Chapter 2

DISCHARGE OF CHEMICAL WASTES INTO UC BERKELEY SEWER SYSTEM: CHEMICAL USE PATTERNS, WASTE DISPOSAL PRACTICES AND SEWER EFFLUENT SAMPLING

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Explanation of Project

University campuses with extensive research programs typically produce a wide variety of liquid chemical wastes. Categories include radioactive waste, acids, caustics, alcohols, organic solvents, petroleum oils, phenols, salt solutions and compounds containing heavy metals. Various ways by which these chemicals may leave the research environment include temporary storage in appropriate laboratory receptacles pending permanent off-campus disposal, discharge through campus sewer systems, consumption in chemical reactions, and evaporation (if volatile).

Since the majority of chemicals follow one of the first two paths, we chose to look more closely at factors affecting these methods of disposal on the Berkeley campus. This report summarizes our findings concerning chemical use patterns, waste disposal practices and sewer effluent sampling. This information will be evaluated for its connection to water quality and effectiveness of disposal practices.

Previous Work

Previous work in these areas has been limited to three efforts: testing of effluent by East Bay Municipal Utilities District (EBMUD) for heavy metals (Appendix C), annual sampling by EBMUD as a condition of UCB's discharge permit (Table 1), and a student report for fiscal year 1976 titled "Fourteen Highest-Volume Use Organic Solvents in the College of Chemistry" (Table 2). The EBMUD sampling results indicate that UCB is in compliance for the pertinent discharge categories. The organic solvent study suggests heavy use of the simple alcohols, perhaps one-fourth as much use of chlorinated hydrocarbons, and heavy use of other common solvents such as ethers and acetone.

Background Information

As a major research institution in the biological and physical sciences, UC Berkeley would be expected to use and produce large amounts of chemicals. However, an examination of all such substances was beyond the scope of this project. We chose to focus on, but not limit our attention to, organic solvents, chlorinated hydrocarbons, phenols and heavy metals. In reaching this decision we considered that:

(1) The Wastewater Control Ordinance (EBMUD Ordinance No. 270) establishes specific wastewater strength limits that the UCB discharge may not exceed (Appendix B);
(2) EBMUD tests annually only for pH, total suspended solids (TSS), and chemical oxygen demand (COD) (Table 1);
(3) Preliminary communications with staff and faculty suggested that organic solvents, chlorinated hydrocarbons, phenols and heavy metals are the categories most likely to exceed discharge limits (Boll, 1/18/83, pers. comm.; Grens, 1/25/83, pers. comm.);
(4) No administrative body associated with the University performs sewer discharge sampling or monitoring (Boll, 1/28/83, pers. comm.; Black, 2/9/83, pers. comm.).

CATEGORY	RESULTS
pH	7.8-8.3
TSS	80 mg/l
COD	80 mg/l

Note: Values averaged over the last 3 years.

TSS = Total Suspended Solids
COD = Chemical Oxygen Demand

Table 1. EBMUD Sampling Results
Source: Wastewater Discharge Permit, 1982.

SOLVENT	VOLUME (GAL)
Ethyl ether	2,340
Ethanol	1,770
Acetone	1,460
Isopropanol	590
Chloroform	420
Hexane	370
Methanol	370
Benzene	360
Pentane	290
Toluene	210
Petroleum ether	200
Dichloromethane	195
Carbon tetrachloride	50
Trichloroethylene	50

Table 2. Fourteen Highest-Volume Use Organic Solvents in the College of Chemistry, FY 1976
Source: Grens, 1983.

The campus sewer system consists of a few main lines which drain at various points into the City of Berkeley's system (Figure 1). The sewer draining into the Oxford-Center Street tie-in is the most prominent line because it carries effluent from most of the northern half of the campus. This half includes the College of Chemistry and the Life Sciences Building, which use the greatest volumes of chemicals (Boll, 1/18/83, pers. comm.). The College of Chemistry consists of Giauque, Gilman, Hildebrand, Latimer, Lewis and PSL (Physical Sciences Lecture) Halls. The Life Science Building (LSB) houses the departments of Botany, Microbiology/Immunology, Physiology/Anatomy and Zoology. Figure 1 indicates other buildings whose sewers drain into the main line.

The campus discharges a total of about 1,200,500 gal. daily to the community sewer system (DOFM, 1982). This figure has been combined with discharge limits as established in EBMUD Ordinance 270 (Appendix B) to calculate maximum permissible daily discharges of total

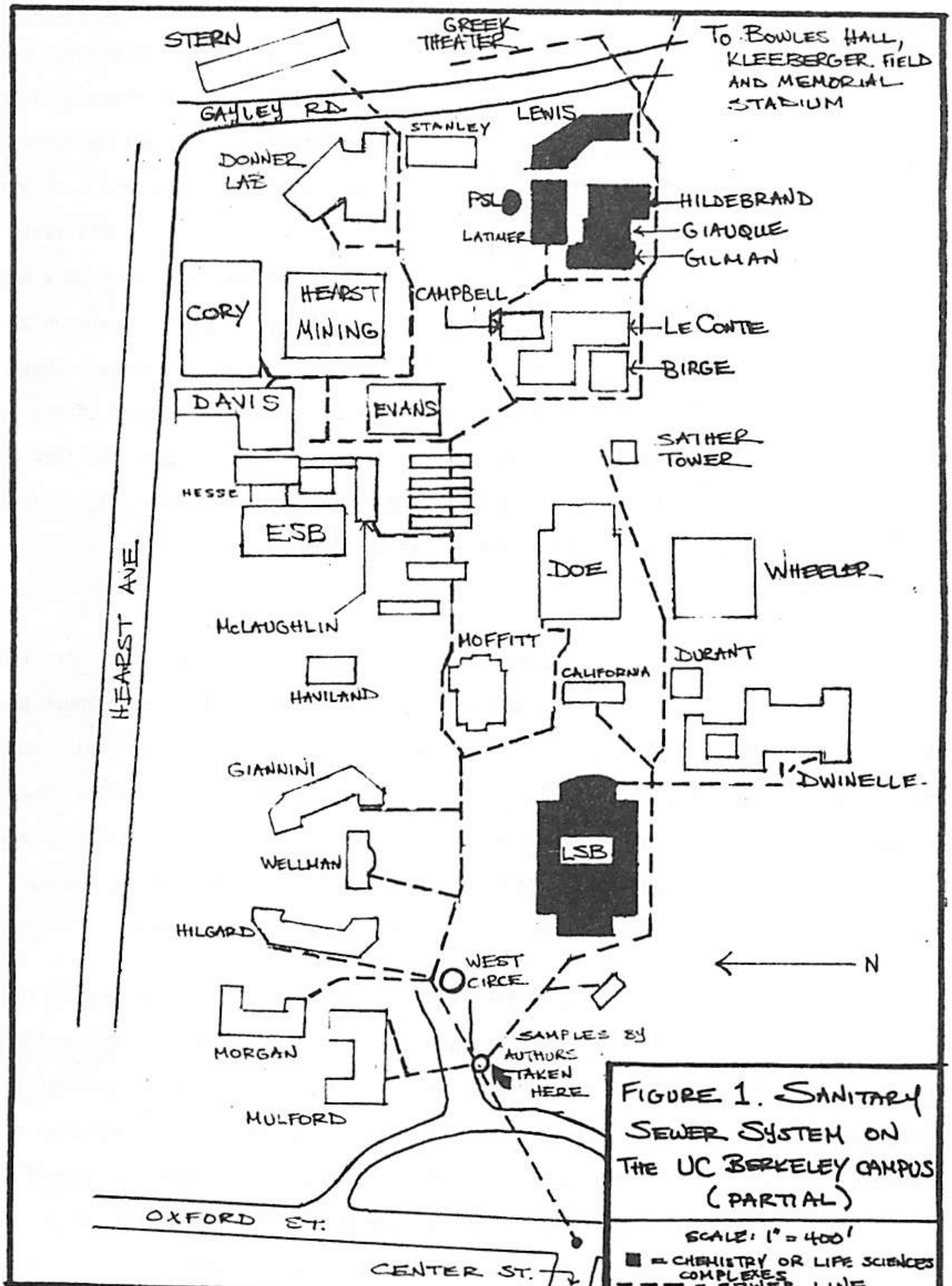

FIGURE 1. SANITARY SEWER SYSTEM ON THE UC BERKELEY CAMPUS (PARTIAL)

DISCHARGE CATEGORY	MAXIMUM PERMISSIBLE DISCHARGE (KG/DAY)
TICH	2.30
Phenols	454.00
Cadmium	4.50
Mercury	.23
Lead	9.10

Table 3. Maximum Permissible Daily Discharges for UC Berkeley Effluent.
Source: See text.

chlorinated hydrocarbons (TICH), phenols, and the heavy metals cadmium, mercury and lead (Table 3). Of course, these values are useful only in estimating the general magnitude of permissible daily discharge, since they assume an average over the entire campus, a time-average over one day, and a constant discharge concentration for each pollutant. The last two assumptions are reasonable because EBMUD monitoring is usually based on 24-hour sampling.

The maximum permissible discharge levels for TICH and mercury are quite low. These values deserve particular attention because not only the College of Chemistry and LSB but most of the other chemical-using departments discharge into the same main line. For this reason we chose to sample this line for the above-mentioned substances. Descriptions of our sampling, our survey of chemical use and disposal patterns, and our results follow in the next sections.

Methodology

Since the topics we researched have received so little previous attention, there exist few written records we could consult. Consequently, much of our information was obtained through personal communications, usually in the form of in-person interviews in lab or in the office. This emphasis on verbal information-gathering means that our results should not be regarded as necessarily complete. For instance, we know from personal experience that many more liquid chemicals are used in some of the chemistry and biology labs than were mentioned to us. For the sake of consistency, however, we have limited our consideration to chemicals specifically designated by interviewees.

Chemical use patterns - We consulted graduate students, storeroom supervisors and departmental business officers for information on chemical use. We interviewed twelve people at length and approximately another ten in less detail. Many interviewees were limited by time and work constraints. We presented those who had time with a list of commonly-used chemicals (Appendix D) and asked them to identify which were used in their lab or department. We also encouraged interviewees to specify use of organic solvents, chlorinated hydrocarbons, phenols and heavy metals. Most respondents distinguished between "normal" use (regular use of less than a liter each time or less frequent use of larger volumes) and "high" use (frequent use of moderate volumes or irregular use of larger volumes).

Disposal practices - Information on the waste disposal program run by the Office of Environmental Health and Safety was obtained mostly from John Boll, until recently the director of the program. Information regarding departmental disposal was obtained from graduate students, storeroom supervisors, business officers and departmental publications.

Sewer effluent sampling - We took our samples from a manhole near the west entrance to campus (see Figure 1), a location near the end of the main sewer line. By this point, all the incoming lines have discharged their effluent; any maximum concentration in the system would most likely show up at this location. After informing EBMUD of our results, we discovered that all previous EBMUD samples had been taken from a different manhole. Although it cannot be confirmed from engineering plans, it is likely that the two points give access to the same sewer line, since both are near only one tie-in to the community sewer system, the Oxford-Center Street junction.

We took two sets of samples. The first was taken between 1:00-2:00 p.m., Wednesday, 5/23/83, during spring break on the Berkeley campus; it was analyzed for TICH and total phenolic compounds ("phenols"). The second set was taken at 11:00 a.m., Friday, 4/8/83, at the end of the second week of spring quarter classes; it was analyzed for TICH, phenols, cadmium, mercury, lead and pH. Both sets of samples were taken to maximize pollutant discharge while avoiding the impact of lunch breaks.

The effluent at this point flows ten feet below ground level, with an inlet spout from Mulford Hall entering at 2½ feet down. We obtained our samples by lowering a cleaned plastic milk container on a line into the current below. We transferred the samples into cleaned glass bottles (for TICH analysis) and plastic bottles (for phenolic and heavy metal analyses).

The pH test was done at the sampling site with standard laboratory pH test paper. The chemical analyses for TICH and phenols were performed using standard methods by the EAL Corporation of Richmond, CA, and were financed by the campus Office of Environmental Health and Safety (EH&S). The authors performed the heavy metals analyses with a Perkin-Elmer 360 Atomic Absorption Spectrophotometer following the manufacturer's recommended standard procedures. We are grateful to Tom Morrison and Mr. Tashinian, technicians in the College of Chemistry, for their assistance.

Results and Discussion

Chemical use patterns - Our interviews pointed out several chemical use patterns within chemical type and within departments. Figure 2 shows these results; note that this chart tells nothing about relative degrees of use between departments--only within departments. Since few interviewees could offer estimated volumes of use, the chart is limited to comparative interpretation. It is clear, however, that all departments use appreciable amounts of inorganic acids. All departments with the exception of Physiology/Anatomy use normal or large amounts of chlorinated hydrocarbons and simple alcohols. Chemistry and Zoology also use generally large amounts of ketones, saturated and aromatic hydrocarbons, and esters. The most-used categories appear to be inorganic acids, chlorinated hydrocarbons, simple

CHEMICAL	CHEMISTRY	BOTANY	MICROBIOLOGY/ IMMUNOLOGY	PHYSIOLOGY/ ANATOMY	ZOOLOGY
Group 1:					
Hydrochloric acid	□	□	■	■	□
Hydrofluoric acid	□	□	■		□
Nitric acid	□	□	■	■	□
Phosphoric acid	□	□	■	■	□
Sulfuric acid	□	□	■		□
Group 2:					
Acetic acid		□			■
Formic acid		□			□
Propionic acid		□			□
Group 4:					
Aniline		□			□
Pyridine					□
Group 5:					
Carbon Tet(CCl_4)	□	□			
Chloroform	■	□	■		□
Dichloromethane	■	□			
Group 6:					
Butanol		■			□
Ethanol	■	■	■		■
Methanol	■	■			■
Propanol	■	■	■		
Ethylene glycol					■
Ethylene glycol monoethyl ether		□			
Glycerine		□			□
Group 8:					
Acetone	■	□			■
MEK	■				
Group 9:					
Hexane	■				
Paraffin wax		□			□
Pentane	■				
Petroleum ether		□			
Group 10:					
Benzene	■	□			□
Toluene	■	□			■
Xylene		□			■
Group 12:					
Mineral spirits		□			
Lubricating oil		□			
Mineral oil					
Penetrating oil		□			
Group 13:					
Amyl acetate		□			
Ethyl acetate	■	□			□
Group 15: Phenol		□	■		□
Group 15: Propylene oxide					□
Group 21:					
Ethyl ether	■				
Tetrahydrofuran	■				

KEY: blank = not mentioned in interviews
□ = mentioned as regularly-used
■ = mentioned as a high-use chemical

Figure 2. Liquid Chemicals Commonly Used In Laboratory Research at UC Berkeley.
Source: See text.

alcohols, ketones, aromatic hydrocarbons, esters and ethers, with high use concentrated in Chemistry and Zoology. Specific high-use chemicals include all the inorganic acids, chloroform, ethanol, methanol, propanol, acetone, methyl ethyl ketone, hexane, pentane, benzene, toluene, ethyl acetate and phenol.

Most of the chemicals mentioned are solvents. Ordering data for 1982 from the College of Chemistry indicate that acetone, ethyl ether and the simple alcohols were the solvents ordered in greatest volume. Chloroform and dichloromethane were the two most-ordered chlorinated hydrocarbons. High-volume ordering is a reasonable measure of solvent use since such chemicals tend to have short residence times on laboratory shelves. Since these chemicals are used mostly for solvation and cleaning purposes, they are usually not consumed in reaction and require eventual disposal. Table 4 lists the other high-volume solvents for 1982.

Comparison of Tables 2 and 4 shows some changes over time in solvent use in the College of Chemistry. Use of acetone, hexane and dichloromethane at least doubled between 1976 and 1982; use of ethyl ether, ethanol and benzene drastically decreased. The College of Chemistry's conscious effort to reduce drain disposal and water consumption during the drought years (Grens, 1/25/83, pers. comm.) may account for the generally lower levels of solvent ordering in 1976.

SOLVENT	VOLUME (GAL)
Acetone	2,860
Ethyl ether	1,356
Hexane	960
Chloroform	720
Isopropanol	588
Ethanol	576
Methanol	552
Dichloromethane	492
Ethyl acetate	312
Methyl ethyl ketone	130
Tetrahydrofuran	156

Table 4. Eleven Most-Ordered Solvents in the College of Chemistry, FY 1982. Source: Chruschiel, 1983.

Heavy use of such chemicals has a potential impact on water quality in the form of toxicity to aquatic organisms. A standard basis for comparison is the median tolerance limit (TLm), the pollutant concentration at which half of an exposed group of aquatic organisms show abnormalities. The literature consulted distinguishes between pollutants with TLm's of "greater than 100 ppm" (>100 ppm) and "less than 100 ppm" (<100 ppm). As Table 5 indicates, benzene is one of the few common solvents with TLm's less than 100 ppm. A concentration of 100 ppm is quite high; in the case of treated effluent entering San Francisco Bay, such toxicity levels

SOLVENT	TLm
Acetone	> 100 ppm
Benzene	< 100 ppm
Ethanol	> 100 ppm
Toluene	> 100 ppm

Table 5. Aquatic Toxicity Data
Source: US Coast Guard, 1974.

assume the solvents remain unaltered through the treatment process. Fortunately, the chance of any solvent reaching the Bay at a concentration approaching 100 ppm is virtually nil.

We received very little information on heavy metal use. Interviewees generally either did not mention use of compounds containing heavy metals or seemed reluctant to discuss it. Several persons in the College of Chemistry felt that mercury-containing equipment, such as thermometers, constitute the greatest potential source of exposure to the environment.

It is clear that an exhaustive records search is the only way to approach estimates of volume use for most chemicals on the Berkeley campus. With the exception of the College of Chemistry, none of the departments investigated maintains records specifically monitoring general chemical use. Since one of the only ways to guess which chemicals get "dumped" down the drain is to determine which chemicals are used in the labs, the lack of information makes the job more difficult and renders any conclusions less authoritative.

<u>Disposal Practices</u>

<u>Environmental health and safety</u> - The campus Office of Environmental Health and Safety (EH&S) maintains a chemical waste disposal program, until recently directed by John Boll; waste pick-ups are funded by the Department of Facilities Management. The program is described by EH&S as follows:

> Departments or individuals wishing to dispose of chemicals should contact the Office of Environmental Health and Safety which has an established program for the disposal of chemical waste. The objective of the program is to provide a safe and controlled method for the disposal of these chemicals. This service is provided to all campus departments at no charge.
>
> (EH&S, 12/82, Safety Bulletin)

Since EH&S has no intervention authority, its policy that "nothing goes down the drain" cannot be enforced. The only enforceable standards relating to handling of chemicals are those promulgated by the EPA and CalOSHA; EH&S attempts to insure on-site compliance with these regulations since its major function is the protection and maintenance of occupational safety. The University itself has no officially recognized policy regarding disposal of chemical wastes (Boll, 1/18/83, pers. comm.).

Until recently the disposal program was staffed by Boll and at least one part-time student worker. If ten or more chemicals need to be picked up, the user is expected to submit an itemized list specifying chemical types and approximate amounts. A pick-up request of fewer than ten chemicals can be phoned in to an EH&S receptionist, who records the information on a standardized form. Unfortunately, the receptionists are generally not well versed in chemistry and sometimes accidentally record false information. This can result in an EH&S technician showing up at a lab expecting to pick up a type of waste very different from that which s/he actually finds.

Until January 1983 student workers made the pick-up rounds. Although Boll took care to brief the workers, he finally decided that the job was too hazardous for students and assumed the responsibility himself. Recently a full-time position was created in EH&S for a technician who would pick up and handle hazardous waste, but the job description was subsequently changed to the handling of radioactive waste alone (Boll, 3/11/83, pers. comm.).

EH&S prefers to pick up chemical wastes where they are generated. Transfer to a temporary collection area within a department increases the possibility of accident. The EH&S handler wears protective clothing and transfers the material to a specially-equipped truck. Recently chemical wastes have been accumulating in several labs in LSB (Gilmore, 3/31/83, pers. comm.) because EH&S was experiencing delays in obtaining a new vehicle (Boll, 3/11/83, pers. comm.).

EH&S has issued specific hazardous chemical waste packaging regulations. A revised version is being prepared, although the current guidelines are "entirely adequate" (Boll, 2/15/83, pers. comm.). Occasionally the EH&S handler refuses to remove materials because they have been improperly packaged and pose a safety hazard (Boll, 2/15/83, pers. comm.).

The hazardous chemical wastes are taken to a storage facility known as the "Acid House" on Centennial Drive across from the Botanical Gardens. They are stored mostly in 55-gallon, 5-gallon and 2½-gallon drums. Approximately every two weeks the contracted hauler is called to repackage and remove the accumulated waste under Boll's supervision. Categories of drumming for transport include acids, alkalis, carcinogens, cyanides, flammables, irritants, organic peroxides, poisons and water reactive/toxic. An itemized list is drawn up and filed by EH&S for each pick-up, naming the types and approximate amounts of each chemical in each drum. These lists can be very lengthy due to the tremendous variety of chemicals used on campus.

The transporter hauls the waste to a treatment, storage and disposal (TS&D) facility in Casmalia, California (Appendix E). All transactions appear to meet the California Hazardous Waste Management specifications, complete with manifests and other documentation. Costs per transactions, including labor, hauling and disposal, are generally between $1,000 - $2,000 (Appendix F).

Departmental practices - We found that all departments using acids and alcohols regularly dispose of them through the drains. Other substances, such as formaldehyde and glutaraldehyde, are poured down the drain only from certain labs. Figure 3 lists other chemicals mentioned as receiving drain disposal at least some of the time. It can be assumed that chemicals not listed either were not mentioned during the interviews or typically are disposed of in waste containers.

College of Chemistry - The College of Chemistry handles most of its own wastes. Rob Steiner serves as the College's handler of hazardous waste. He transfers collected materials to B8 Latimer, a small preparation room to which supposedly only he and his supervisors have access. However, chemical waste

CHEMICAL	CHEM	BOT	MICRO/ IMM	PHYS/ ANAT	ZOO
Acids (inorganic)	■	■	■		■
Acetic acid					■
Acetone	■				■
Acrylamide (unpolymerized)			■		
Alcohols	■	■	■	■	■
Dinitrophenol			□		
Ethydium bromide			□		
Formaldehyde					■
Glutaraldehyde					■
Picric acid					■
Propylene oxide					■
Toluene	■				
Neutralized salt solutions				■	

CHEM = Chemistry: BOT = Botany: MICRO/IMM = Microbiology/ Immunology; PHYS/ANAT = Physiology/Anatomy; ZOO = Zoology
KEY: blank = not disposed of through drain
□ = disposed of through drain only in very small amounts and/or infrequently
■ = disposed of through drain regularly

Figure 3. Drain Disposal Patterns on the UC Berkeley Campus.

occasionally appears in the room with no indication of who brought it. Apparently the room is in "good shape" now, although it needed extensive cleaning and removal of potentially explosive materials when Steiner assumed the position (Steiner, 4/8/83, pers. comm.).

Class C carcinogens are stored in a cabinet in a room behind the Physical Science Lecture Hall. Steiner is responsible for maintaining these chemicals according to OSHA regulations.

Individual research labs were stocked years ago with at least six waste solvent cans each. Many of these cans have since disappeared or are no longer in use. Organic chemistry instruction labs contain poorly-labeled waste bottles in fume hoods and special disposal containers for MEK (methyl ethyl ketone).

Our impression after touring the department is that the research areas are generally cramped and frequently dirty and disorderly, whereas the storerooms seem neat and well-organized. In many labs bottles of chemicals are strewn about on work bench areas. Virtually every lab is equipped with shelf space and fume hood area, but not all have special solvent cabinets. We saw no notices near sinks warning students and researchers about proper disposal techniques.

A handbook entitled "Who Does It and Where to Find It" is given to new graduate students in the College. It contains specific guidelines for the handling of chemical waste; there is only a brief mention of drain disposal:

> Spent acid solutions, ordinary salts and moderate amounts of solvents are best disposed of by being poured down the drain intermixed with large quantities of water. Examinations in the past have shown that these materials are decomposed by natural bacterial action and the sewage treatment process.
>
> (College of Chemistry, 1982)

Life Sciences Building - Wastes in the Department of Botany are picked up from the storeroom. Some, but not all, labs are equipped with waste cans. The Botany research areas seem very neat and well-organized. No departmentally-published guidelines are distributed to new graduate students; it is assumed that "everyone here is well-trained" (Rauls, 3/30/83, pers. comm.).

Most labs in the Department of Microbiology/Immunology have waste disposal cans in the fume hood area. Waste is picked up by EH&S from individual labs. There are no published departmental guidelines, although a general handbook has been discussed.

The Physiology/Anatomy labs appear clean and well-organized. Although there are no departmental guidelines, individual labs make an effort to educate new students on the proper handling and disposal of pertinent chemicals (Miller, 4/1/83, pers. comm.). Wall charts with data on the properties of dangerous materials were clearly visible.

Our impressions of disposal practices in the Department of Zoology are somewhat inconclusive. Some labs we visited, although very cramped, are well-organized and maintained, with numerous clearly-labeled disposal containers. Other labs are near-chaotic, with equipment and bottles of chemicals everywhere. The awareness of researchers we spoke with ranged from active concern to near-disregard of the effects of drain disposal. Suggestions to new students for proper disposal techniques are transmitted only through word of mouth.

In sum, few labs in LSB have an organized system of waste disposal. Many of the labs contain waste cans or bottles, but usually too few and too-vaguely labeled. In two instances, we saw boxes of waste awaiting pick-up stacked near doorways--clearly an unsafe place. Greater efforts in educating students and organizing responsible waste collection might reduce drain disposal of potentially obnoxious substances.

Sewer Effluent Sampling

The authors' sampling shows that UC Berkeley is in compliance for all tested categories except the TICH (total chlorinated hydrocarbons) level obtained on April 8, 1983, which exceeds the maximum by a factor of almost sixty (Table 6). Several phenomena could account for this particularly high value. Since the March sample was taken during a vacation, the April value may simply reflect typical differences caused by a full campus population and research intensity. However, an interesting characteristic of the result suggests other possibilities. Ninety percent of the intensity of the gas chromatograph for this sample came from one peak, meaning that one chemical was responsible for 90% of the measured TICH. A standard literature search by the analysts (CAL Corp.) produced no clue as to the identity of the chemical. This suggests two possibilities: either this high value represents a one-time "spot" dumping of some obscure chemical (perhaps someone was cleaning out an old cabinet), or it reflects a chemical reaction between other chemicals present in the effluent. We favor the first possibility because it seems unlikely that a reaction in the sewer line could produce a spot concentration of such magnitude.

ANALYSIS	UNITS	3/23/83	4/8/83	MAXIMUM PERMISSIBLE
TICH	mg/l	.019	29	.5
Phenols	" "	<.1	<.1	100
Cadmium	" "	---	0.0	2
Mercury	" "	---	0.0	.05
Lead	" "	---	0.0	1
pH	--	---	5-6	≥5.5

Table 6. Results of Authors' Sampling of Sewer Effluent.

After hearing of our results, EBMUD took additional samples for TICH on May 12 and 13, 1983; three out of four of the samples were taken from the access point used by the authors. All analyses showed "Undetectable" levels of total identifiable chlorinated hydrocarbons. However, we learned that the TICH analysis done by EBMUD detects only pesticides and PCB's, whereas the analysis by EAL specifically excludes those two categores but detects all chlorinated solvents. Since the samples tested by EAL and EBMUD were analyzed for different chemicals, EBMUD's results do not help in determining whether the high discharge level on April 8 noted by the authors represents a chronic or a one-time condition. Clearly, further sampling is needed; such samples as taken by the authors are useful as indicators of a potential problem but cannot by themselves be considered conclusive.

The next sections present our conclusions regarding waste disposal on campus, the implications for water quality, and suggestions for improvement.

DISCUSSION

A.M. Ujihara and Jennifer Jolly

The purpose of this project was to measure and assess the impact of chemical discharges from labs on the UCB campus. Through both test results and lab surveys, we sought to identify and quantify these discharges. The results of both effluent testing and lab surveys identified potential problems with chemical discharges from labs.

Although the results of the first test indicated UCB was below Ordinance 270 limits for TICH, the results of the second test, taken during the second week of classes, showed UCB was above the Ordinance limits. This sample's concentration of TICH at 29 mg/l was considerably higher than that of the first sample taken during the spring break, which suggests increased lab activities occurring when classes are in session. It is difficult to draw any definitive conclusions from a single sampling, however. A result from an instantaneous sample could be interpreted as a chronic problem, i.e., continuously high TICH concentrations, or as a temporary problem, i.e., the presence of TICH was high only when the sample was taken. Since one chemical substance was responsible for most of the TICH in this sample, the latter interpretation appears most plausible, and since the second sample was above the Ordinance limitation of .5 mg/l, UCB was technically in violation of the Ordinance for chlorinated solvents. However, many of these solvents are quite volatile and evaporate before reaching the Bay and possibly before reaching SD1. For this reason, EBMUD is not overly concerned about such violations and concentrates on the non-volatile pesticides and PCB's.

EBMUD maintains its effluent concentrations of TICH well below the limits defined in its permit to the RWQCB. Thus, even if our testing showed an Ordinance violation and even if UCB's TICH discharges proved to be a chronic problem, the direct impact on the Bay water quality would be small. EBMUD's discharge of TICH into the Bay from SD1 is .00006 mg/l (averaged over June 18, 1980 to June 19, 1982) (EBMUD, 1982), which is well below the state permit's standard of .002 mg/l. For this reason, UCB's discharge of TICHs is unlikely to have a significant direct impact on San Francisco Bay's water quality, even if UCB's TICH discharges proved to be a chronic problem

Test results also showed UCB to be in compliance with EBMUD's Ordinance for phenolic compounds, mercury, lead, and cadmium when the samples were taken. The low or undectable concentrations of these substances suggest UCB has a negligible impact on the water quality of the Bay for these substances.

From the lab surveys we sought to identify what chemicals were used in UCB labs and how chemical wastes were disposed of. Our lab surveys did not show large quantities of any of the substances tested. Nonetheless, our surveys revealed additional information on chemical discharges.

Our surveys revealed the difficulty in obtaining comprehensive data on chemical usage. Departments vary in how chemicals are ordered. Some departments do not have stockrooms, and professors and graduate students order their chemicals individually. Information on the amounts of chemicals ordered could be obtained by going through every purchase order and receipt. The vast number of these makes it almost impossible to make accurate estimates of chemical usage.

Departments also vary in how they address the disposal of waste chemicals. There is a wide variation among departments in educating new graduate students as to chemical disposal methods. Thus, researchers have varying degrees of awareness as to what is safe to discharge and what is not.

In our investigations, we also examined the EH&S campus-wide waste disposal program, since any liquid wastes not being properly disposed of are likely to go down the drain. We found that lab users requesting the EH&S services often did not package wastes properly. This indicates ignorance of how to dispose of wastes safely. We also found pick-ups by EH&S were periodically delayed. This is likely to discourage those persons generating the waste from using the EH&S service.

Recommendations

Our investigation has identified a problem with chemical discharges from campus. We make several recommendations to remedy this problem.

First, ambiguities surrounding TICH limits need to be resolved. For one, regulations need to be developed to encompass the chlorinated hydrocarbons not currently addressed. Furthermore, EBMUD needs to specify to which chlorinated hydrocarbons it is referring in Ordinance 270. Finally, EH&S should perform further testing to identify the substance found in our second test sampling.

Second, UCB needs to recognize the scope of the chemical discharges problem and address it directly, not only for TICH but for other substances as well. This could best be achieved with the development of a policy aimed specifically at chemical discharges. This policy would be the responsibility of UCB's Office of Environmental Health and Safety. Furthermore, EH&S needs to notify the individual departments of the problem and explain its goals to reduce it.

Third, UCB needs to improve the management of disposing of all chemical wastes on campus. We concur with EH&S in that improving the disposal of all wastes will reduce chemical discharges. This could be done in a number of ways, including improving communications between labs and EH&S for waste pick-up requests. Currently, EH&S supports the building of a new waste disposal facility in Richmond in order to monitor and remove wastes more effectively from campus.

Fourth, the individual departments need to insure that their new students know proper chemical disposal techniques. This could be done by mandatory reading of materials discussing laboratory safety and disposal practices for all lab users. These materials could include a specific list of chemicals that should not be disposed of through the drain.

Fifth, UCB needs to improve lab facilities. Each lab should have a clearly designated and well-maintained area for the temporary storage of wastes pending pick-up by EH&S. Such areas should have clearly labelled containers for each category of waste chemical. Also, there should be signs above the sink areas in all labs reminding users of safe disposal practices.

Finally, UCB needs to resolve staffing problems at EH&S. The current staff is not large enough to operate a chemical waste program adequately.

Conclusion

The purpose of our project was to identify and measure chemical discharges from UCB labs and determine the resultant impact on water quality. The review of policies showed how chemical discharges from campus are connected to water quality in San Francisco Bay. Test results showed high levels of TICH in UCB's effluent; however, these are not presently addressed by law. Consequently, UCB was in compliance for all substances tested that include TICH, phenolic compounds, mercury, lead, and cadmium. The concentrations of these substances in our test samples indicated, however, that they are unlikely to have a significant impact on the Bay's water quality.

The lab survey showed how little is known about chemical discharges on campus and that researchers in the labs have varying degrees of awareness of the problem. The lab surveys also showed that UCB lacks a comprehensive management of its chemical waste disposal.

Chemical discharges by UCB labs are a serious problem because of their implications regarding disposal of all chemical wastes generated by the labs. UCB must recognize this problem and take corrective measures.

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Appendix A

Effluent Limitations - California Regional Water Quality Control Board San Francisco Bay Region Permit to East Bay Municipal Utility District Special District No. 1
Source: California RWQCB, NPDES no. CA0037702

Constituent	Unit of Measurement	6 Month Median	Daily Maximum
Arsenic	mg/l(kg/day)	.01(4.54)	.04(18.2)
Cadmium	mg/l(kg/day)	.02(9.08)	.08(36.4)
Total Chromium	mg/l(kg/day)	.04(18.2)	.16(72.8)
Copper	mg/l(kg/day)	.2(90.8)	.8(364)
Lead	mg/l(kg/day)	.1(45.4)	.4(182)
Mercury	mg/l(kg/day)	.001(.454)	.004(1.82)
Nickel	mg/l(kg/day)	.1(45.4)	.4(182)
Silver	mg/l(kg/day)	.02(9.08)	.08(36.4)
Zinc	mg/l(kg/day)	.3(136.3)	1.2(545)
Cyanide	mg/l(kg/day)	.1(45.4)	.4(182)
Phenolic Compounds	mg/l(kg/day)	.5(227)	2.0(908)
Total Identifiable Chlorinated Hydrocarbons*	mg/l(kg/day)	.002(.908)	.004(1.82)

*Total Identifiable Chlorinated Hydrocarbons shall be measured by summing the individual concentrations of DDT, DDD, DDE, aldrin, BHC, chlordane, endrin, heptachlor, lindane, dieldrin, polychlorinated biphenyls, and other identifiable chlorinated hydrocarbons.

Appendix B

Waste Water Strength Limits
Source: East Bay Municipal Utility District Ordinance No.270

(1) Arsenic	2 mg/l
(2) Cadmium	1 mg/l
(3) Chlorinated Hydrocarbons (total identifiable)	0.5 mg/l
(4) Copper	5 mg/l
(5) Cyanide	5 mg/l
(6) Iron	100 mg/l
(7) Lead	2 mg/l
(8) Mercury	0.05 mg/l
(9) Nickel	5 mg/l
(10) Oil and Grease	250 mg/l
(11) pH (not less than)	5.5
(12) Phenolic compounds	100 mg/l
(13) Silver	1 mg/l
(14) Temperature	150 °F
(15) Total Chromium	2 mg/l
(16) Zinc	5 mg/l

Appendix C

East Bay Municipal Utility District Testing of University of California Effluent, May 6, 1982, 9:30 am to 2:00 pm
Source: Alan Thompson, EBMUD

pH	6.9 - 8.3	Iron	.6 mg/l
Chemical Oxygen Demand	120 mg/l	Lead	.1 mg/l
Total Sustpended Solids	84 mg/l	Nickel	.07 mg/l
Cadmium	.05 mg/l	Silver	.04 mg/l
Total Chromium	.08 mg/l	Zinc	.10 mg/l

APPENDIX D Commonly-Used Research Chemicals

GROUP 1: INORGANIC ACIDS

chlorosulfonic acid
hydrochloric acid (aqueous)
hydrofluoric acid (aqueous)
hydrogen chloride (anhy.)
hydrogen fluoride (anhy.)
nitric acid
oleum
phosphoric acid
sulfuric acid

GROUP 2: ORGANIC ACIDS

acetic acid
butyric acid (n-)
formic acid
propionic acid
tall oil
rosin oil

GROUP 3: CAUSTICS

caustic potash solution
caustic soda solution
sodium hydrosulfide solution

GROUP 4: AMINES and ALKANOLAMINES

aminoethylethanolamine
aniline
caprolactam solutions
diethanolamine
diethylamine
diethylenetriamine
diisopropanolamine
diisopropylamine
dimethylamine
dimethylethanolamine
dimethylformamide
di-n-propylamine
ethylamine
ethylenediamine
isopropylamine
2-methyl-5-ethyl pyridine
monoethanolamine
monoisopropanolamine
morpholine
propylamine (iso-)
pyridine
tetraethylene pentamine
triethanolamine
triethylamine
triethylenetetramine

GROUP 5: HALOGENATED COMPOUNDS

allyl chloride
carbon tetrachloride
chlorobenzene
chloroform
chlorohydrins
dichlorobenzene (o-)
dichlorodifluoromethane
dichloroethyl ether
dichloromethane
dichloropropane
dichloropropene

GROUP 5: CONT'D

ethyl chloride
ethylene dibromide
ethylene dichloride
freon
methyl bromide
methyl chloride
monochlorodifluoromethane
perchloroethylene
propylene dichloride
1,2,4-trichlorobenzene
1,1,1-trichloroethane
trichloroethylene

GROUP 6: ALCOHOLS, GLYCOLS and GLYCOL ETHERS

allyl alcohol
amyl alcohol
butyl alcohol
butylene glycol
corn syrup
cyclohexyl alcohol
decyl alcohol
dextrose solution
diacetone alcohol
diethylene glycol
diethylene glycol monobutyl ether
diethylene glycol monoethyl ether
diethylene glycol monomethyl ether
diisobutyl carbinol
dipropylene glycol
dodecanol
epoxylated linear alcohols, C - C
ethoxylated alcohols
ethoxytriglycol
ethyl alcohol
2-ethylbutyl alcohol
2-ethylhexyl alcohol
ethylene glycol
ethylene glycol monobutyl ether
ethylene glycol monoethyl ether
ethylene glycol monomethyl ether
furfuryl alcohol
glycerine
hexanol
hexylene glycol
isooctyl alcohol
methoxytriglycol
methyl alcohol
methylamyl alcohol
methyl isobutyl carbinol
molasses
nonyl alcohol
penta decanol
polyethylene glycols
polypropylene glycol methyl ether
polypropylene glycols
propyl alcohol
propylene glycol
sorbitol
surfonic N-95 (ethoxylated nonyl phenol)
tetradecanol

GROUP 6: CONT'D

tetraethylene glycol
tridecyl alcohol
triethylene glycol
tripropylene glycol
undecanol

GROUP 7: ALDEHYDES

acetaldehyde
acrolein (inhibited)
butyraldehyde
crotonaldehyde
decaldehyde
ethyl hexaldehyde
2-ethyl-3-propylacrolein
formaldehyde solution
furfural
isooctyl aldehyde
methyl butyraldehyde
methyl formal
pentyl aldehyde
propionaldehyde
valeraldehyde

GROUP 8: KETONES

acetone
camphor oil
cyclohexanone
diisobutyl ketone
isophorone
mesityl oxide
methyl ethyl ketone
methyl isobutyl ketone

GROUP 9: SATURATED HYDROCARBONS

butane
cyclohexane
ethane
heptane (n-)
hexane (n-, iso-)
methane
nonane
paraffin wax
pentane (n-, iso-)
petrolatum
petroleum ether
petroleum naphtha
propane

GROUP 10: AROMATIC HYDROCARBONS

benzene
benzene, toluene, xylene (crude)
coal tar oil
cumene
p-cymene
decyl benzene
diethylbenzene
diphenyl-diphenyl oxide
dodecyl benzene
ethyl benzene
naphtha, coal tar

GROUP 10: CONT'D:

naphthalene
tetradecyl benzene
tetrahydronaphthalene
toluene
tridecyl benzene
triethyl benzene
undecyl benzene
xylene (m-, O-, p-)

GROUP 11: OLEFINS

butylene
decene
dicyclopentadiene
diisobutylene
dipentene
dodecene
ethylene
hexene
nonene
1-pentene
polybutene
polypropylene
propylene
propylene tetramer(dodecene)
tetradecene
tridecene
turpentine
undecene

GROUP 12: PETROLEUM OILS

asphalt
gasolines
- casinghead
- automotive
- aviation

jet fuels
- JP-1 (kerosene)
- JP-3
- JP-4
- JP-5

kerosene
mineral spirits
naphtha (non-aromatic)
naphtha
- solvent
- stoddard solvent
- VM&P

oils
- absorption oil
- clarified oil
- coal oil
- diesel oil
- fuel oils
  - No. 1 (kerosene)
  - No. 1-D
  - No. 2
  - No. 2-D
  - No. 4
  - No. 5
  - No. 6
- lubricating oil
- mineral oil
- mineral seal oil

APPENDIX D CONT'D:

GROUP 12: CONT'D:

motor oil
penetrating oil
range oil
residual oil
resinous petroleum
road oil
spindle oil
spray oil
transformer oil
turbine oil

GROUP 13: ESTERS

amyl acetate
amyl tallate
butyl acetate
butyl benzyl phthalate
castor oil
cotton seed oil
croton oil
dibutyl phthalate
diethylene glycol monobutyl ether acetate
diheptyl phthalate
diisodecyl phthalate
dinonyl phthalate
dioctyl phthalate
diundecyl phthalate
ethyl acetate
ethyl diacetate

GROUP 13: CONT'D.

ethylhexyl tallate
ethylene glycol monobutyl ether acetate
ethylene glycol monoethyl ether acetate
fish oil
glycol diacetate
methyl acetate
methyl amyl acetate
neatsfoot oil
octyl epoxytallate
olive oil
peanut oil
propyl acetate
resin oil
soya bean oil
soybean oil
sperm oil
tallow
tanner's oil
triethylene glycol di(2-ethyl butyrate)
vegetable oil
wax, carnauba

GROUP 14: MONOMERS and POLYMERIZABLE ESTERS

acrylic acid (inhibited)
acrylonitrile (inhibited)

GROUP 14: CONT'D.

butadiene (inhibited)
butyl acrylate (n, iso)(inhibited)
ethyl acrylate (inhibited)
2-ethylhexyl acrylate (inhibited)
isobutyl acrylate (inhibited)
isodecyl acrylate (inhibited)
isoprene (inhibited)
methyl acrylate (inhibited)
methyl methacrylate (inhibited)
β-propiolactone
styrene (inhibited)
vinyl acetate (inhibited)
vinyl chloride (inhibited)
vinylidene chloride (inhibited)
vinyl toluene (inhibited)

GROUP 15: PHENOLS

carbolic oil
creosote, coal tar
cresols
nonyl phenol
phenol

GROUP 16: ALKYLENE OXIDE

ethylene oxide
propylene oxide
butylene oxide

GROUP 17: CYANOHYDRINS

acetone cyanohydrin
ethylene cyanohydrin

GROUP 18: NITRILES

acetonitrile
adiponitrile

GROUP 19: AMMONIA

GROUP 20: HALOGENS

bromine
chlorine

GROUP 21: ETHERS

diethyl ether (ethyl ether)
1,4-dioxane
isopropyl ether
tetrahydrofuran

GROUP 22: PHOSPHOROUS, ELEMENTAL

GROUP 23: SULFUR, MOLTEN

GROUP 24: ACID ANHYDRIDE

acetic anhydride
phthalic anhydride
propionic anhydride

Source: Boll, 1983.

APPENDIX E

Hazardous Waste Transporter and TSD Facility Used by UC Berkeley

Transporter:	TSD Facility:
North State Environmental	Casmalia Disposal
CAD009603738	CAD020748125
Pres. Frank Balistieri	N.T.U. Road
3612 Callan Blvd.	Casmalia, Ca. 93429
So. San Francisco, Ca. 94080	(805) 937-7544
(415) 558-2838	

Source: EH&S, 1981-1982. Hazardous Waste Transport Manifests.

APPENDIX F

Costs for Transport and Disposal of Waste

Volume and Type of Waste	Cost
1 55-gal. drum of extremely hazardous waste	$80.00
1 55-gal. drum of hazardous waste	43.00
1 15-gal. drum of hazardous waste	14.00
1 5-gal. drum of hazardous waste	6.50
1 2½-gal. drum of hazardous waste	4.00
California State Health Fee (per ton)	1.00

Source: EH&S, 1981-1982. Hazardous Waste Transport Manifests.