expand and assist with the monitoring program. The resulting information will be made available to other interested parties through EPA's Technology Transfer publications.

Groundwater Management

A. Introduction

The Simpson Paper Co. treated effluent irrigation system was designed to receive an annual average of 4 million gal./day (MGD) with short term applications up to 7 MGD. For calendar year 1976, the actual average was about 2.7 MGD. This was distributed over 400 acres of land which had been prepared to receive the effluent and grow cash crops. The layout was such as to minimize changes to ground water composition at the land boundaries, consistent with Shasta County Use Permit #90-74.

During the first 17 mo. of operation, groundwater composition changes and groundwater movement were closely monitored via more than 70 test wells. In general, these conditions were found to be in accordance with the predictions of Company consultants (hydrologists) who studied the original plan in 1974. However, the actual operating experience of the past 17 mo. has given Company officials good basis for refining the groundwater management plan.

Hydrophiles (groundwater contours, absolute elevations) plotted in 1974 indicated that groundwater flow was toward the Sacramento River. Measurements since that time have not revealed any significant changes, with the slopes continuing to show mass flow toward the River. The basic concept, which is established fact, is that groundwater (like surface water) seeks to flow toward a lower absolute elevation relative to sea level. (Stated another way, water flows "downhill" by the influence of gravity). The rate of flow or movement is dependent upon the steepness of the slope (gradient), and, in the case of groundwater, this is also related to soil permeability (capability of the soil to allow water to pass through it).

The subsoil on the effluent-irrigated fields of the Simpson Shasta Ranch is characterized by unusually high permeabilities, in the range of 1,000 to 5,000 gallons per day per square foot. While the surface infiltration or water-acceptance rate is also high, it is only a small fraction of the subsoil permeability. Thus, any water admitted at the surface, upon becoming a part of a continuous groundwater mass, will rapidly move in the direction of the lower absolute elevation, namely the River bed.

While natural rainfall can raise the absolute groundwater level, this does not necessarily change the slope of the contour lines, especially in high permeability soils.

The contour of the soil surface (i.e. topography) does not necessarily give a reliable clue as to the groundwater hydrophile - in fact, this can be deceptive. Hence, to properly establish the hydrophile, it is necessary to place a number of test wells in accordance with the judgment of a qualified geologist or hydrologist. As previously indicated, the Company has done this, and also engages the same specialists to help interpret the results.

As previously stated, the Ranch soils have high infiltration rates, in the range up to two million gallons per acre per day (if uniformly flooded). On any given day, the actual application rate is less than 10% of this, and over a period of a month, the average rate is less than 10,000 gal./day per acre. This is only 0.5% of potential water admittance rate of the soil.

Of the water (effluent) applied to the Company's Ranch, a sizeable amount is ultimately taken up by the atmosphere. Some of this is by direct evaporation from the topsoil. However, a much larger amount leaves, by the process called evapo-transpiration, from the vegetation growing on the soil. On a typical summer day, this can amount to as much as 9,500 gal./acre.

All of the above-mentioned factors, plus several more, were taken into account by the Company and its several consultants in the original project design and management plan. Each month of operation adds to the knowledge which can be employed to improve the management plan, but the evidence to date shows that the original concepts were correct.

One fact that is sometimes overlooked or misunderstood is that the fully-treated effluent from Simpson's Shasta Mill is 99.85% water, and is the product of "best practicable control technology" as defined by the U. S. Environmental Protection Agency. (Actually, this effluent meets

State standards which are more stringent than those shown in EPA's criteria). From a water quality standpoint, this effluent is superior to many of the irrigation waters now used within the State of California - especially that now used in the rich farm lands of the Sacramento River delta area. Further, scientists at (or affiliated with) the University of California have demonstrated or otherwise become aware that almost all of the crops grown in California can accept irrigation water of an overall quality similar to, or inferior to, that of the Shasta Mill effluent. This includes fruit and nut trees, cereal grains, and hay crops. To verify this, the Company has engaged independent consultants who are familiar with this subject, and their reports will be provided to the Planning Commission staff.

B. Groundwater Management Concepts

1. Groundwater movement can be and is determined via development of general or specific hydrophiles. There are a sufficient number of observation wells on the Simpson Shasta Ranch for this purpose. Static water depths in these wells can be measured precisely, since the absolute elevation of each casing has been carefully ascertained.

2. Groundwater composition can be and is determined via samples from a network of fourteen specifically-identified "U.P. water quality test wells".

While a number of tests are done, a key test is chloride ion measurement. Chloride ion was selected as the effluent tracer because:

(1) It is stable, non-reactive, non-substitutional.

(2) The analysis is simple and accurate.

(3) Background levels are low relative to chloride ion concentration in the treated effluent.

It should be understood that most other components of the effluent are changed upon contact with soils. In particular, the organic components are biodegraded by soil bacteria to essentially unmeasurable levels. On this basis, supported by extensive measurements, the Central Valley Regional Water Quality Control Board has concluded that the effluent percolate entering the Sacramento River is not, in this case, a pollutant. Separate monitoring requirements by that Agency include routine testing of six "WQCB water quality test wells" located along the shoreline of the River. The Agency did not prescribe a limit for chloride ion concentration, but did include it among the substances to be tested in the shoreline wells. In more than 17 mo. of operation, the Company's treated effluent and the subsurface effluent (percolate) entering the Sacramento River have met all of the very stringent requirements of the Central Valley Board, including a fish toxicity limit (no acute toxicity as defined).

a. The biomass (vegetation, soil bacteria) growing on and in the effluent-irrigated fields can indirectly reflect the quality of the irrigation water and its manner of use. Barren fields will not be a good receptor of the effluent - or any water. While maintaining the simplest forms of vegetative cover would meet the basic project objective, it has been the Company's objective to produce crops which have a greater benefit to society as a whole and to itself. Accordingly, the grains and legumes are to be grown to the most practicable extent, with a portion of the total acreage set aside for experimental crops.

   It should be pointed out that the extensive leaf testing done to date has not shown any indication that the vegetation grown on effluent-irrigated fields has a composition significantly different from similar vegetation irrigated with other kinds of water.

b. Soil chemistry is closely integrated with groundwater composition and cropping plans, and to assure perpetual beneficial usage of the fields, the Company has undertaken a continuing evaluation of the physical and chemical aspects of soil quality.

C. Groundwater Management Practices

1. Effluent distribution to the fields.

   a. The project includes a semi-automated flood irrigation system, relatively uncommon in California. Ordinarily, this would have reduced manpower requirements, but in this case the Ranch contractor also has a full-time irrigation tender on the site. This combination provides a high degree of flexibility (via human judgment) plus better process control.

   b. With a diversified cropping plan (including some row crops and some random-seeded crops), with differences in field slopes or grades, with differences in soil composition and structure, it is not practicable to apply the effluent uniformly over all of the fields. However, the Company is developing control charts which will assure that no field receives a hydraulic loading beyond its capabilities. The Environmental Project Engineer will manage this program, working with the Ranch foreman, and the Environmental Control Engineer.

c. At any given time and upon short notice, it is possible to change the irrigation program. The flow to any given field or portion thereof can be reduced, ceased, or increased (within the constraint of item 1b, above), to suit groundwater management needs as indicated in following sections of this program.

2. Groundwater movement.

a. Static depths to groundwater are measured for each observation well on a monthly basis. The absolute groundwater elevation is then computed and plotted on a contour map (hydrophile). This map becomes a part of the several sources of information used in managing effluent distribution to the fields.

b. If an unfavorable hydrophile develops, the frequency of static depths measurements is increased and/or the rate of application of effluent to the particular field or fields is reduced or temporarily ceased.

3. Groundwater chemistry.

a. While the hydrophiles are useful in predicting the rate and direction of groundwater movement, the several "water quality test wells" are monitored concurrently. Once a month, these are tested for chloride ion, pH, electrical conductance, color, alkalinity, sodium ion, total and calcium-only hardness, potassium ion and nitrate ion.

b. As previously indicated, the chloride ion is the effluent "tracer". If the hydrophiles appear to become unfavorable, the Environmental Control Engineer may elect to increase the frequency of testing of chloride ion in the wells in the affected area, to assure that appropriate corrective action is taken before Use Permit Conditions are violated.

4. Corrective actions for adverse conditions described in C2 and C3, above.

   a. The principal corrective action is described in Clc. In this respect, the Company has considerable flexibility, as follows:

      (1) Up to ten days of effluent storage are provided at the Mill, in the #2 Aerated Stabilization Basin.

      (2) As River flow increases, the proportion of the effluent that may be discharged to the River also increases. (Based on 17 months of actual experience, essentially all of the effluent can be discharged to the River when River flow past the point of discharge exceeds 10,000 cfs. In any case, all of the effluent can be so discharged if the River flow exceeds 28,000 cfs. With River flows between 5,000 and 10,000 cfs, the amount of effluent used for irrigation has been found to be less than 2 million gal. per day, or less than half of the original design criterion).

      (3) The use of PUD (ACID) or well water for irrigation on properties generally west of the effluent-irrigated fields (including some Simpson-owned properties) tends to cause a more favorable hydrophile, and also dilute the effluent percolate.

      (4) Natural precipitation ultimately results in greater River flow past the point of discharge, with the benefit explained in a(2), above. However, rainfall is not unfavorable to the hydrophile and tends to dilute the effluent percolate.

      (5) In extreme cases, there are procedures which can be employed at the Mill liquid waste treatment systems which can temporarily change the effluent parameters to the point where larger discharges to the River can be made without risking Permit violations.

Soil Management Concepts and Practices

A. The treated effluent contains minute amounts of suspended solids, most of which are the biomass residual from the biological waste treatment process itself. The remainder is an inert paper coating mineral (kaolin, calcium carbonate, etc.). In development work done prior to the full scale project, it was found that these solids were filtered out in the first inch of soil. In this layer, the organic matter (biomass) composts to stability, and the ash or mineral becomes incorporated into the soil. The standard tilling has been found sufficient to blend the residuals with the topsoil without any adverse effects.

B. The sodium absorption ratio (SAR) was also given intensive study in the years preceding the startup of the full-scale system. (Among other things, SAR influences subsoil permeability, an important consideration in the Company project). These studies showed that SAR values in the soil could be maintained within the acceptable limits for intensive agriculture by the controlled addition of gypsum, limestone, or dolomitic limestone. While no permeability problems have been encountered in the full-scale system, the Company has made field applications of three calcium and magnesium compounds, over a 15 acre test plot, to verify the laboratory data.

C. In general, the Company believes that soil chemistry is now, and will continue to be, properly managed. Soil samples are taken at intervals more frequent than in conventional agriculture, and analyzed in the Company's Soil and Water Laboratory and by independent laboratories. The results are interpreted by qualified consultants who make appropriate recommendations.

Cropping Plans, Pest and Disease Control

A. After four years of experimentation with effluent irrigation, the Company has concluded that any crop historically grown on its property with other irrigation water can also be grown with the treated effluent, and with comparable yields.

B. To date the following crops have gone full cycle: field corn, wheat, oats. The following crops are now on the fields: seed onions, alfalfa (experimental), field corn, wheat, kidney beans (experimental), plus several smaller experimental plots growing different varieties of barley and wheat.

C. Leaf and seed samples are taken at intervals more frequent than in conventional agriculture and analyzed by an independent laboratory. Among other things, this information is used to determine fertilizing schedules and any other treatments that may be necessary to ensure a high quality product.

D. The Company and its agents are alert to possible insect, fungus, and weed problems. In addition to the expertise of the principal contractor, advice on pest control is obtained from an independent consultant. No extraordinary controls have been found necessary.

E. Simpson's Shasta Ranch, and adjoining properties, are now within the Shasta Mosquito Abatement District. The District provides on-site mosquito control, and advises the Ranch contractor on other procedures and practices which will minimize nuisance-insect problems.

APPENDICES

APPENDIX G, EXHIBIT 1. TYPICAL SHASTA MILL MONTHLY REPORT TO THE CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

Following are excerpts from the report for July, 1977.

Discussion of Compliance

Discharges 001 and 002. All measured parameters were in compliance.
Discharge 003. Ceased as of February, 1975.
Discharge 004. No discharge this month.
Discharge 005. Project not yet in operation, no discharge.

Discharge Data - 001

Station 1E. "Packaged" Sanitary Sewage Treatment System.

Flow, MGD		Total Coliform
Range	Average	MPN/100 ml
0.029-0.109	0.046	<3 (7/7/77)

Station 2E*. Industrial Discharge to River.

144 Hour Bioassay
(Salmonoid species of fish - fingerlings)

		Percent Survival by Effluent Concentration					
Date	Tu-MGD	Control	100%	75%	56%	42%	32%
6/29-7/5	0	95	100	100	100	100	100
7/6-7/12	0	100	100	100	100	100	95
7/31-7/19*	--	0	0	0	0	0	0
7/20-7/26	0	100	100	95	100	100	100
Ave.	0						

*Chiller failure on 7/18 resulted in bioassay temperatures of 79 deg.F, killing all test specimens. Survival to date of failure was 100% in all dilutions.

CHEMICAL ANALYSES

Date:	Constituent:	Conc., mg/l:
7/8	Mercaptans	<0.3
7/21	Resin Acids	<0.7
	Sulfate Soaps	14
	Ammonia (N)	1.2
	Nitrate (N)	1.2
	Nitrate (N)	<0.03
	Total Kjeldahl (N)	2.6
	Total Phosphorus (P)	0.41

Other Data

Other data reported to the RWQCB are shown in Tables G-1, G-2, and G-3. In addition, the data in Table G-4, under the headings pH, Temperature, and Settleable Solids, are also reported to RWQCB on a routine basis.

TABLE G-1. SHASTA MILL EFFLUENT, MONITORING REPORT DISCHARGE 001

July 1977	Flows		TSS Suspended Solids			BOD-5			True Color	EC Spec. Cond.
	River	Effl.	Permit	Effluent		Permit	Effluent			
Date	cfs	MGD	lb/day	mg/l	lb/day	lb/day	mg/l	lb/day	TCU	Micro Mho/cm
1	10,800	11.17	5,300	12	1,120	4,500	8	750	625	1,250
2	10,800	11.20	"	--	--	"	-	--	--	--
3	10,100	6.36	"	11	580	"	6	320	625	1,300
4	--	3.42	"	--	--	"	7	200	--	--
5	11,800	3.43	"	13	370	"	7	200	600	1,200
6	9,500	3.48	3,720	6	170	3,320	8	230	600	1,200
7	9,400	6.71	"	10	560	"	8	450	600	1,250
8	9,300	6.55	"	13	710	"	10	550	625	1,375
9	6,900	6.77	"	21	1,190	"	9	510	750	1,425
10	10,100	5.40	5,300	40	1,800	4,500	15	680	875	1,375
11	9,700	6.82	3,720	57	3,240	3,320	21	1,190	750	1,400
12	9,300	7.16	"	46	2,750	"	20	1,190	750	1,550
13	8,800	10.55	"	68	5,980	"	19	1,670	750	1,550
14	9,300	9.65	"	46	3,700	"	15	1,210	1,000	1,300
15	9,700	10.56	"	39	3,430	"	13	1,140	875	1,300
16	9,700	10.59	"	13	1,150	"	11	970	740	1,450
17	9,700	8.82	"	14	1,030	"	9	660	750	1,400
18	9,600	7.92	"	16	1,060	"	8	530	750	1,350

TABLE G-1 (continued). SHASTA MILL EFFLUENT, MONITORING REPORT, DISCHARGE 001

July 1977	Flows		TSS Suspended Solids			BOD-5			True Color	EC Spec. Cond.
	River	Effl.	Permit	Effluent		Permit	Effluent			
Date	cfs	MGD	lb/day	mg/l	lb/day	lb/day	mg/l	lb/dav	TCU	Micro Mho/cm
19	9,700	9.39	3,720	14	1,100	3,320	10	780	625	1,350
20	9,800	9.48	"	19	1,500	3,320	11	870	625	1,225
21	9,800	10.13	"	19	1,610	"	11	930	750	1,350
22	9,600	10.63	"	13	1,150	"	11	980	750	1,325
23	9,800	11.29	"	16	1,510	"	10	940	625	1,200
24	10,000	11.88	5,300	16	1,590	4,500	8	790	625	1,225
25	9,800	12.13	"	21	2,120	"	13	1,320	625	1,400
26	9,800	10.04	"	25	2,090	"	8	670	625	1,200
27	9,300	11.58	"	15	1,450	"	8	770	750	1,325
28	9,300	11.05	"	17	1,570	"	6	550	625	1,150
29	9,700	11.22	"	16	1,500	"	5	470	750	1,100
30	10,050	11.30	5,300	18	1,700	4,500	6	570	750	1,250
31	10,000	11.20	5,300	16	1,490	4,500	6	560	750	1,200
Ave.	9,692	8.96	4,179	22.4	1,594	3,663	10.2	755	709	1,309

TABLE G-2. SHASTA MILL, RANCH GROUNDWATER MONITORING, DISCHARGE 002

July 1977	Test Well No.	BOD-5	True Color	EC Spec. Cond.	pH	Temp.	SAR	Specific Ion Conc. mg/l		
Date		mg/l	TCU	Micro-Mho/cm		C°	Ratio	Cl	B	Se
6	9	<1	5	290	6.6	18.8		4	0.12	<0.01
	25	<1	5	640	6.4	17.1		70	0.09	<0.01
	32	<1	5	1,060	6.4	17.8		170	0.05	<0.01
	45A	<1	5	360	6.6	17.8		30	0.12	<0.01
	62	<1	5	340	6.6	17.7		16	0.08	<0.01
	70	<1	5	460	6.7	17.7		20	0.23	<0.01
21	9	<1	5	280	7.2	19.0		4		
	25	<1	5	575	6.8	17.7		60		
	32	<1	5	1,025	6.6	17.0		173		
	45A	<1	5	470	6.7	18.2		51		
	62	<1	5	350	6.8	17.2		19		
	70	<1	5	420	6.7	18.0		20		
28	9		5	280	6.8	18.8	0.46	5		
	25		5	560	6.7	17.8	0.63	55		
	32		5	1,040	6.9	16.6	0.69	171		
	45A		5	550	7.0	18.5	0.79	51		
	62		5	345	6.9	17.1	0.95	18		
	70		5	450	6.9	17.4	0.77	18		

July 1977	Sample Station No.	Temp.	pH	DO	True Color	Tur-bidity	Fish Toxic-ity	River Condition
Date		C°		mg/1	TCU	FTU	Percent Survival	
1	11	15.2	7.3	8.9	5			Interstitial gravel
1	12	15.6	7.1	9.4	5			" " "
6	11	15.8	7.2	10.5	5	4.0		Free flowing water
6	12A	15.8	7.0	10.6	5	4.3		" " "
6	14	16.3	7.0	10.4	5	4.8		" " "
7	11	16.3	7.1	8.6	5		95	Interstitial gravel
7	12	16.5	6.7	7.6	5		100	" " "
11	11	16.0	7.2	10.4	5	3.4		Free flowing water
11	12A	16.0	7.2	10.5	5	4.2		" " "
11	14	16.3	7.2	10.5	5	4.6		" " "
14	11	17.1	6.9	8.5	5			Interstitial gravel
14	12	17.6	6.4	7.3	5			" " "
28	11	19.0	7.3	9.9	5	6.4		Free flowing water
28	12A	19.3	7.2	9.8	5	7.2		" " "
28	14	19.3	7.3	9.8	5	7.8		" " "
29	11	18.5	7.2	8.4	5			Interstitial gravel
29	12	19.0	6.9	7.6	5			" " "

TABLE G-3. SACRAMENTO RIVER WATER QUALITY MONITORING

APPENDIX G, EXHIBIT 2. ADDITIONAL EFFLUENT DATA FOR SHASTA MILL

Table H-4 shows typical data for the month of July, 1977. Data in the first two columns headed "Effluent Flows" are not routinely reported to the RWQCB, but are available for the agency's inspection.

As indicated elsewhere in this Report, the application of effluent to Ranch fields during the summer months is done almost exclusively to satisfy agricultural needs, not to assure compliance with the Waste Discharge Permit or receiving water quality standards. As can be seen in Table H-1, the effluent quality for July, 1977, was well within Permit limits. Tables H-2 and H-3 show that for the same month, the quality standards were met for both the Ranch groundwater (which, in a sense, is a "receiving water") and the Sacramento River. (During the thirteen years that the Shasta Mill has been in operation, an intensive monitoring of Sacramento River water quality has shown that the Mill discharge has not caused any violations of receiving water quality standards, relative to the principal indicators.)

Theoretically, a reduction in a waste discharge should bring about some degree of improvement of receiving water quality. However, the upper reach of the Sacramento River has exhibited, historically, a very high quality, most of the measureable variations being due to non-man-made causes. The improvement in the quality of this water as a result of the Simpson-Shasta effluent irrigation project appears to be below the range of detection. Therefore it might be said that this project was carried out primarily to meet uncommonly stringent waste discharge requirements which do not necessarily reconcile with receiving water needs.

TABLE G-4. SHASTA MILL, FINAL EFFLUENT, MISCELLANEOUS DATA

July 1977		Effluent Flows				Effluent Properties			
		Total	Ranch	River		pH	Temp.	Set. Solids	
Date		MGD	MGD	MGD			C°	ml/l	
1		15.17	4.00	11.17		7.3	30	<0.1	
2		14.70	3.50	11.20		--	--	--	
3		6.36	0.00	6.36		7.6	30	<0.1	
4		3.42	0.00	3.42		--	--	--	
5		9.50	6.07	3.43		7.4	28	<0.1	
6		4.14	0.66	3.48		7.4	28	<0.1	
7		6.71	0.00	6.71		7.2	27	<0.1	
8		7.49	0.94	6.55		7.5	27	<0.1	
9		11.90	5.13	6.77		7.6	25	<0.1	
10		8.30	2.90	5.40		7.5	25	<0.1	
11		10.45	3.63	6.82		7.3	27	<0.1	
12		7.56	0.40	7.16		7.3	29	<0.1	
13		10.55	0.00	10.55		7.3	28	<0.1	
14		12.12	2.47	9.65		7.3	28	<0.1	
15		12.00	1.44	10.56		7.4	29	<0.1	
16		10.59	0.00	10.59		7.4	29	<0.1	
17		13.52	4.70	8.82		7.6	30	<0.1	
18		15.07	7.15	7.92		7.5	30	<0.1	

TABLE G-4 (continued). SHASTA MILL EFFLUENT, MISCELLANEOUS DATA

July 1977		Effluent Flows				Effluent Properties			
		Total	Ranch	River		pH	Temp.	Set. Solids	
Date		MGD	MGD	MGD			C°	ml/l	
19		14.76	5.37	9.39		7.4	30	<0.1	
20		12.65	3.17	9.48		7.4	30	<0.1	
21		12.32	2.19	10.13		7.5	30	<0.1	
22		11.37	0.74	10.63		7.5	30	<0.1	
23		11.89	0.60	11.29		7.4	29	<0.1	
24		13.90	2.02	11.88		7.3	30	<0.1	
25		13.03	0.90	12.13		7.3	30	<0.1	
26		14.08	4.04	10.04		7.3	30	<0.1	
27		15.62	4.04	11.58		7.2	31	<0.1	
28		15.08	4.03	11.05		7.2	29	<0.1	
29		15.25	4.03	11.22		7.2	29	<0.1	
30		15.33	4.03	11.30		7.2	29	<0.1	
31		13.06	1.86	11.20		7.3	30	<0.1	
Ave.		11.545	2.581	8.694		7.38	28.9	<0.1	

APPENDIX G, EXHIBIT 3. EXAMPLES OF TEST WELL DATA FROM MONITORING WELLS AT THE SIMPSON-SHASTA RANCH

Table G-5 gives an example, for the month of December, 1975, of the pre-project groundwater characteristics at the Simpson-Shasta Ranch, as indicated by six of the test wells. Table G-6 gives similar data for the month of July, 1977, by which time the Ranch fields had received about 4854 cu. meters of effluent, and an "equilibrium" was assumed to prevail in the groundwater. While not all of the Ranch groundwater data are routinely reported to the RWQCB, the complete records are available for inspection by that agency and also by the Shasta County Health Department. The Health Department also performs independent tests on samples taken from the Ranch wells, to assure compliance with Use Permit conditions (Appendix B).

TABLE G-5 SIMPSON-SHASTA, GROUNDWATER QUALITY DATA, PRE-PROJECT

Test Well No.	Dec. 1975 Date	BOD-5 mg/l	MO Alkalinity mg/l	True Color TCU	EC Spec. Cond. Micro-Mho/cm	pH	Total Hardness $CaCO_3$ mg/l	Specific Ion Conc. mg/l Na	Cl	NO_3
9	2		106	6	300	7.1	118	12	12	2
11A	2		98	10	300	7.1	112	12	13	3
15	2		100	10	320	7.0	126	9	13	3
19	2		112	9	325	7.2	136	10	12	2
22	3		64	8	210	7.3	76	6	7	1
24	3		152	10	375	7.6	168	13	14	1
25	11		88	5	340	7.0	134	9	5	2
32	11		106	6	340	6.9	120	16	5	4
34	3		138	10	330	7.4	146	9	11	1
42	4		90	35	220	7.3	100	6	6	1
45A	11		72	12	250	7.0	80	7	8	1
47	4		70	14	220	7.2	86	7	7	1
49	4		52	10	190	7.2	72	5	7	1
53	4		62	10	220	7.2	80	7	7	1
57	4		68	8	220	7.2	88	6	6	1
59	4		90	8	270	7.4	106	8	6	2
62	4		92	5	280	7.5	110	10	8	3
70	11		154	8	660	7.0	250	30	47	12

TABLE G-6. SIMPSON-SHASTA RANCH, GROUNDWATER QUALITY DATA. POST-PROJECT

Test Well No.	July 1977	BOD-5	MO Alka-linity	True Color	EC Spec. Cond.	pH	Total Hard-ness $CaCO_3$	Specific Ion Conc. mg/l		
	Date	mg/l	mg/l	TCU	Micro-Mho/cm		mg/l	Na	Cl	NO_3
9	21	<1.0	92	5	280	7.2	98	11	4	3
11A	20	--	50	5	340	7.3	118	13	5	6
15	20	--	62	5	220	7.0	50	9	4	1
19	20	--	60	5	140	6.8	54	9	4	1
22	20	--	60	5	135	6.8	50	8	4	1
24	20	--	100	5	190	6.7	78	12	5	1
25	21	<1.0	116	5	575	6.8	214	21	60	4
32	21	<1.0	128	5	1,025	6.6	426	33	173	2
34	--Inaccessible due to irrigation--									
42	21	--	120	5	340	6.7	106	13	5	1
45A	21	<1.0	80	5	470	6.7	140	22	51	1
47	22	--	70	5	280	7.2	68	8	5	1
49	21	--	64	5	155	7.1	56	8	5	1
53	22	--	62	5	340	6.9	108	11	30	3
57	22	--	50	5	135	7.0	42	8	4	1
59	22	--	84	5	350	6.9	130	11	26	3
62	21	<1.0	80	5	350	6.8	112	11	19	3
70	21	<1.0	110	5	420	6.7	150	22	20	6

APPENDICES

APPENDIX H. ANALYSIS OF GROUNDWATER FLOW REGIMEN

Dr. Clinton Parker

General

Due to changes in chemical form, ion exchange, adsorption and oxidation of organics in the soil, groundwater movement can best be related to irrigation practice by changes in groundwater contours and changes in conductivity or chlorides. (From a practical standpoint chlorides and conductivity are sufficiently related for either to be used in monitoring groundwater and irrigation management.) In this study both changes in chlorides and groundwater elevations were documented.

An important part in this study was the response of the groundwater flow regimen to the fields irrigated and the rate of irrigation. Chloride content, direction of groundwater flow and changes in groundwater elevation were response variables that reflected soil condition and types, infiltration, geological characteristics, and hydraulic characteristics (including aquifer permeability). From groundwater level data collected during this work groundwater contours and flow nets for successive periods of irrigation were constructed to assess groundwater movement and aquifer permeability. The application of flow net theory to the operating field data and the use of geological information gathered prior to the undertaking of this study provides logical extension of the pre-operational field hydrologic investigation. Data based on the irrigation practices provide a new segment of knowledge upon which to quantify aquifer performance and, as a result, were used to obtain a better estimate of aquifer permeability in this complex hydrologic setting.

Irrigation Data

At the beginning of the project in 1976, the emphasis was mainly on the total amount of effluent applied to the project, with the assumption that the distribution of effluent would be fairly uniform. It turned out that some fields received more effluent than others, so in December 1976 an accounting system was set up to determine the amount of effluent applied to each field. The irrigation data for months prior to this program were prorated on the basis of acreage and subsequent application rates.

Data from January 1976 through June 1977 were divided into six periods identified with changes in irrigation practice. These periods were: January - April 1976; May - June 1976; July - September 1976; October - December 1976; January - March 1977; and April - June 1977. Table H-1 gives the amount of effluent applied to the fields for each period and the average application rate. The amount of water entering the groundwater table was less than the amounts shown in the table due to evapotranspiration losses. Pre-operational analyses estimated evapotranspiration losses for forage crops to range from 19,000 gallons per acre per month (gpam) in winter to 240,000 gpam in the summer. Based on actual irrigation practice, crops grown and crop management, these estimates were higher than experienced during the study. A more realistic estimate of the total effluent losses experienced during this study is from 5 percent during winter to 20 percent during summer. Due to the dry weather conditions from January 1976 to June 1977 water addition from precipitation did not significantly contribute to changes in groundwater levels.

Groundwater Data

Groundwater contours prior to the study and at the end of each irrigation period are shown in Figures H-1 through H-7. These contours provided a means for examining groundwater flow patterns and estimating aquifer permeability. Initially it was assumed that Anderson Creek was part of the groundwater contours. Since this was not substantiated, groundwater contours in Figures H-1 through H-7 were based only on well data.

Chloride data obtained at the end of each irrigation period is presented in Table H-2. Changes in chloride concentrations were related to effluent application and shifts in groundwater contour patterns.

Groundwater levels measured prior to the study showed a groundwater divide near the southern corner of the ranch, therefore, it was recognized that the application of effluent to fields near the divide would have a significant affect on the groundwater flow pattern. Because of the sensitivity of the flow regime near the divide, the water level and chlorides in the test wells played a vital role in selecting the fields to be irrigated.

January - April 1976

The first of the irrigation periods was from January through April 1976. During this period effluent was applied to fields C, D, E, F, I, J, K, L, M, N, O, P, Q and R (for field designation see Figure 2). The average application rate for this period was 180,000 gpam. Changes in groundwater contours during this period can be seen from a comparison of Figure G-1, December 1975, with Figure H-2, April 1976. As a result of irrigation, groundwater levels over most of the ranch rose about 2 feet. The southern and southeastern part of the ranch (near the groundwater divide) experienced a groundwater level increase of 2 to 4 feet.

Since the ranch fields that received effluent were located along a northwestern - southeastern axis and the natural groundwater slope was toward the Sacramento River, the contour changes between December 1975 and April 1976 followed a predictable pattern. The groundwater flow pattern along the eastern boundary of the ranch showed some movement toward the northeast. In addition, the contours in this area moved closer together. These changes reflect the increase in groundwater table slope caused by addition of irrigationwater to the groundwater. Prior to the application of effluent, Figure H-1, the water movement under fields O, P, Q and R was in an eastern direction and part of the groundwater divide was under the southwestern edge of these fields. The significance of irrigating the fields in this area from January to April 1976 can be seen from the contour changes in this part of the ranch. The close proximity of P, Q and R to the divide, the application rate, and the mounding of irrigated effluent resulted in a northeastern movement of the divide and a steeping of the groundwater table slope. These changes caused the flow pattern under fields in the southern corner of the ranch to become more southerly oriented. Sensitivity of groundwater addition by infiltration in this area is reflected in the shift of the 372, 374, 376, 378, 380 and 382 foot contours under fields N, O, P, Q and R. Since a southern groundwater flow was undesirable, the application of effluent to fields P, Q and R ceased in April 1976, and, as a result it is not known whether the April 1976 contours represent a steady-state condition for the irrigation practiced during this four month period.

Chloride data for April 1976 supports the changes observed in the groundwater flow regimen. Movement under fields Q and R shifted to a more southern direction, toward wells 57 and 66. The general direction of groundwater movement was away from wells 22, 24 and 34, however, the increase in groundwater level under fields I, J, K, L, N and O accounted for chloride changes in these wells. The only abnormality that may have occurred was in the area of fields O, P, Q and R. Based on flow lines in the vicinity of these fields the original eastern movement had shifted to a more southern direction by April 1976. Chloride data for wells at the southern edge of field Q (well numbers 42 and 49) should have increased to reflect mounding in this area and the change in flow direction, however, no increase in chlorides was observed.

May - June 1976

Contours at the end of the May - June 1976 period reflected changes in the groundwater regimen after irrigation of fields P, Q and R ceased. During these two months application rates were: 140,000 gpam to fields L, M, N and O; 150,000 gpam to fields C, E and F; 190,000 gpam to fields D, I and K; and 210,000 gpam to field J. Irrigation rate changes and a change in season had a profound affect on the groundwater system. A comparison between Figure H-1 and Figure H-3 shows that the groundwater contours reverted to the general configuration found in December 1975 and water levels were approximately one to two feet above levels observed in 1975. Although the general direction of groundwater movement remained eastnortheast, a comparison with the April 1976 contours shows that the groundwater divide in the area of fields P, Q and R became less pronounced and the flow in this area changed from the southeastern direction observed in April 1976 (Figure H-2) to the more eastern direction, observed in the December 1975 flow pattern.

July - September 1976

The same fields were irrigated during this period as were irrigated in May - June 1976. The average application rate was 170,000 gpam. Except for the 380 and 382 foot contours in the vicinity of field I, J, K, N, and O, the groundwater system remained approximately as observed in June 1976. Based on the groundwater contours for this period, Figure H-4, and the previous period, Figure H-3, it appears that the flow regimen reached a steady state for the application rate of 170,000 gpam to fields C, D, E, F, I, J, K, L, M, N and O.

Between April 1976 and September 1976 a significant change in chlorides was observed in wells 25 and 32. A shift in the direction of flow appears to account for this change. The result of applying effluent to fields I, J, K, E, D and L was realignment of the contours along the eastern and northeastern boundary of the ranch. Contours in this area essentially became parallel to the Sacramento River, Shifting the direction of flow to more of a northeastern direction, i.e. perpendicular to the river. In addition to this shift in flow direction, contours 380 and 382 migrated to a position closer to the river. Flow nets constructed in this area indicate a substantial amount of effluent that infiltrated from fields D, E, I, J, K and N and parts of L and O moved in the direction of wells 25 and 32. It appears that approximately 65 percent of the total infiltrated effluent between May and September 1976 flowed in the general direction of these two wells. The chloride data suggests that the full impact on water quality due to irrigation practice between May and September 1976 did not occur until late summer.

October - December 1976

Significant variations in irrigation rates were recorded for this period and fields P and Q received effluent for the first time since April 1976. Field P received 150,000 gpam and field Q received 60,000 gpam. Application rates to other fields were: C, D, I, N and O, between 270,000 and 330,000 gpam; E, F and M, between 200,000 and 240,000 gpam; and J, K and L, between 600,000 and 700,000 gpam. Changes in irrigation practice for this period caused a drastic shift in the 378, 380 and 382 foot groundwater contours (see Figure H-5), lesser (but significant) changes in the 372, 374 and 376 contours, and a mounding trend under fields I, J, K, L, M and O. In the general location of the original natural groundwater divide at the southern boundary of the ranch, groundwater levels rose approximately 2 feet above September 1976 levels (or 4 feet above the groundwater elevation in December 1975). At the end of this period groundwater contours along the northeastern boundary moved closer and more parallel to the river than in September 1976.

Impact on the groundwater (additions to the groundwater and a decrease in evapotranspiration) was reflected by chloride concentration changes in wells 25, 32 and 45A. The chloride concentration in well 34 supports the change in groundwater flow to a southernsoutheastern direction along the southern boundary of the ranch (towards Anderson Creek).

January - March 1977

Effluent was restricted to fields I, J, K and L during this period. Application rates were: I, 470,000 gpam; J and K, 180,000 gpam; and L, 810,000 gpam. Although the application of effluent was highly localized and the rate was higher than previously used, the groundwater contours, Figure H-6, conformed to a pattern very similar to those in December 1975 (Figure H-1), June 1976 (Figure H-3) and September 1976

(Figure H-4). A comparison of contours formed at the end of this period with previous contours suggests that the limiting constraint of effluent application was aquifer permeability and not soil infiltration rate. These data indicate that localized high rates of 200,000 gpam to 800,000 gpm to fields in the central and south-central part of the ranch can be used if fields that contrubute to the groundwater table north, northeast and east of these fields are not being irrigated with effluent. Soil infiltration rates were high but aquifer constraints controlled the hydraulic system. As a result, if mounding is to be avoided in the future, application rates when all fields are in service, except P, Q and R, should be limited to 170,000 gpam. (The areal extent and thickness of the aquifer may be a limiting constraint on groundwater movement, see aquifer permeability discussion in this section). These data indicate continous application of 170,000 gpam to fields C, D, E, F, I, J, K, L, M, N and O can be adequately handled by the hydraulic system, but at higher rates field selection becomes important.

Wells with high chloride concentrations during the previous period (September - December 1976) remained high. The most significant chloride change was in well 22. The concentration in this well appeared to reflect mounding of effluent due to high application rates in the vicinity of the well during September - December 1976 and January - March 1977.

May - June 1977

The fields irrigated during this period were the same as those used in October - December 1976. The average rate applied to all the fields was about the same as May through September 1976. Application rates to fields F, M and P were 390,000 gpam, 340,000 gpam and 310,000 gpam, respectively. Fields D, E, I, J, K and L received between 150,000 gpam and 230,000 gpam; and fields C, N, O and Q received 30,000 gpam to 90,000 gpam. Groundwater contours, Figure H-7, returned to a pattern similar to those in September 1976, Figure H-4. Based on application rates of previous periods and fields irrigated, a similarity with previous contours was as should be expected. The only major exception to similarity with the previous contours was the 380 foot contour in the southern part of the ranch. The lowering of the groundwater table and the movement of this contour to a position similar to the December 1975 contour, Figure H-1, reflects the very low rates applied to fields N and O.

Except for wells 25 and 22 the chloride content of the test wells in March 1977 and June 1977 were approximately the same. The concentration in well 25 decreased by about

50 percent and in well 22 the concentration returned to the preirrigation value. A like variation in well 25 occurred between September 1976 and December 1976. High chloride concentrations in well 25 were consistent with the groundwater movement, as defined by the contours, but the variation was unexplainable. Also, a drop in chlorides in well 22 was predictable but the return to a preirrigation concentration was unexplainable.

Aquifer Permeability

Based on the preirrigation geological data from test borings that defined the shallow aquifer under the ranch and irrigation data and groundwater contours from well water level measurements from this study, the field permeability of that part of the aquifer along the eastern and northeastern edge of the ranch (east of the irrigated fields) was better defined. Since groundwater flow under irrigated fields varied due to addition to the groundwater table by infiltration, permeability determinations were limited to that part of the aquifer that lay between the easternnortheastern most irrigated fields and the Sacramento River.

When viewing changes in the groundwater contours it must be recognized that as a result of infiltration the volume of water flowing under irrigated fields varied. Although changes in aquifer permeability could have existed, changes in contour spacing under the irrigated fields were not taken as changes in aquifer permeability. In this study changes in contour spacing and flow lines observed under irrigated fields were assumed to reflect only incremental increases in groundwater due to infiltration.

The aquifer permeability along the eastern and northeastern boundary of the ranch was quanitified by flow net construction, changes in groundwater table slope and elevation, and water balances (irrigation rates less evapotranspiration). Table H-3 presents groundwater table slopes that were determined from preirrigation conditions and from contours at the end of each irrigation period for that part of the ranch between the river and the irrigated fields. If an aquifer thickness of 10 to 20 feet is assumed (as indicated from preirrigation geologic and hydrologic studies), analyses using the slopes in Table H-3 give field permeabilities from 20,000 to 30,000 gallons per day per square foot (gpd/ft^2). This estimate for aquifer permeability is higher than estimates made in preirrigation studies.

Well pump test data collected prior to this study were analyzed by ideal aquifer well equations and these data indicated an aquifer permeability between 2,000 and 8,000 gpd/ft^2. (It should be noted here that although the pre-irrigation hydrologic assessment fully utilized all available geological and hydrological data, the quantative determination of aquifer permeability was limited by many constraints; e.g., a suitable mathematical model, limited field data, and boundary condition assumptions.) The preirrigation hydrologic assessment of the groundwater regimen used 2000 gpd/ft^2 as aquifer permeability. Groundwater table slopes generated, using 2000 gpd/ft^2, an aquifer thickness of 10 to 20 feet and the irrigation data and groundwater table elevations changes observed in this study are much higher than the slopes shown in Table H-3. These results indicate that an aquifer permeability higher than 2000 gpd/ft^2 must exist along the eastern boundary of the ranch.

Although the data collected from this study could not be used to calculate aquifer permeabilities for many parts of the ranch, it provided a suitable data base for estimating aquifer permeability along the eastern and northeastern boundary of the ranch. It is believed that 20,000 gpd/ft^2 represents a reasonable estimate for permeability along this boundary. The disparity between computed pre-irrigation permeabilities using test wells, and 20,000 gpd/ft^2, can be attributed to variations that could have existed in the aquifer underlying the ranch and how adequate the assumptions upon which the well equations were based, were met by the actual field conditions.

EFFLUENT APPLICATION AND GROUNDWATER MANAGEMENT PRACTICE

Results from this study provide a basic understanding of the criteria necessary for establishing good irrigation management practice for the ranch.

All fields except P, Q and R can be irrigated at an average rate of about 170,000 gpam on a routine basis without exceeding NPDES limitations and without significantly contributing to the groundwater south or west of the ranch. Irrigation of fields along the southern boundary of the ranch, (including field P, Q and R) can be practiced, however, water level and water level and water conductivity measurements along the boundary must be monitored on a continuous basis. On a limited basis irrigation rates in excess of 170,000 gpam (up to 300,000 gpam on 100 to 120 acres) may be used on fields located in the central, northern or eastern parts of the ranch, however, careful consideration must be given to field selection. Due to high soil infiltration rates more water can reach the groundwater table than can be effectively transmitted by the groundwater flow regimen, therefore, application of effluent to a field near the eastern boundary while a central, southern or southweatern field is being irrigated at a high rate can result in significant mounding and changes in groundwater flow direction. At rates higher than 170,000 gpam irrigation of fields that contribute to the groundwater flow regimen along what might be considered the same flow lines (indicated by a flow net constructed from groundwater contours) should not be practiced, e.g., fields I, J, K and L should not be irrigated in excess of 170,000 gpam at the same time fields D and E are being irrigated.

Irrigation management practices should be made at least three months in advance and significant deviations should be limited to conditions dictated either by changes in groundwater contours, color, well water conductivity (chlorides) or unusually low flows in the Sacramento River (flows of <5000 CFS restricts allowable discharge rates to the river and the amount of effluent discharged to land must be increased accordingly).

Control of water quality and groundwater movement can be satisfactorily implemented by well monitoring. Measurement of water level and water conductivity (chlorides) in selected wells should be the only measurement routinely needed. Reliable instrumentation is available for recording changes in both parameters on a continuous basis. The best candidates for use in monitoring along the northeastern and eastern boundary of the ranch are wells 70, 25, 32, 45A, and 62. Wells along the southeastern and southern boundary should be further evaluated to establish which wells will best describe this sensitive area. Water quality in wells 19, 22, and 24 along the western and northwestern boundary should be sufficient to follow critical changes in this part of the ranch.

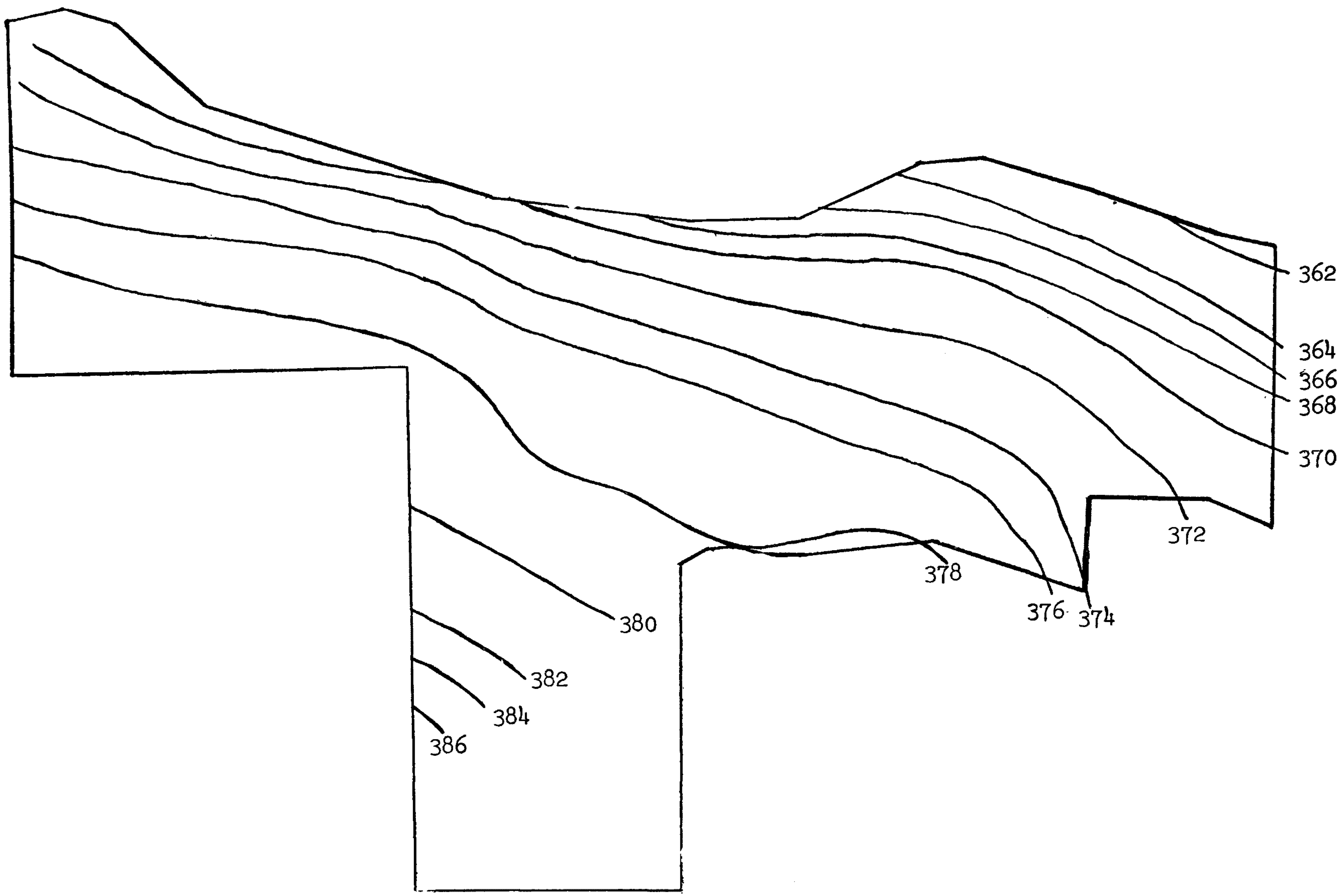

FIGURE H-1. GROUNDWATER CONTOURS* - DECEMBER 1975

*Elevation in feet above mean sea level

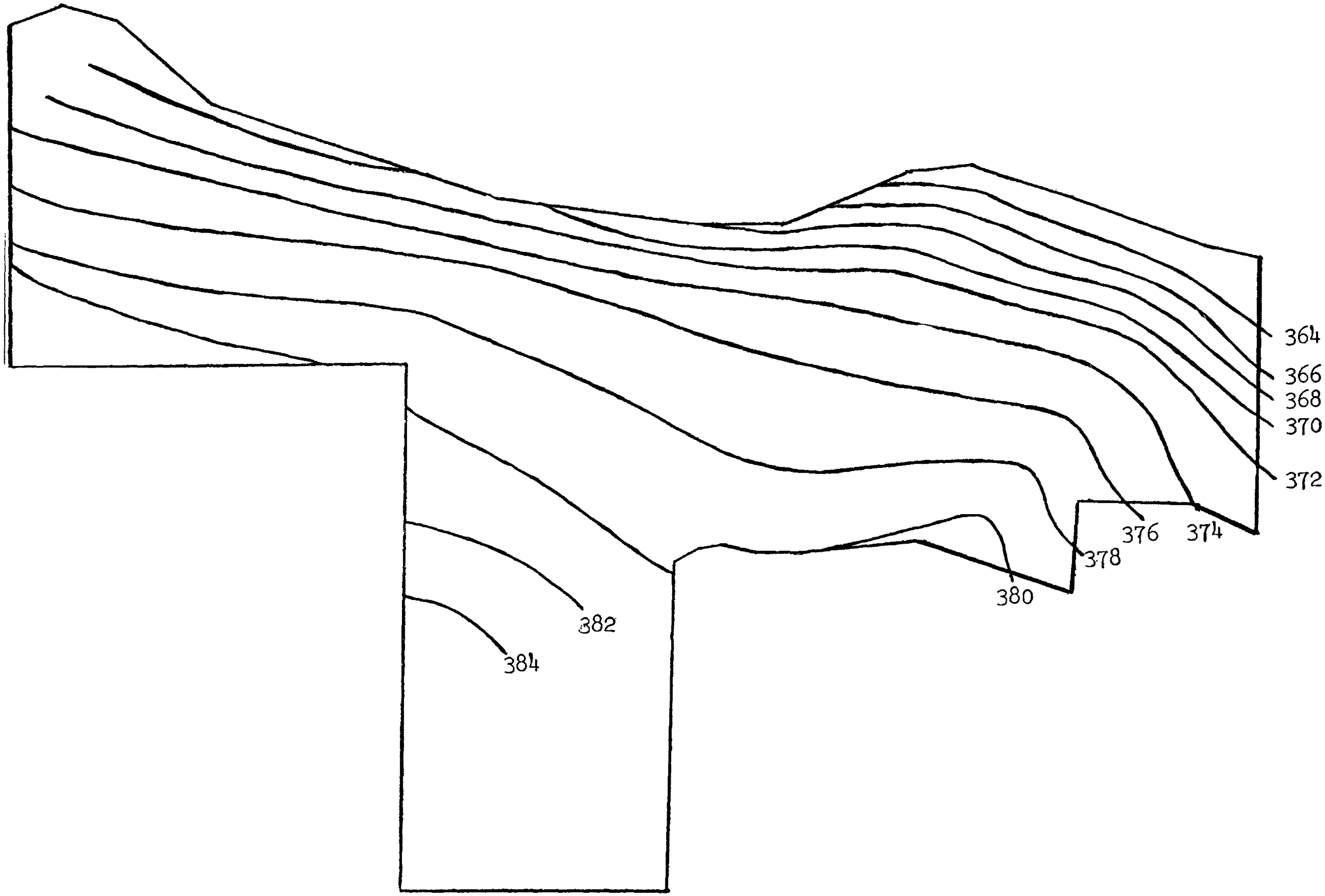

FIGURE H-2. GROUNDWATER CONTOURS* - APRIL 1976

*Elevation in feet above mean sea level

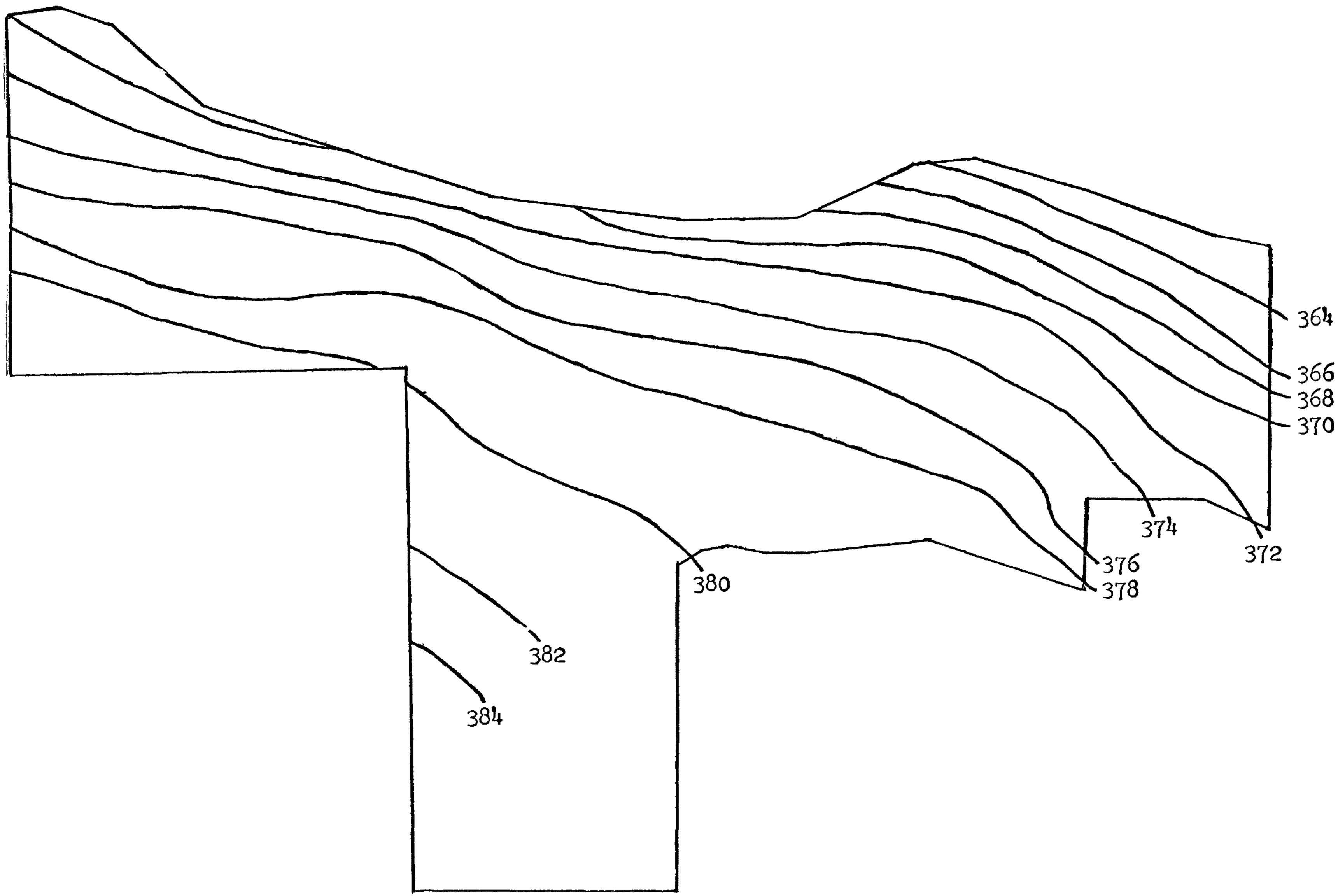

FIGURE H-3. GROUNDWATER CONTOURS* - JUNE 1976

*Elevation in feet above mean sea level

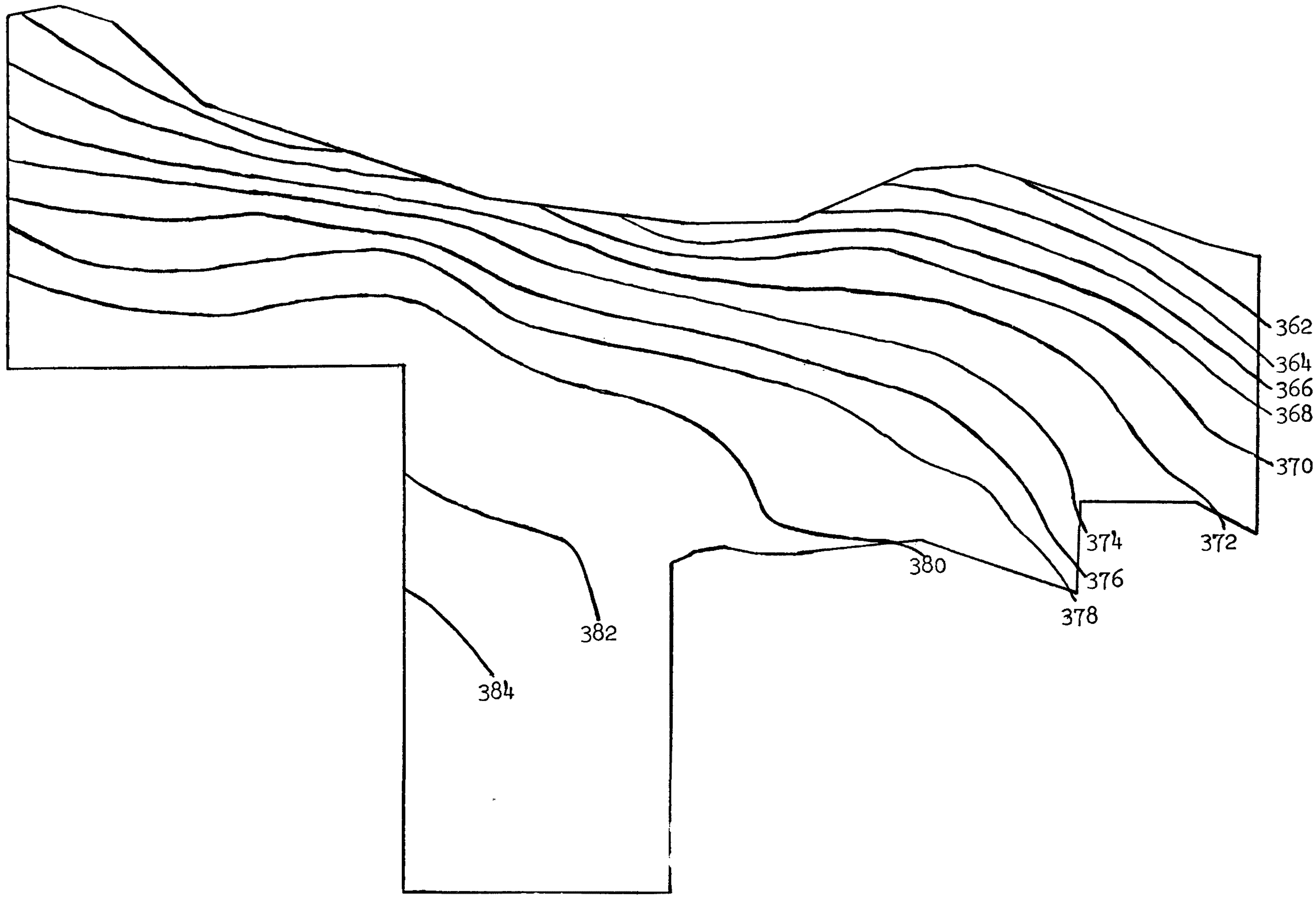

FIGURE H-4. GROUNDWATER CONTOURS* - SEPTEMBER 1976

*Elevation in feet above mean sea level

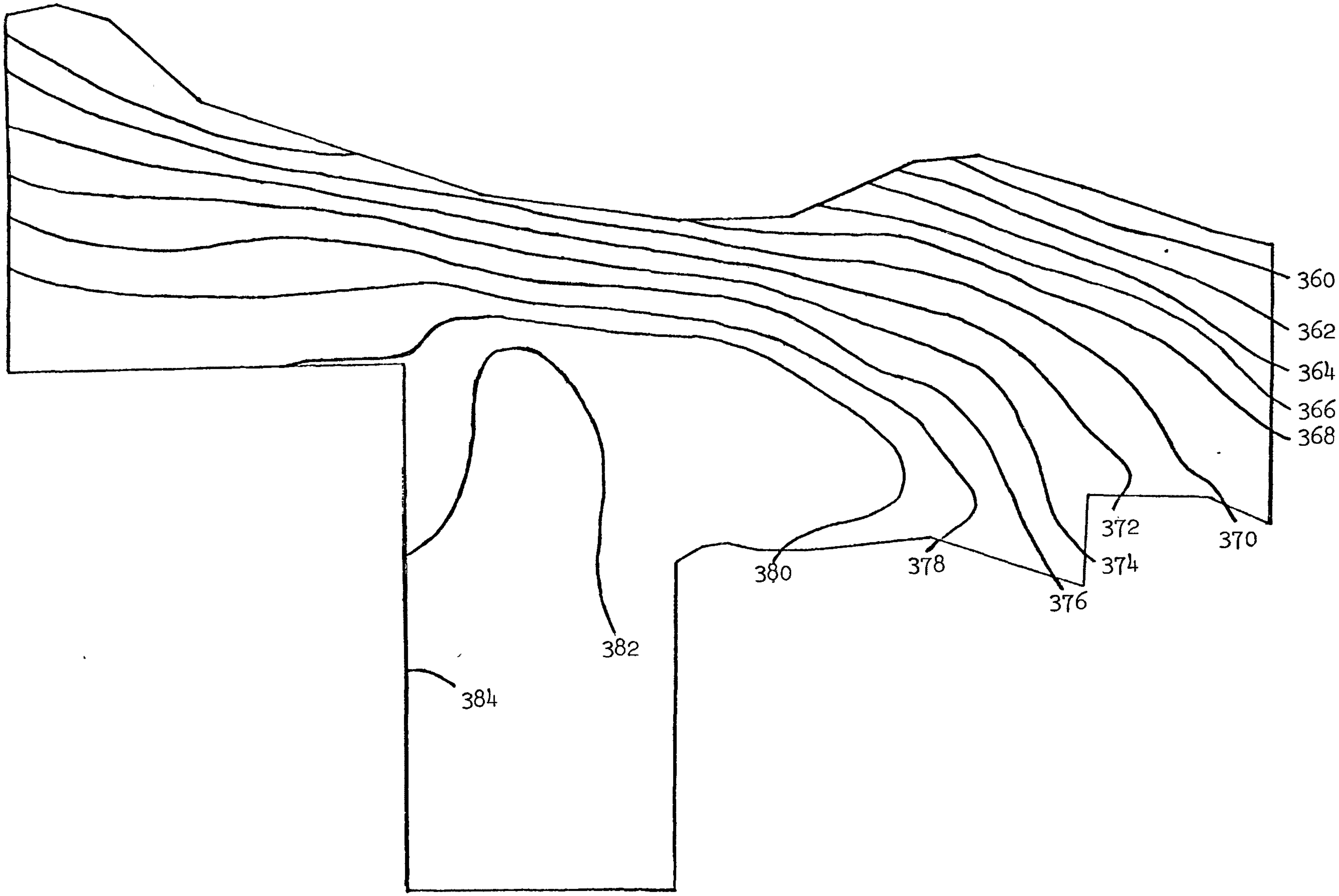

FIGURE H-5. GROUNDWATER CONTOURS* - DECEMBER 1976

*Elevation in feet above mean sea level

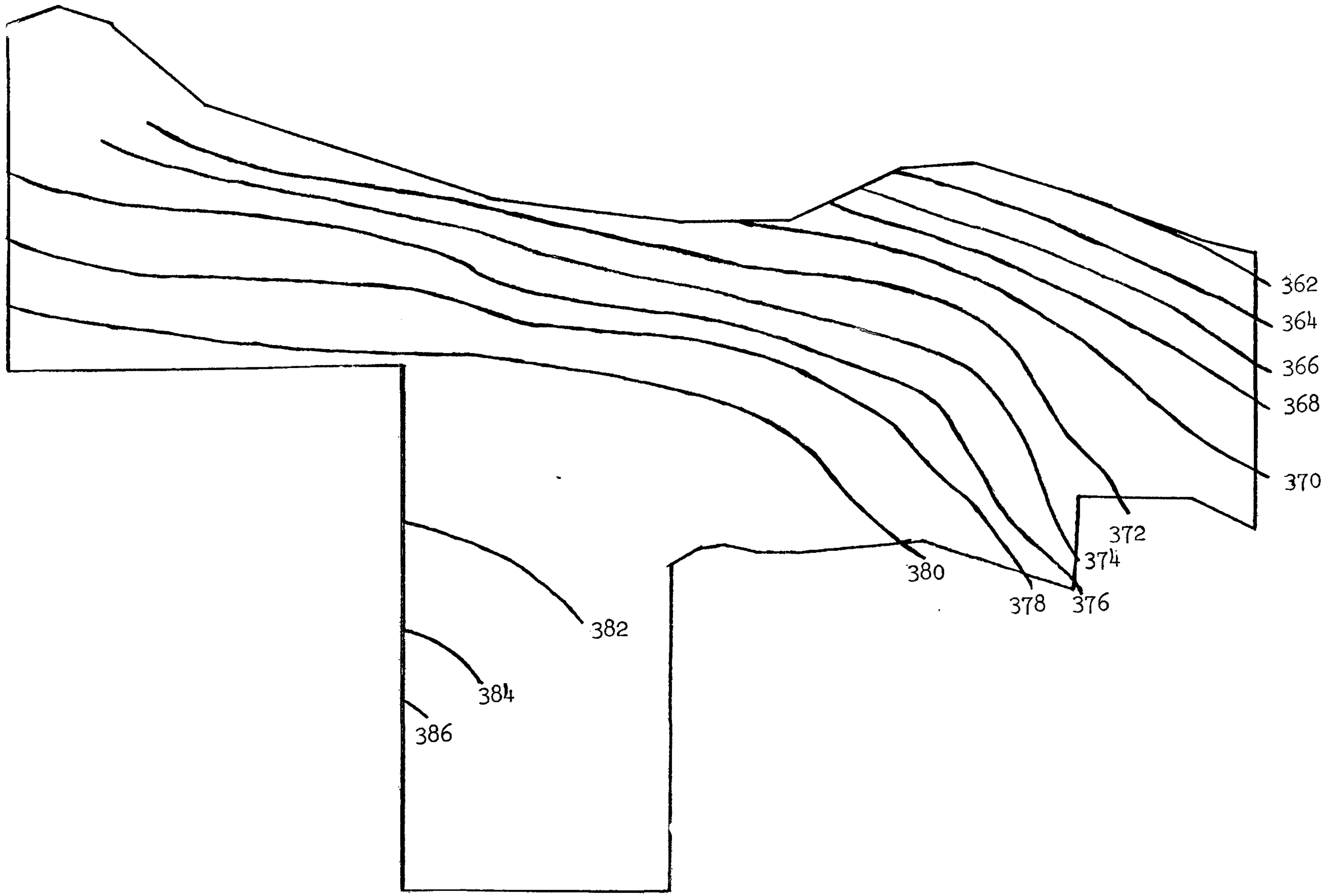

FIGURE H-6. GROUNDWATER CONTOURS* - MARCH 1977

*Elevation in feet above mean sea level

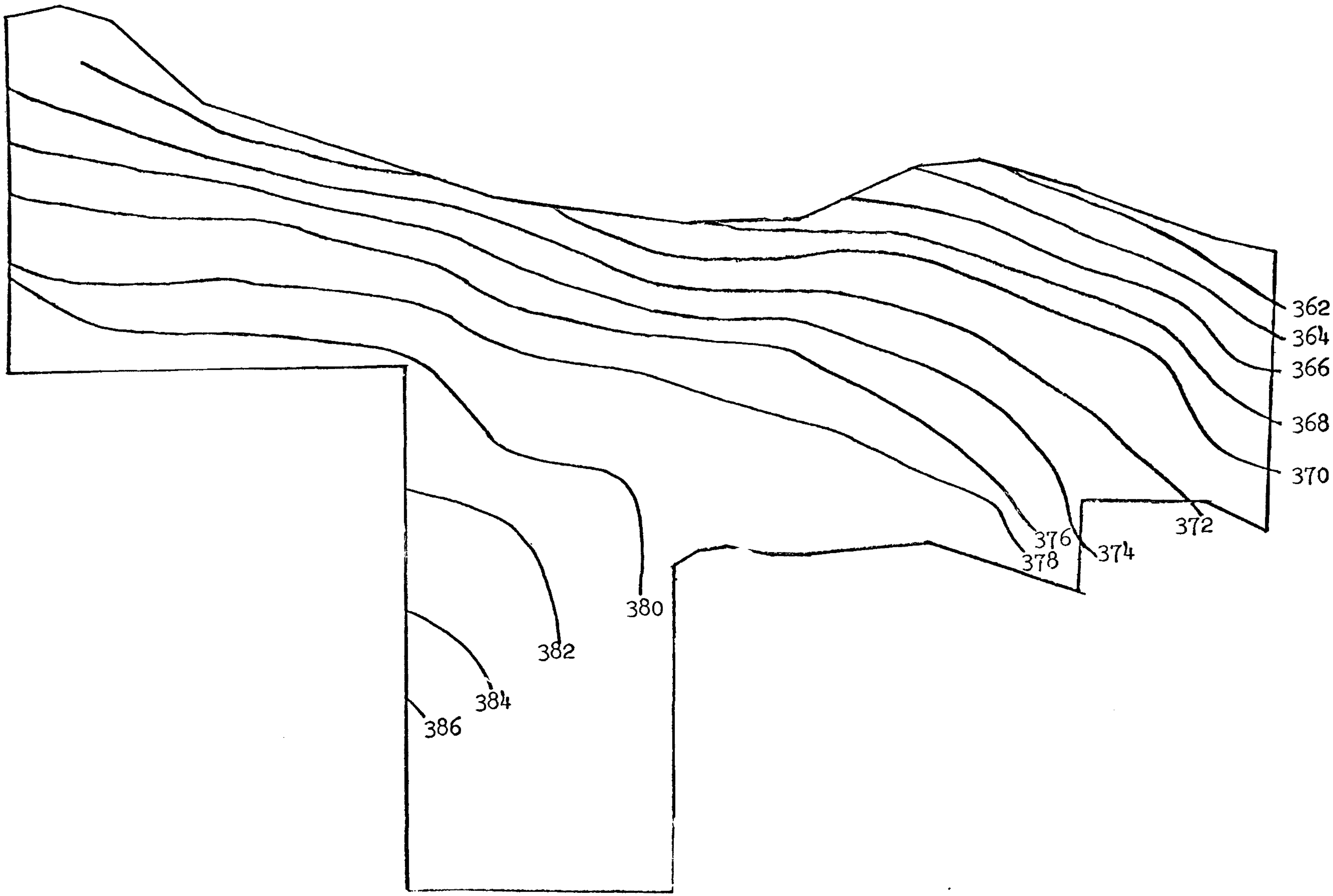

FIGURE H-7. GROUNDWATER CONTOURS* - JUNE 1977

*Elevation in feet above mean sea level

Table H-1. Irrigation Rates(1)

Field No.	Acres	Jan-April 1976 For period MG	Jan-April 1976 gpam ÷1000	May-June 1976 For period MG	May-June 1976 gpam ÷1000	July-Sept 1976 For period MG	July-Sept 1976 gpam ÷1000	Oct-Dec 1976 For period MG	Oct-Dec 1976 gpam ÷1000	Jan-March 1977 For period MG	Jan-March 1977 gpam ÷1000	April-June 1977 For period MG	April-June 1977 gpam ÷1000
C	80	57.74	180	23.25	150	40.79	170	73.44	310	0	0	8.34	30
D	25	18.05	180	9.52	190	12.75	170	24.51	330	0	0	14.71	200
E	104	75.07	180	30.21	150	53.00	170	74.64	240	0	0	63.17	200
F	8	5.76	180	2.32	150	4.07	170	4.91	200	0	0	9.29	390
I	28	20.21	180	10.66	190	14.26	170	24.23	290	39.59	470	13.61	160
J	22	15.87	180	9.40	210	11.22	170	39.55	600	12.09	180	14.96	230
K	15	10.82	180	5.71	190	7.64	170	27.73	610	8.24	180	9.18	200
L	35	25.26	180	10.17	140	17.84	170	70.37	670	85.22	810	15.97	150
M	9	6.48	180	2.62	140	4.59	170	5.60	210	0	0	9.29	340
N	22	15.87	180	6.39	140	11.22	170	19.17	290	0	0	6.25	90
O	15	10.81	180	4.36	140	7.64	170	12.08	270	0	0	1.47	30
P	10	7.23	180	0	0	0	0	4.62	150	0	0	9.30	310
Q	25	18.05	180	0	0	0	0	4.50	60	0	0	3.44	40
R	16	11.54	180	0	0	0	0	0	0	0	0	0	0

(1) 1 acre (Ac) = 4.05 x 10^{1} hectare (he)
1 million gallons (MG) = 3.78 x 10^{3} cubic (m^3)
1 gallon per acre per month (gpam) = 9.34 x 10^{-3} cubic meter per hectare per month (m^3/ha/Mo)

Table H-2. End of Irrigation Period: Chloride Levels in Ranch Test Wells(1)

Well No.	May 1975	Dec. 1975	Jan. 1976 through Apr. 1976	May 1976 through June 1976	July 1976 through Sept. 1976	Oct. 1976 through Dec. 1976	Jan. 1977 through Mar. 1977	May 1977 through June 1977
9	3	12	5	6	6	5	5	4
11A	-	13	6	8	7	4	5	6
15	3	13	5	-	-	4	6	4
19	3	12	3	3	5	4	3	4
22	2	7	3	2	5	19	102	4
24	5	14	24	3	6	5	6	9
25	5	5	10	11	144	68	128	79
32	4	5	10	30	42	94	139	178
34	2	11	6	3	6	18	22	-
42	2	6	4	4	7	5	5	-
45A	-	8	13	18	9	34	34	23
47	2	7	29	4	6	4	5	5
49	2	7	4	4	6	3	3	5
53	4	7	43	99	40	23	22	15
57	2	6	34	3	6	5	5	4
59	4	6	21	14	27	17	19	26
62	3	8	8	10	14	16	14	16
66	5	7	31	48	39	17	26	27
67	-	-	-	-	8	3	5	5
70	83	-	45	31	29	23	19	24

(1) All results in mg/l

Table H-3. Groundwater Table Slopes

Last Month of Irrigation Period	East of Field C percent	East of Field F percent
December 1975	.50	.71
April 1976	.83	.83
June 1976	.59	.71
September 1976	.83	.77
December 1976	.91	.91
March 1977	.56	.69
June 1977	.55	.71

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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16. ABSTRACT

In 1973, Simpson Paper Company initiated a research program to explore the use of the fully-treated secondary effluent from its Shasta Mill for beneficial crop irrigation. This program included the operation of laboratory soil columns and field test plots, plus hydrological studies. Potential problems were identified, and remedies for those problems were developed.

After obtaining the necessary permits, construction of a 162 hectare irrigation project began in early 1975, with the first effluent irrigation taking place in January, 1976. During the next 20 months, over 5.3 million cubic meters of effluent were applied to the carefully prepared fields, using an innovative, highly automated, flood irrigation system.

Several crops have been grown, including wheat, oats, corn, alfalfa and beans. In most cases, the yields were equal to, or better than, the California averages for those crops.

The effluent percolate, which eventually enters the Sacramento River, is essentially devoid of suspended solids, BOD-5, chemical oxygen demand (COD), color, and toxicity compontnts. Both the indirect percolate discharge, and the direct secondary-treatment effluent discharge to the river meet all of the necessary environmental requirements.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Pulp Mills, Paper Mills, Industrial Waste Treatment, Waste Disposal, Wastewater, Irrigation, Farm Crops,	Secondary Effluent Color Removal	13B

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