D. Houck

University Regulator Source Control Project

Reducing the Potential for Water Pollution from Businesses in an Urban Watershed

METRO

Clean Water A Sound Investment
Municipality of Metropolitan Seattle

UNIVERSITY REGULATOR SOURCE CONTROL PROJECT

Reducing the Potential for Water Pollution from Businesses in an Urban Watershed

by

Louise R. Kulzer

A degree project submitted in partial fulfillment of the requirements for the degree of

Master of Public Administration

University of Washington

1991

Approved by _____

and _____

Publication 469
March 1991

UNIVERSITY REGULATOR SOURCE CONTROL PROJECT

REDUCING THE POTENTIAL FOR WATER POLLUTION FROM BUSINESSES IN AN URBAN WATERSHED

Prepared by

Louise Kulzer
Industrial Waste Investigator

Municipality of Metropolitan Seattle
821 Second Avenue
Seattle, Washington 98104

PREFACE

This Source Control Project was carried out as part of the University Regulator Combined Sewer Overflow Control Project. Drainage from the north Aurora area, which now enters the sanitary sewer, will be diverted to Lake Union in the future. This diversion will send untreated stormwater runoff into Lake Union. The Source Control Project was undertaken to reduce the likelihood that polluted runoff from the drainage area would enter Lake Union.

This is the first source control project that Metro has carried out in a commercial/residential, rather than industrial, drainage basin. Techniques that were appropriate in previous source control projects were found less suitable in this situation. Other potential approaches were identified, and a mix of strategies relying on technical assistance and public information was pursued. The other approaches considered are presented as part of this paper to assist others faced with similar challenges.

Staffing for the project was three-quarters of one full-time position for a 1-year period.

ACKNOWLEDGMENTS

The author would like to acknowledge helpful review comments and suggestions from a great many people:

Elsie Hulsizer and Ray Carveth from Metro's Industrial Waste Section

Leon Maday, Metro Capital Project Manager

Dave Galvin, Metro Water Resources Section

Mary Lundt, Metro Community Relations Section

Jenny Goldberg and Cindy Thrush, Seattle Drainage & Wastewater Utility.

Particularly valuable insights were provided by

Douglas Houck, Metro Facilities Planning

Fritzie Reisner and Jim McIntire, Graduate School of Public Affairs.

The document was published by Peggy Paulson, Metro Technical Publications Section.

Though the report is not expected to be all things to all people, the review and insights provided by those named has helped make the report more things to more people.

EXECUTIVE SUMMARY

Water pollution in this country has, for the most part, been approached by controlling easily identified point sources of pollution. Yet it is widely recognized that pollution from diffuse or nonpoint sources, is a major remaining water quality problem. Controlling nonpoint pollution with the same end-of-the-pipe treatment approach used for point source control usually is not feasible. Instead, controlling pollutants at the source, before they get into waterways, is the most prudent and effective approach.

Several alternative approaches have been used to control pollution. Major approaches applicable to nonpoint pollution source control include:

- Command and control regulation. This approach involves setting water quality standards, monitoring to ensure the standard is met, and enforcing by fines or other sanctions if it is not.

- Economic incentives. A number of options for pollution control make use of the market system to achieve the ends desired. Taxing undesirable uses, subsidizing desirable ones, extending liability to include pollution damages, and enhancing demand by providing technical assistance or waste management certification programs can all be used to reduce pollution.

- Market development. In cases where pollution control markets are incomplete or only beginning to emerge, assisting market development through mechanisms such as low-interest loans can be useful.

- Public education and awareness. Increasing the level of awareness about the consequences of pollution and appropriate prevention measures can also be effective in reducing pollution.

The University Regulator Project, which was conducted in preparation for sewer separation, is the first Metro source control project carried out in a predominantly commercial/residential drainage basin. Previous source control projects were in industrial areas. The project drainage basin is large (1,700 acres) and dominated by commercial land uses along Aurora Avenue North. Runoff from the drainage basin exhibits lower than average pollutant concentrations for urban runoff, but some metal concentrations exceed EPA Quality Criteria for freshwater.

About 500 businesses are in the drainage basin, most small in size. A survey showed that business operators were well informed about basic waste management issues, employed good waste disposal practices, and had a fairly high level of environmental awareness. However, site visits revealed that housekeeping practices often were in need of improvement. Three problem of inappropriate disposal to storm drains were identified:

- Oily shop floor wash water
- Chronic gasoline spills from fueling stations
- Soap from vehicle wash water

Fecal coliform bacteria and other water chemistry data were used as an indicator of cross-connections—sanitary lines connected to the storm drain system. The relatively low levels of fecal coliform and other pollutants indicated cross-connections were not a major problem. This conclusion was further supported by the fact that in over 80 sites visited, only one cross-connection was found.

The source control project used a mix of implementation approaches that moved away from a typical command and control approach. Technical assistance, involving direct mailing of relevant information and site visits, was the predominant approach used. Some public education elements were also used. All businesses were mailed information about the sewer separation project, and 80 businesses were visited onsite. Businesses were selected for visits based on their potential for handling pollutants that might be discharged or spilled into the storm drainage system.

Awareness-raising activities included writing waste management articles for community and business publications, as well as stenciling storm drains along major streets and parking lots.

Two of the disposal problems identified—oily shop floor wash water and chronic gasoline spills from fueling stations—were addressed during site visits. The third problem identified—soapy vehicle wash water entering storm drains—was partially addressed. Since the sanitary line along Aurora Avenue is currently undersized, redirecting the water to the sewer was not an option. To determine the potential severity of the problem, information on the toxicity of soaps was developed. Complete evaluation of the impacts of soapy water in the receiving waters of Lake Union has not been completed. This evaluation will take place in 1991 as a followup of the 1990 source control efforts.

To evaluate effectiveness of the source control project, two measurement techniques were employed. One measure used a modified benefit/cost approach. The cost of cleaning up a major source of pollution discovered during the project was compared to the cost of conducting the project. If the source had not been discovered, cleanup costs after 3 years of discharge to Bitter Lake are estimated to be $57,000, and could be as much as $103,000 (1990 dollars). Cleanup costs do not include intangible impacts to Bitter Lake or to lake residents and users, nor the benefits from preventing smaller, incremental pollution problems. The source control effort, with nominal followup for 3 years, is estimated at $58,000 (1990 dollars). Thus, the expected benefits gained from the program very nearly equal the cost of conducting the program. When the benefits of incremental pollution control and intangible benefits are considered, benefits exceed the cost.

A before/after survey approach also was used to evaluate changes in level of knowledge and attitudes about waste management. Questions also were asked about perceived risks, both to business liability and to the environment, from common pollution-prone situations. The surveys revealed the following:

- Level of knowledge. In the baseline survey, respondents exhibited a high level of knowledge of waste disposal and management consequences. On the postsurvey, only one question showed an increase in frequency of correct response. When asked whether sewage treatment plants could adequately treat all the wastes produced by business, 72 percent of respondents were aware that this was not the case after the outreach

effort, compared to 60 percent before the effort. However, businesses visited onsite did not show a similar increase, making the significance of this finding questionable.

- Attitudes. The attitudes of business owners about the accessibility of government concerning waste management problems improved after the outreach effort. There was also an increase in the proportion of respondents disagreeing that attention to waste management was paid only when required by regulations.

- Waste management practices. Improvements in waste management practices rose from 46 percent to 64 percent among survey respondents who were visited onsite during the project (90 percent confidence level*). The outreach effort may have had this effect, but other related activities, such as Fire Department inspections or Earth Day publicity, cannot be ruled out as possible causes.

  For those businesses visited onsite, the reasons for making changes were attributed to the following concerns:

  - The environment (80 percent)
  - Economic advantages (37 percent)
  - Liability (37 percent)
  - Enforcement (33 percent)
  - Public image (34 percent)

- Information transfer. The highest-ranked methods for learning about waste management regulations were printed information such as fact sheets, articles in trade or business journals, onsite consultations with specialists, and information hotlines.

* The 90 percent confidence level means that we can be 90 percent sure that the increase was not due simply to chance.

- Risk Perception. Spills of oil or solvents, fuel, and antifreeze were perceived to be the highest-risk situations, both to the environment and to business liability. In general, risk to the environment was more frequently identified as major than was risk to business liability.

SPECIFIC PROGRAM FOLLOWUP RECOMMENDATIONS

Two of the three storm drain disposal problems identified in the watershed—shop floor wash water and spills from fueling stations—were dealt with during the project. However, changes in operating practices need to be reinforced. Therefore it is recommended that:

- The City of Seattle provide signs warning of fuel spillage dangers, free of charge, to all businesses with fuel tanks or pumps.

- Metro and the City jointly publish a newsletter containing information about construction of the new storm drain, and reinforce the need for proper fueling and disposal of floor wash water.

Soap toxicity information that was developed in this project should be used to evaluate the impact on Lake Union of dry weather soap use in the watershed. A recommendation for dealing with the problem should be coordinated with the City of Seattle and the Department of Ecology.

In the interim, it is recommended that low-toxicity soaps, including Believe (Johnsons wax) and Simple Green, be recommended for outdoor car washing. Other low-toxicity soaps available only from distributors are Xotox (Ecology Technology) and ESP (Zep Manufacturing).

GENERAL SOURCE CONTROL CONSIDERATIONS

Site visits to disseminate specific information were a useful element of a technical assistance program. Further use of this technique is recommended.

Outreach to businesses and the general community should be conducted at the same time so that opportunities to reinforce messages can be captured.

Conducting source control projects on a watershed-by-watershed basis is effective in allowing pipes to be checked for illicit connections and for personal visits to a large number of sites. However, opportunities inherent in other pollution control approaches are sometimes lost. Source control projects conducted over a broader area have the flexibility of adopting a wider range of pollution control strategies than do single-watershed approaches.

CONTENTS

		Page
PREFACE		iii
EXECUTIVE SUMMARY		v
LIST OF TABLES		xiii
LIST OF ILLUSTRATIONS		xiv
SECTION		
1	THE SOURCE CONTROL CHALLENGE	1-1
	Strategies for Change	1-2
	Summary	1-12
	Previous Source Control Efforts	1-14
2	PROJECT DESCRIPTION	2-1
	Background	2-1
	Project Objectives	2-2
	Authority	2-2
	Watershed Characteristics	2-4
	Drainage and Stormwater Quality	2-7
	Land Use	2-8
	Business Characteristics	2-9
3	PROJECT IMPLEMENTATION	3-1
	Water Quality Monitoring	3-1
	Survey of Businesses in the Drainage Basin	3-11
	Source Control Program Approach	3-20
	Source Control Program Elements	3-21

CONTENTS (continued)

SECTION		Page
4	RESULTS AND EVALUATION	4-1
	General Waste Management Findings	4-1
	General Problems and Solutions Identified	4-3
	Site-Specific Problems	4-6
	Evaluating Effectiveness	4-11
	Discussion and Recommendations	4-41
	Summary and Conclusions	4-45
APPENDIX		
A	EVALUATION OF POTENTIAL STRATEGIES FOR CONTROLLING NONPOINT SOURCES OF WATER POLLUTION	A-1
B	BUSINESS INFORMATION	B-1
C	WATER QUALITY SAMPLING METHODS AND WASTEWATER DATA	C-1
D	SURVEY INFORMATION AND ANALYSIS	D-1
E	OUTREACH MATERIALS USED	E-1
F	SOAP USE AND TOXICITY INFORMATION	F-1
G	BUSINESS SITES VISITED DURING THE SOURCE CONTROL PROJECT	G-1
REFERENCES		References-1

TABLES

Table		Page
1-1	Elements of Successful Public Education Projects	1-11
1-2	Source Control Strategies Applicable to Pollutants Entering Receiving Waters Through Storm Drainage Systems	1-13
2-1	Businesses Likely to Generate Pollutants or Liquid Wastes	2-10
3-1	Comparison, Average 1990 Storm Metal Data with EPA Quality Criteria for Water: Freshwater	3-4
3-2	Conventional Pollutant and Metal Concentrations During Storm Events; Selected Storm Drains, Bitter Lake/Haller Lake Drainage Basin	3-5
3-3	Toxic Organic Pollutant Concentrations During Storm Events; Selected Storm Drains, Bitter Lake/Haller Lake Drainage Basin	3-7
3-4	Questionnaire Responses Summary, Baseline Case	3-13
3-5	Baseline Survey: Attitudes About Waste Management	3-16
3-6	Baseline Survey: Best Way to Learn About Waste Management	3-17
3-7	Baseline Survey: Why Changes in Waste Management Might Be Made	3-18
3-8	Baseline Survey: Under What Conditions Would You Like Information About Waste Management	3-19
4-1	Soaps Selected for Fish Bioassay Testing	4-5
4-2	Evaluation of Site Visits	4-8
4-3	Businesses in SIC Categories Specified in 40 CFR Part 122	4-10
4-4	Cost of Solvent Spill Cleanup	4-14
4-5	Cost Estimates for Cleanup of 100 Cubic Yards of Metal-Contaminated Sediment	4-17
4-6	Labor and Equipment Costs Used in Cleanup Cost Estimate	4-19
4-7	Survey Comparison, Baseline and Postsurvey	4-22
4-8	Comparison Group Responses, Baseline and Postsurvey	4-27
4-9	Types of Changes Made	4-33
4-10	Perceived Risk From Common Pollution-Prone Situations	4-37

ILLUSTRATIONS

Figure		Page
2-1	North Aurora Drainage Basin Site Map (Bitter Lake/Haller Lake Drainage Basin)	2-5
3-1	Subbasin Stormwater Boundaries	3-2
3-2	Sewerage Subbasin Boundary	3-10
4-1	Vehicle Wash Area With Drain to Sanitary Sewer . .	4-2

SECTION 1
THE SOURCE CONTROL CHALLENGE

The nation's efforts to control water pollution have focused, for the most part, on point sources of pollution. Point sources include discharges from factories, sewage treatment plants, or other large, easily identifiable sources. The most common approach to control point sources is the use of discharge permits specifying pollution limits or specific treatment technology. The discharge is then treated to meet permit requirements before entering natural waters.

Yet, it is widely recognized, both nationally and locally, that point sources comprise only part of the water pollution problem (U.S. EPA, 1987; Puget Sound Water Quality Authority, 1991). Nonpoint sources, or pollution from smaller, less concentrated sources, such as runoff from highways or urban areas, also are significant causes of water quality deterioration. Nonpoint pollution can be characterized as being contributed by multiple sources, the individual pollution contributions of which are typically small. Nonetheless, these small pollution contributions collectively result in significant damage or deterioration of lakes, streams, and marine waters (Rogers and Rosenthal, 1988).

This set of characteristics makes it difficult to apply a traditional economic approach to decision making, since for each individual source, the marginal costs of pollution damages does not justify the marginal cost of control. It is typically only the damages resulting from the collective pollution contributions that justify control. Direct damages from nonpoint pollution, such as fish kills and decertification or closure of shellfish beds, occur even in the Puget Sound area. Those damages also include intangibles, which are difficult to quantify or assign monetary values. Examples are loss of recreational or aesthetic opportunities and reduction in quality of life. Ecological costs, such as loss of habitat quality and decline in species diversity, are also direct costs of nonpoint pollution, which are difficult to quantify.

Nonpoint pollution consists of small contributions from a large number of sources. Therefore, to deal with nonpoint pollution problems successfully, a large number of individuals and/or firms must change the way they behave or do business. Controlling nonpoint pollution with the

same end-of-pipe or point-of-discharge treatment used for point sources is not usually practical or effective. It is acknowledged that control of pollutants at the source, before they can get into waterways, is the most prudent and effective method of dealing with nonpoint pollution (U.S. EPA, 1987; Thomas, 1987).

Different approaches can be used to change the behavior of individuals and firms toward providing better source control. In addition to the use of regulation, usually by discharge permit, viable pollution control strategies include economic incentives, provision of public awareness and education, and developing markets.

This section will explore some of the approaches which are most applicable to source control of water pollutants. The application of these strategies to the University Regulator Project, a source control project aimed at the business sector of an urban watershed, will then be examined.

STRATEGIES FOR CHANGE

Pollutants are as diverse as our technology itself, but they have one thing in common. Pollutants result in costs to the environment or to society as a whole which are not adequately taken into account in the specific decision to pollute (Mishan, 1971). These costs may have monetary value or they may be less tangible costs. Dirty water, for instance, can mean that an alternative drinking water source must be located or bottled water purchased. It can also mean that satisfaction with daily life is reduced, fish and wildlife resources are depleted, and aesthetic or recreational opportunities are denied. It follows that pollution can be reduced if producers and consumers face the total cost of their decisions—not only the direct costs, but also the social and environmental costs of their actions.

Four broad strategies that reduce pollution by making the social costs of use and disposal decisions more explicit will be examined:

- Command and control regulation
- Economic incentives
- Market development
- Public awareness and education

Command and Control Regulation

Conventional regulation involves a three-step process. First, the regulator sets standards, either for the receiving environment, or the discharge itself; or prescribes the technology that must be used to control pollutants. Then, monitoring is used to determine if the regulated sources are complying with the standards set. The final step is enforcement, which becomes necessary if the regulated source is not in compliance with the standard.

An example of the command and control approach is the Uniform Fire Code, Article 80 (1988), which deals with hazardous material storage. The Code is uniform throughout most of the nation, but does have to be adopted locally to be activated. Once adopted, all businesses with hazardous chemicals onsite are required to meet the same specifications for handling and storage. If a particular business had a better alternative for achieving the same result, it could not be implemented. The Code is strictly and uniformly applied and enforced.

This approach has strong points. It is equitable in one sense because everyone is treated equally and held to the same standards. It is relatively simple to administer and enforce because all inspectors follow the same rules. And with adequate enforcement, the desired end product—reducing risks of fire hazard—can be achieved. However, there are also drawbacks.

While it is equitable and effective in one sense, it is unfair and inefficient in another. Adjustments for special circumstances, more efficient or innovative processes, or disparate economic burden are typically not allowed (Dorfman & Dorfman, 1977). For instance in the example of the Uniform Fire Code, businesses located in the city, where land is expensive, would have to locate flammables an equal distance from the property line as would businesses in rural areas where land is less expensive. Because urban businesses could more cheaply offer equal assurance of safety offsite by other methods, such as sturdier storage structures, the Code forces inefficiency in use of the firm's resources.

Administrative costs of the command and control approach are high because of the need for monitoring and enforcement. There are also hidden costs to society as a whole. In the example given, businesses in the

city must spend more money than necessary to meet the objective of the regulation—safe storage of hazardous materials. This forced inefficiency is paid for by society in some way, be it higher service or product prices, or general lack of competitive fitness. Because the administrative costs and inefficiencies of command and control options are real, these costs must be assessed and taken into account in comparing the advantages of this strategy to other options for pollution reduction.

Economic Incentives

Another approach for reducing pollution involves using the market system itself. Termed "economic incentives," this strategy seeks to make the cost of pollution, and benefits of not polluting, directly experienced by firms. By making firms pay for the pollutants they produce, regulators can induce them to adjust their own behavior to select pollution reduction or control options as part of their production decisions, rather than having those options imposed by outside regulation.

Economists typically favor economic incentives as being more efficient of society's overall resources than the command and control approach (Portney, 1990; Hahn, 1989). However, the use of incentives also involves administrative and information costs, which must be assessed when evaluating the application of this approach.

The economic incentives that may be applied to various pollution source control situations include the following:

- Lump sum taxes
- Lump sum subsidies
- Subsidies that affect demand
- Tradeable permits
- Extended liability to include pollutant damages.

Lump Sum Taxes. Increasing the cost of a product discourages use. If the product or behavior causing pollution is taxed, in effect it becomes more expensive, and less of the product or behavior will be used or produced. However, there are different kinds of taxes. To remedy pollution problems, economists dislike per-unit taxes and instead favor what is called a lump sum tax (Rosen, 1988). A lump sum tax seeks to equate the total amount of the tax to the value of the damages incurred. A

problem with trying to implement a lump sum tax is determining the appropriate total amount.* In addition, it is often difficult to determine which of many co-occurring pollutants caused the damage of concern (Fischer & Peterson, 1976). And since many environmental, aesthetic, and health damages from pollutants do not have well-accepted monetary values, the problem is especially difficult. For instance, how much does an oil-tainted fish, or an unappealing lake, cost society?

Once the right amount of overall tax (the lump sum) is estimated, deciding how to distribute the tax so that all polluters face the proper cost is not easy either. In implementing a tax, there are usually two choices: taxing the producer of the polluting good or service, or taxing the consumer. Although the effect of taxes in remedying the amount of pollution is theoretically the same either way (Rosen, 1988), often who pays (producer or consumer) makes a difference for social and political reasons. The size of the geographic area to which the tax is applied also makes a difference because of border or boundary effects.

Another form of tax is a deposit-refund system for waste-producing products (Russell, 1988). The deposit is paid when the product is purchased and refunded only when disposed of properly. Such a system was begun in this state in 1989 for vehicle batteries (personal communication, Steve Barrett, 1990).

Sales taxes have the advantage of taking very little effort to maintain, and there is minimal need for monitoring or enforcement. The tax is paid and behavior is adjusted accordingly. Other taxes require enforcement in the form of audits. A distinct advantage offered by taxes is that revenue is produced, which can be used in the general coffers or targeted for further pollution reduction activities.

Lump Sum Subsidies. An alternative to taxing a polluting product or activity is paying to prevent the pollution from occurring. Whereas taxing discourages use, subsidies encourage use. Examples of subsidies applied to source control include giving tax credits or rebates for installing pollution control equipment, or reducing or waiving license or utility fees in return for specified behavior. As in the case of lump sum

* If the tax is too high or too low, it is no longer socially efficient. If the tax is too low, too much pollution will still occur. If the tax is too high, other social benefits (useful products or services) will be cut back too much.

taxes, the overall amount of the subsidy should equal the value of damages to be averted (Rosen, 1988).

Two possibilities seem applicable to source control efforts. One is establishing a low-interest loan fund or matching grant program for installation of specified pollution control technology, such as oil/water separators, solvent recovery units, or other capital equipment. The state of North Carolina Challenge Grant program to industries for pollution reduction activities also includes hiring technical experts to evaluate process or equipment changes (Department of the Environment, Health and Natural Resources, 1990). In Washington state, Centennial Clean Water funds are used for clean water grant and loan programs, but the use of funds for businesses is expressly prohibited. Providing a similar grant or loan fund for business and industry pollution control initiatives would be an effective way to encourage source control efforts.

A second possibility is waiving payment of utility fees for a period of time upon documentation that specific maintenance activities took place, such as cleaning oil/water separators or catch basins. This type of subsidy would encourage the activity desired, and allow the business owner to share in some of the resultant public benefits such maintenance activity is expected to provide.

A potential problem in using subsidies can be illustrated by the following example. Say that in order to reduce the amount of industrial detergent used, all shops that typically use detergents were given a tax credit in proportion to their reduction in use. A shop might say they used detergent daily, but agree to cut back to monthly use and apply for a large tax credit. In truth, they may have used detergent only weekly. In general, the subsidy approach can be prone to abuses, and hence requires careful design. Another problem is finding the funds to provide the subsidy, or making up for lost revenue from tax or fee credits.

Subsidies That Affect Demand. In addition to subsidies that directly reduce pollution, other possibilities exist. Two possibilities are rewarding firms that manage waste properly through advertising or certification that can be used in marketing (the Good Housekeeping Seal approach), and providing free or low-cost technical assistance to firms in areas of pollution control and reduction.

Certification Programs. Certification programs, in which the pollution management and prevention efforts of businesses are actively advertised, offer potential for reducing pollution problems. In return for completing specified training and implementing specific waste management requirements, firms would receive a certificate or other public acknowledgment demonstrating this fact. The public entity granting the certificates would actively promote the program and encourage patronage of participating businesses. One advantage is that if successful, there would be demand for the program. Businesses would pursue certification rather than avoid involvement—avoidance being a common response to regulatory approaches. A certification program would also mean that agency resources would be spent on actions that have a high probability of success, rather than in searching out problems and dealing with them on a case-by-case basis.

Monitoring to ensure continued compliance with expectations would, however, be needed. The public could also act as an important force to ensure compliance, since they would, in effect, be purchasing responsible waste management along with the primary product or service, and would be interested in getting their money's worth.

The City of Bellevue is currently beginning a "Business Partners for Clean Water" program using this marketing strategy. Although the program is just beginning, initial response by business leaders has been positive (personal communication, Nancy Hanson, 1990). The cooperative atmosphere encouraged by such a program is desirable in terms of encouraging efficiency and innovation, rather than the inefficiencies and inflexibility that can be characteristic of regulatory approaches.

A certification program approach would be most effective if implemented on a regional basis, since publicity for the program would be most effective on that scale. Also, people frequently patronize firms over a broad geographic area, so the targeted customer base is already regional. Once begun, the program could be expanded to include many facets of waste management, not just clean water. This integration is desirable not only for businesses, but for agencies. By working together, agencies could realize efficiencies by reducing overlapping efforts. Currently, a team consultation approach to working with small businesses is being tried under a grant from the Puget Sound Water Quality Authority to the Small Business Association. In a joint effort,

several agencies are performing no-fault inspections for a limited number of small businesses requesting such services. This program points the way for future initiatives, and could also be applied in the context of a certification program.

Technical Assistance. Technical assistance and education to businesses on a low or no-cost basis has two effects: it reduces the businesses' costs to obtain this service, and it ensures that proper waste management is more likely to take place. The option is particularly useful when businesses are willing to do the right thing but don't know how, and are unable to bear the cost of acquiring sufficient expertise. This is often the situation small businesses are in. Workshops, waste fairs, waste exchanges, audits, and onsite consultations are some of the possible avenues for providing such assistance.

In implementing a technical assistance program to reduce pollution problems, the monetary cost of the benefits to industry should be matched to the pollution damages averted. This "ideal" or equilibrium amount is not easy to identify, and better means to estimate benefits from averted pollution damages are needed.

Tradeable Permits. A tradeable permit system is very similar to a traditional permit system, except that trades or exchanges are allowed of unused pollutant discharge allowance. For instance, say Batteries Plus, a firm discharging a contaminated waste stream to the sanitary sewer, has a permit that allows for the discharge of 0.6 parts per million (ppm) cadmium in their waste discharge. Their process can easily reduce cadmium to 2 ppm, but they'll have to install $50,000 worth of equipment to meet the lower standard of 0.6 ppm. Another firm, BB Batteries, is able to discharge at 0.1 ppm by installing $40,000 worth of equipment. Under a tradeable permit system, BB Batteries could offer its excess discharge allowance to Batteries Plus for a fee. Theoretically, Batteries Plus would be willing to purchase the excess permit allowance if the cost were some amount less than $50,000, minus the cost to administer the trade. This would be good for both firms, and still meet the permit authority's overall limit. Since the pollution reduction would be done in the most economically efficient way, no hidden social cost from inefficiency would result.

Monitoring and enforcement are important to prevent abuse and ensure compliance, just as in the traditional command and control approach. Another problem is ensuring that the overall limit is set low enough so that even if all companies discharge to their respective limits, the environment is adequately protected. For discharges to the sanitary sewer system, where further treatment ensues, this is far easier than for discharges to natural waters. Permits for discharge to natural waters are typically at small, discrete outfalls. Higher pollutant concentrations in one location can cause damage that is not compensated by lower concentrations in another. Application of a tradeable permit system may be appropriate, therefore, to some programs, such as industrial pretreatment permits, but inappropriate for others, such as stormwater discharges. However, some discharge limits in pretreatment programs are adopted to ensure worker safety. In this case, trading among those particular pollutants would not be appropriate.

Recently, this approach has been considered by the Puget Sound Water Quality Authority (PSWQA) for application regionally. However, conflicts with the wording of the State Water Pollution Control Regulation 90.48 RCW, and enforcement and administrative concerns have influenced a decision by PSWQA not to pursue this approach (personal communication, Valana Piccolo, 1991).

Extended Liability to Include Pollutant Damages. This is the last of the strategies referred to as economic incentives. This approach is essentially that used in federal hazardous waste legislation (the Resource Conservation & Recovery Act [RCRA]). It establishes cradle-to-grave responsibility for hazardous wastes generated by a business or industry. Out of sight is not out of mind. If problems develop, even after disposal, the original generator of the waste is still responsible for remedies, along with all other handlers of the waste (Grigalunas & Opaluch, 1988). This approach has provided strong incentives to "do it right," but does have limitations. It can only be applied to wastes that are identified through market transactions. And reporting and record keeping is complex and time-consuming both for business and for the regulator.

It is difficult to suggest a legally binding way to extend liability for small incremental pollutant damages. However, in a way, strict enforcement of water quality regulations provides this effect. The threat of fines provides a sense of liability in cases where charges for damages are difficult

to determine and unlikely to be levied. Thus, tougher more active enforcement for inappropriate waste disposal could also serve this function.

Market Development

One of the problems faced in the area of waste reduction and management is the lack of fully functioning markets. Often there is demand, but no supplier. For instance, in the north Aurora area, many business operators have expressed interest in recycling cardboard. However, there is currently no dependable pickup service to recycle this material. It is also possible that suppliers exist but demand lags behind. Subsidies in the form of low-interest loans, underwriting or sharing insurance costs, or other means, would encourage establishing sound, long-term waste reduction and management markets.

Another example is the Industrial Materials Exchange (IMEX), a clearinghouse for making exchanges of potentially hazardous materials or solid waste that are no longer wanted but could be used by others. IMEX is currently operated by the Seattle/King County Health Department, and listings are taken free of charge. Although theoretically the exchanges could take place without this intermediary, in reality they would not. The cost of finding an appropriate recipient would be prohibitively high.

Public Awareness and Education

Awareness and education programs to increase recognition of the social costs of inappropriate waste management is addressed in this last category of source control strategies. Public awareness and education is perhaps the most well-known approach for addressing sources of nonpoint pollution. Techniques that can be used include: meetings, workshops, public service announcements on radio and TV, billboards, posters, brochures, and other written materials. Community action projects can also be promoted. Good examples of this latter technique include the recently established Public Involvement and Education program of the Puget Sound Water Quality Authority and local community action grant programs.

In the past, public education efforts have been rather diffuse in their general message, and little evaluation has been done to assess their effectiveness. However, recently the EPA has reviewed several public outreach efforts having clean water or source control objectives (Ryan, 1989). Several key elements of successful programs were identified and are summarized in Table 1-1.

TABLE 1-1. Elements of Successful Public Education Projects (After Ryan, 1989)

Make the problem as specific as possible.
Provide complete information about the problem and how it correct it.
Provide adequate technical assistance.
Make personal contact.
Provide financial incentives.
Encourage peer education and involvement.
Provide adequate funding for outreach effort and use educational specialists.
Encourage interagency coordination to pool resources and effort.
Involve the community early in the development of solutions; grant local and individual autonomy.
Consider threat of future regulation.
Use participatory events. They are often more effective than traditional public meetings.
Utilize newsletters as an effective communication tool.

Major elements applicable to businesses include the following:

- Framing the problem in a specific, local context rather than as a general environmental concern.
- Ensuring that adequate technical assistance is provided or available to solve the problem.
- Providing financial and other incentives to make changes. Tax reduction, cost sharing, agency assistance, in addition to public recognition and other non-financial incentives, seem to be effective.
- Promoting personal contacts between agency staff and the public, and providing for participatory events, which are more effective than passive information sources.

In summary, Ryan concludes that public involvement is most effective if people are aware of the specific negative impact of their actions, and have the information, know-how, and resources to solve the problem. It also helps if people believe the problem is important, if not to them personally, at least to the environment. Incentives, and even the threat of future regulation, can be important in designing solutions that fit the individual's situation.

Technology transfer and information dissemination are often considered forms of public education. But to the extent that information transfer reduces the variable cost to a business of complying with environmental regulation or other requirements, it can more properly be considered an economic incentive strategy.

SUMMARY

Most of the source control strategies examined have general applicability to nonpoint control of pollution. Some, such as tradeable permits, were found difficult to apply specifically to pollutants which enter receiving waters through storm drains.

In all, eight specific alternatives appear to be most promising for control of pollutants to storm drains, as summarized in Table 1-2. These include five alternatives in the category of economic incentives: taxes, subsidies certification programs, technical assistance programs, and extending liability to include pollution damages.

Additional alternatives that offer promise are command and control regulation, development of waste management markets, and provision of public awareness and education.

Although each of these eight alternatives offers potential, they have particular strengths and weaknesses in achieving pollution control goals. They also differ in ease of implementation, ability to achieve long-range pollution goals, and in social and political acceptance. In addition, the geographic scale at which each is most easily applied varies.

TABLE 1-2. Source Control Alternatives Applicable to Pollutants Entering Receiving Waters through Storm Drainage Systems

Economic Incentives

1. Taxes on Pollution
2. Subsidies on Nonpolluting Behavior
3. Certification Programs
4. Technical Assistance Programs
5. Extending Liability to Include Pollution Damages

Other Strategies

6. Command and Control Regulation
7. Market Development
8. Public Awareness and Education

Summary

Sometimes one technique is clearly more effective to achieve a particular objective. In many cases of application, however, a combination of techniques is desirable to achieve a given level of pollution reduction, especially if the sources are diverse. This combination approach was used in the University Regulator Source Control Project, and its implementation is discussed in Section 3.

A systematic evaluation of the eight alternatives identified is given in Appendix A. This evaluation is provided using specific source control objectives identified in the University Regulator Project. Information presented in the rest of this report about the University Regulator Source Control Project will give the reader insights into the objectives and constraints that influenced the evaluation.

PREVIOUS SOURCE CONTROL EFFORTS

Several local source control programs have been pursued in recent years, both by Metro and by other local and regional agencies. The remainder of this section discusses three of the efforts, which represent a range of situations and approaches.

The Duwamish Action Program

One of the earliest regional source control efforts was the Duwamish Action Program, begun in 1982. The area targeted, the lower Duwamish River, was a highly polluted, tidally influenced river in the South Seattle industrial area. A study of both surface and groundwater contamination of the river had been done, and this program sought to correct problems identified. Low gradients in the drainage system meant that sediment accumulation in pipes and ditches was fairly common, and tracing of sources by sampling sediment was developed as an effective technique to locate pollution sources (Hubbard & Sample, 1988).

Many large industries in the area were point sources, and had direct industrial discharges into the river. Several were engaged in manufacturing, and thus had process discharges. Metro's approach was to inform industries of their obligations under the state and federal laws, and make recommendations for correcting problems. In cases where problems

existed and industries were not cooperative, referral was made to the Washington State Department of Ecology and the EPA. Several enforcements were done by these agencies. In addition to enlisting assistance from regulatory agencies, the press was an active ally in the program. Articles were frequently featured about the cleanup effort. A citizens' group, "Friends of the Duwamish" was also organized. This approach combined command and control elements with technical advise and assistance, as well as public awareness.

The Duwamish Action Program was successful in catalyzing agency cooperation and focusing attention on this highly polluted section of river. A recent evaluation by Paulson and colleagues (1989) found that dramatic decreases in lead fluxes in Elliott Bay could be demonstrated due to the cleanup of a major industrial point source of lead (from 0.4 ppm lead to 0.003 ppm). The dramatic reduction in pollution was due in part to the high initial pollutant concentrations, and the fact that the polluting company was no longer operating, making complete cleanup possible.

However, results from less concentrated pollution sources, including other industries, were not easily documented. The Duwamish Action Program has subsequently evolved into an interagency effort, the Elliott Bay Action Team, to continue work on less obvious sources of pollution.

The Lander Source Control Project

In 1988, a source control effort was conducted by Metro as part of a sewer separation project in a small industrial basin of South Seattle, also draining to the Duwamish River. Called the Lander Separation Project after the name of the street at which the outfall is located, the area is characterized by industries engaged in manufacturing, heavy equipment repair and servicing, automobile-related uses, as well as commercial activities. There was no residential land use in the basin.

Local storm drainage was combined with sanitary sewage flows for most of the local lines. Therefore, sampling in sewers provided information on both inputs to the sanitary sewer as well as inputs to the storm drain system. Since Metro has authority to regulate discharges into the sanitary sewers, this fact was used to control discharges into both

systems. A quasi-regulatory approach was used. Source tracing and site visits were important strategies used to identify problems. Once problems were identified, companies were informed of requirements to bring their discharges into compliance with limits set for sanitary sewers and for storm drains. If changes were not made voluntarily, industries were put on an informal compliance schedule, stating improvements needed and target dates for completion. At the end of 1 year, about half of the affected businesses had made the identified changes, some of which were costly (True, 1989).

A second-year followup has shown that improvements are being implemented, but more slowly than desired. About half of the 50 companies needing followup work still had not completed required modifications. An outgrowth of this project has been the development of an overall strategy to regulate highly contaminated wastes from radiator shops.

Kirkland Hazard-Free Community

A public awareness and education approach to source control is being pursued in Kirkland by the MetroCenter YMCA. Unlike the Duwamish and Lander areas, Kirkland is not an industrialized area nor is it highly polluted. The project seeks to work with homeowners and businesses in the community to increase their awareness of hazardous products and minimize use. Public education efforts include door-to-door solicitations for a "Hazard-Free Pledge," school programs, public workshops, and household hazardous waste collection days. The project uses volunteers who are trained to conduct most of the door-to-door outreach efforts. A separate pledge for businesses was developed, along with a media tour to call attention to businesses making waste reduction and management improvements (personal communication, Richard Conlin, 1990).

The project is unique in targeting an "average" community, and in integrating its approach to include both businesses and the community in the same effort. The project will be completed in March 1991.

SECTION 2
PROJECT DESCRIPTION

BACKGROUND

This Source Control Project is an integral part of a larger pollution control effort: the University Regulator Combined Sewer Overflow (CSO) Control Project. CSOs occur in the Seattle area sewerage collection system because in the past, storm drainage has been routed to sanitary sewers rather than today's standard practice of routing to natural waters. The University Regulator Station, located near the University of Washington Medical Center, governs the flow of sewage to the West Point Treatment Plant. When more flow occurs than the system can safely handle, excess water is spilled into the Lake Washington Ship Canal. Since the water spilled contains sanitary sewage as well as rainwater, the existence of CSOs constitutes an important water quality problem. Metro is working to reduce CSOs throughout its service area.

The University Regulator Station receives much of its stormwater from the Green Lake Trunk, a large sanitary sewer which contains three major sources of stormwater:

- The outflow from Green Lake
- Storm runoff from a portion of Interstate 5 (I-5)
- Storm runoff and groundwater from the Densmore drain—a large storm drain collecting water from the North Seattle area along Aurora Avenue North.

In order to reduce the CSO problem at the University Regulator Station, Metro is diverting the stormwater runoff, which now enters the Green Lake Trunk, into a new storm drain. This new drain will take the outflow from Green Lake and stormwater from I-5 and the north Aurora area to a discharge point in Lake Union. By removing this stormwater, there will be more capacity in the Green Lake Trunk for sewage, greatly reducing the frequency and volume of CSOs into the Ship Canal.

However, there is concern that this project not simply transfer pollution from the Aurora area to Lake Union. This Source Control Project was thus designed to reduce the likelihood that potential pollution from the north Aurora drainage basin would adversely affect Lake Union.

PROJECT OBJECTIVES

In order to meet the overall goal of ensuring that the University Regulator Sewer Separation Project would not result in increased pollution problems in Lake Union, the Source Control Project identified the following general objectives:

- Identify and correct illicit connections to the storm drainage system (that is, connections that should be plumbed to the sanitary sewer rather than storm drains).
- Identify business activity that might contribute pollutants to the storm drains and work with those businesses to control the release of those pollutants.
- Reduce the likelihood of accidental spills of chemicals or petroleum products into the storm drains.
- Increase the awareness of business operators in the watershed about the connection between their activities and the introduction of pollutants into the storm drains.

In addition to formulating these objectives, the project also incorporated an evaluation scheme to determine whether they were achieved. Evaluation strategies will be discussed in Section 3.

AUTHORITY

Metro operates an Industrial Waste Pretreatment Program that regulates major industrial discharges to the sanitary sewer. The authority to issue industrial waste discharge permits was delegated to Metro in 1976 by the Washington State Department of Ecology. The authority to operate a full pretreatment program under the Federal Clean Water Act was

delegated to Metro by the EPA in 1981. Resolution 3374 of the Council of the Municipality of Metropolitan Seattle (Metro) formally specifies restrictions of pollutants to the sewerage system tributary to the region's wastewater treatment plants.

Significant industrial dischargers to the sanitary sewer are regulated by a permit system detailing pollutant concentrations that their discharges must meet. Monitoring and reporting requirements are also specified. Smaller industrial dischargers are regulated by discharge authorizations, again detailing specific conditions the discharge must meet but with less rigorous reporting provisions. Businesses without regular process discharges are, in general, not formally regulated. Strictly speaking, all nonresidential users of the sewerage system must meet the limits set by Resolution 3374, but in reality few smaller businesses are aware of those limits.

In the case of combined sewers receiving both sewage and stormwater, Metro responds to specific problems or complaints even if they pertain to the stormwater inputs. However, stormwater quality is not within Metro's regulatory jurisdiction. The Department of Ecology retains authority for discharges to the State waters, including stormwater discharges. Water quality standards have been promulgated for all waters of the State, which the Department has defined to include natural and manmade storm drainage systems.

Local jurisdictions may pass ordinances pertaining to the discharge of pollutants into either sewerage lines or storm drains within their jurisdiction. The City of Bellevue has such an ordinance which prohibits the discharge of pollutants, including soap, into the storm drainage system. Fines for violations are specified (personal communication, Dave Renstrom, 1990). The City of Seattle, which owns the drainage system in the north Aurora area, has a more general ordinance, and has encountered limitations in its application to storm drains (personal communication, Cindy Thrush, 1990).

In implementing a program to reduce pollutants in the north Aurora area storm drainage system, Metro is working cooperatively with the City of Seattle, which owns the lines, and the Washington State Department of Ecology, which has formal regulatory authority for discharges to natural waters.

WATERSHED CHARACTERISTICS

The north Aurora drainage basin, also referred to as the Bitter Lake/Haller Lake Drainage Basin, is about 1,700 acres (2.7 square miles) in size. The drainage basin is bounded by North 145th Street on the north, by Green Lake to the south, and extends roughly between Greenwood Avenue North and Densmore Avenue North on the east and west, respectively (Figure 2-1). Currently, rain runoff and natural drainage from this area flows to the south, toward Green Lake's northern tip.

There are two lakes—Bitter Lake and Haller Lake—in the watershed. Both are surrounded by residential development and have relatively small catchment areas (Kramer, Chin & Mayo, 1990). Licton Springs, an area of pronounced groundwater seepage, is also an important feature of the basin. Baseflow from Licton Springs currently enters the piped storm drainage system.

Green Lake, which before development was the receiving water body for flow from the drainage basin, no longer has a natural outlet. Discharge from Green Lake currently enters the Green Lake Trunk, as described above. Historically, overflow from Green Lake entered Ravenna Creek and drained to Union Bay in Lake Washington.

The topography of the basin is gently rolling, with an elevation gradient of about 350 feet from the south to the north (Kramer, Chin & Mayo, 1990). There are no ravines or streams in the basin. The original creeks draining Bitter and Haller Lakes have been integrated into a system of ditches and culverts which drain the northern part of the basin. In the southern part of the basin, all drainage is via pipes. Runoff from both the ditch and culvert system in the northern watershed, and from the piped system in the southern watershed, eventually enter the Densmore drain at North 85th Street. From North 85th Street, water from the drainage area is transported south toward Green Lake, where it enters the Green Lake Trunk. Thus, stormwater is not combined with sewage at any point in the collection system until entering the Green Lake Trunk. Drainage from the small area between North 85th Street and Green Lake enters a local combined sewer system which reaches the Green Lake Trunk at various other connection points.

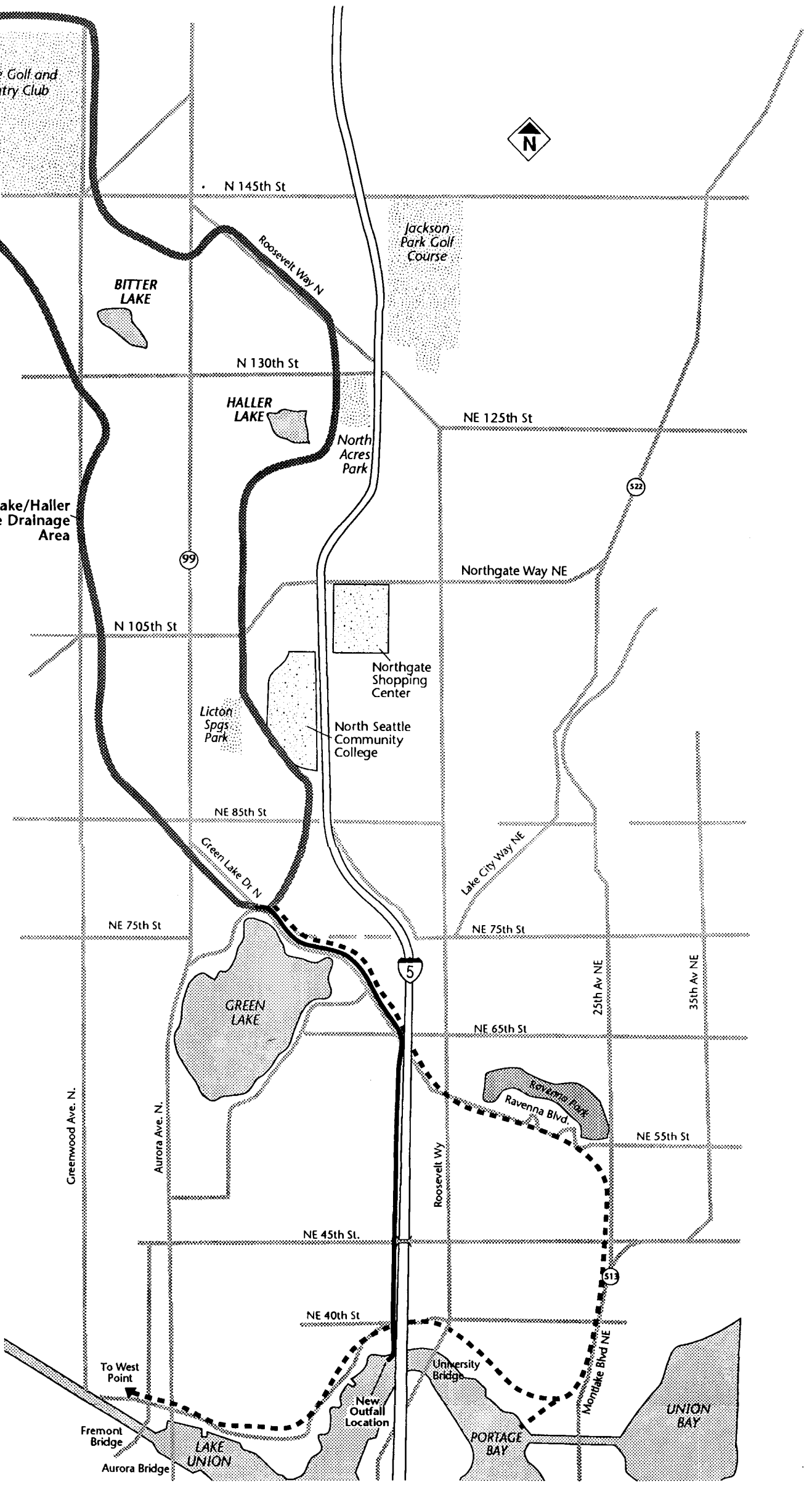


Figure 2-1. North Aurora Drainage Basin Site Map
(Bitter Lake/Haller Lake Drainage Basin)

DRAINAGE AND STORMWATER QUALITY

During the preliminary design phase of the University Regulator CSO Control Project, samples of water representing the entire drainage area were taken from the Densmore drain near the discharge point. The sampling was done as a cooperative study between Metro and the City of Seattle to characterize pollutants in urban stormwater. Two samples of baseflow, taken in October 1986, and three storms, October through December 1986, were examined. Both baseflow and storms were sampled at the same point, near the discharge point of the Densmore drain. The site was downstream from a small, privately owned duck pond. Conventional pollutants, nutrients, metals, and organic toxicants were determined and compared to typical urban runoff values in previous Seattle area studies (James M. Montgomery, 1987; Brown and Caldwell, 1989).

Nutrients were similar in the baseflow and for storm events. Ortho phosphorus, a key nutrient in lake eutrophication, was 0.1 to 0.2 ppm, somewhat lower than reported for other storm drains in the region (Pitt & Bissonnette, 1984; Tomlinson et al., 1978). Fecal coliform levels were between 2,000 and 5,000 MPN/100 ml, in the low range for urban stormwater (Shapiro & Associates, 1989; U.S. EPA, 1983). Oil and grease levels were about 10 ppm both in the baseflow and the storm samples—a moderate level.

Metal concentrations were higher in storms than in baseflow, particularly for lead and zinc. Both lead and zinc are common pollutants associated with automobile use. The metal concentrations from the Densmore drain storm events were similar to those from drainage off the I-5 corridor collected during the same two storms. Most metal concentrations, particularly lead, were below concentrations seen in Metro's historical database (1974 to 1981) (Brown & Caldwell, 1989). However, values were above EPA Quality Criteria for Water for chronic and in some cases for acute exposures.

Three pesticides were found in trace quantities in the baseflow, and in one of the storm events. Few polynuclear aromatic hydrocarbons (PAHs), which are associated with fuel combustion sources, or phthalate esters, common plasticizers, were found in the baseflow. Both were, however, found in storm runoff at low concentrations.

PAE

These low levels of pollutants, especially nutrients and fecal coliform bacteria, indicate that cross-connections (sanitary lines

connected to the storm drain system) are not a major problem in the watershed. The moderate oil and grease values indicate that petroleum sources should be considered in conducting the source control project.

Data has also been collected in a small subbasin representing commercial land uses. The sample point was at North 92nd Street and Stone Avenue North. Five storms from June to November 1989 were sampled.

In general, metal levels were higher in storms from the commercial subbasin than seen in the Densmore drain. This is particularly true for zinc, and to a lesser extent for lead and copper. Little difference was seen in the total PAH concentrations in the two areas. Insufficient data was collected on phthalate esters to make a comparison. Nutrient data was not determined for the commercial subbasin. Data is included, along with recent data, in Section 3.

LAND USE

The Bitter Lake/Haller Lake Drainage Basin is dominated by a major arterial, Aurora Avenue North. This arterial used to be the major north-south traffic route through the city before I-5 was built, and is still heavily traveled. Traffic lights are located at many intersections. Stop-and-go traffic and heavy congestion are typical.

Businesses are located on either side of Aurora Avenue North, and along major east-west streets. Several small shopping centers as well as larger shopping plazas are located along Aurora Avenue. Oak Tree Plaza and the K-Mart complex are among the largest. Commercial development is characterized by a higher proportion of impermeable surface and less landscaping than is typical of many newer commercial developments.

Several parks and park-like land uses occupy the basin, including Bitter Lake Play Field, Licton Springs Park, three school play fields, Evergreen Washelli Cemetery, and the Seattle Golf Club.

Residential land uses are located east and west of Aurora Avenue. Both single- and multi-family residences are common. Single-family residences are predominantly on small lots. Residential areas north of North 100th Street are drained by ditches. Areas south of North 100th Street are

more likely to have a curb and gutter drainage system, though some of these areas are still drained by ditches. In the northern Greenwood/Bitter Lake area, condominium development has mushroomed in the past several years, and a large retirement home complex is located near Bitter Lake. Several condominiums have also been built near Aurora Avenue in the southern watershed.

BUSINESS CHARACTERISTICS

Over 500 businesses are present in the drainage basin. Most are small, both in size and in number of persons employed. The majority of businesses employ six or fewer people, but there are also several large firms (those employing over 50 people). The average number of employees is 13, based on responses to a mail-back survey. Appendix B lists businesses in the watershed, along with their Standard Industrial Code (SIC) classification. The SICs are used by the Department of Commerce to classify various industrial activity into broad functional categories. Based on these classifications, the most prevalent business types in the watershed are as follows:

- Retail sales stores
- Motels
- Automobile repair shops
- Automobile sales shops (new & used)
- Restaurants

Several large vehicle operating bases are located in the area. Seattle City Light and Washington Natural Gas have operating bases; and the City of Seattle has a large vehicle maintenance and equipment yard. Several private companies also have operating yards, including freight lines and mechanical and electrical contractors. Some wholesale warehouses, several auto wrecking yards, and two towing yards are present. Few manufacturers, however, are present. Exceptions include two metal fabrication shops, an electrical assembly plant, and a furniture manufacturer.

Over half the businesses in the drainage basin were judged to have a low potential for generating pollutants or liquid wastes. The other half were considered to have a moderate to moderately high potential for generating pollutants. Table 2-1 lists business categories in the moderately high category.

TABLE 2-1. Businesses Likely to Generate Pollutants or Liquid Wastes

	Number
Discharges probably only to sewer	
Medical offices	5
Dentists	6
Nursing facilities	7
Medical labs	5
Veterinary hospitals	2
Photographic developing services	2
Printing companies	5
Dry cleaners	8
Beauty shops	15
Antique shops	1
	56
Discharges may reach storm drains	
Cement suppliers	1
Rent-a-tool shops	5
Metal products production	5
Auto dealers/repair shops	25
Auto repair only	20
Auto body shops	5
Auto parts and wrecking yards	4
Auto towing yards	2
Motorcycle and boat shops	3
Vehicle maintenance yards	3
Taxi/limousine services	1
Service stations	6
Miscellaneous auto services	4
Paint shops	3
Pesticide services, suppliers	2
Golf course (grounds and vehicle maintenance)	1
Sign companies	1
Tank cleaners	1
Roofing companies	4
Masonry companies	3
Plumbing, heating, and air conditioning companies	8
Construction companies	11
	118

SECTION 3
PROJECT IMPLEMENTATION

The intensive portion of the University Regulator Source Control Project was budgeted to take no more than 1,560 hours, about three quarters of a full-time workload for one person. The project was to be completed during 1990, with minimal followup in subsequent years.

In order to design a source control project within the budget and time constraints identified and that met specific needs of the north Aurora watershed, additional information was sought. A water quality monitoring effort, focused on the small commercial subbasin previously sampled, was undertaken to recheck the validity of the 1988 storm data which showed no major pollution problems. Storm monitoring was also carried out to establish a "before" condition so that potential changes in pollutant load could be determined. Baseline monitoring of wastewater from the sanitary sewers was also conducted in the same commercial subbasin to determine pollutant loads for a typical commercial area.

In addition to monitoring, a before/after survey of businesses was designed to measure waste management knowledge, practices, and attitudes prevalent in the drainage basin. These additional data gathering tasks are described in the following subsections.

WATER QUALITY MONITORING

To establish a baseline to evaluate possible changes in water quality resulting from the project, stormwater samples were taken before active outreach efforts were begun. Samples were collected at North 92nd Street and Stone Avenue North, the commercial area sampled earlier (see Section 2, Project Description).

The subbasin is largely commercial, although some residential use is located along Fremont and Linden Avenues in the eastern portion of the area. Figure 3-1 shows the subbasin boundaries. Businesses located in the drainage area are listed in Appendix B. A number of auto repair shops, as well as other moderate risk businesses, are present in the area. No construction was observed during the time of sampling.

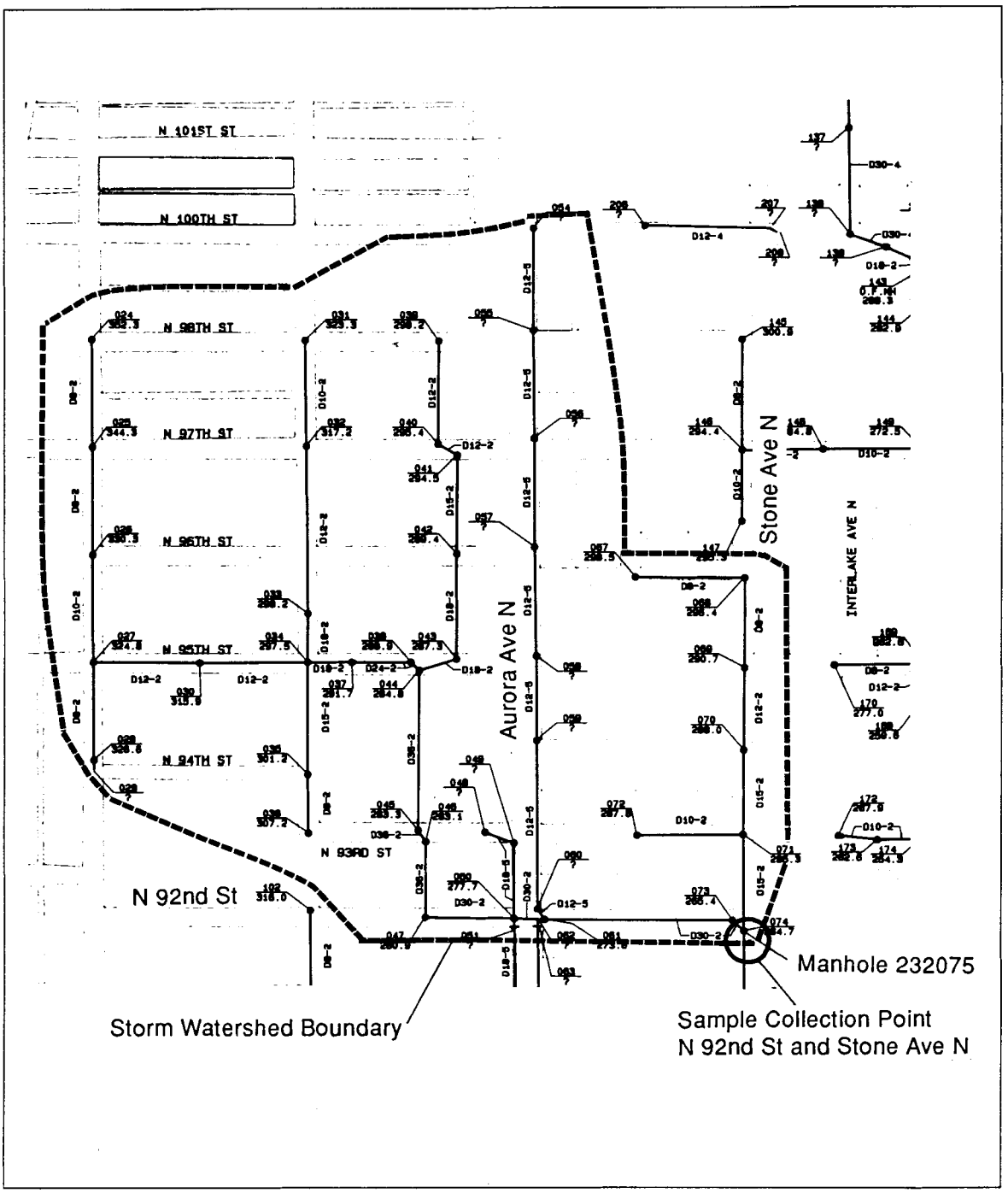


Figure 3-1. Subbasin Stormwater Boundaries

The smaller subbasin area was chosen to reduce dilution volumes inherent in whole watershed flows. By focusing on the smaller commercial subbasin, which had numerous auto-related uses, a "worse-case" indication of pollutant levels would be seen.

Stormwater Samples

Five storms were sampled in May and June of 1990. Two of the storms (May 14 and 29) were squalls lasting only 2 hours. The remainder were 8-hour events. Storm samples were manually composited based on flow monitoring conducted during the storm period. Sampling methods are described in Appendix C.

Conventional parameters analyzed include total suspended solids (TSS) and presence of oil sheen. Only one of five storms sampled had an oil sheen. TSS levels were low, probably due to the low intensity of the storms rather than a reflection of watershed characteristics.

Metals analyzed included Arsenic (As), Cadmium (Cd), Copper (Cu), Chromium (Cr), Lead (Pb), Nickel (Ni), Silver (Ag), and Zinc (Zn). All metals levels showed similar or lower than those found in 1988. The most pronounced reductions were in zinc and lead. Since these metals tend to be associated with particulate matter (Randall et al., 1982), this finding is in keeping with the lower particulate levels seen in these storm samples.

Mean metal concentrations were compared to EPA Quality Criteria for Water (1986) for the protection of freshwater aquatic life, calculated using a hardness of 40 mg/l. Even though these levels are lower than in 1988, and are lower than historical stormwater concentrations, four of the metals—Cd, Cu, Pb and Zn—exceeded EPA chronic criteria for freshwater*. Copper and lead also exceeded the acute criteria. Table 3-1 shows average concentrations in relation to the EPA criteria for freshwater. Local stormwater monitoring done during the Nationwide

* There is some question whether the chronic freshwater criteria apply to storm discharges, since the chronic criteria are for a 96-hour exposure. Storm discharges are typically for much shorter time periods. This issue was raised during the Nationwide Urban Runoff Program (U.S. EPA, 1983), and will likely become important again with the advent of NPDES stormwater permits.

TABLE 3-1. Comparison, Average and Maximum 1990 Storm Metal Data with U.S. EPA Quality Criteria for Water: Freshwater*

Metal	Frequency of Detection	Average** (1990)	Maximum (1990)	Chronic Criteria[1]	Acute Criteria[2]
Cd	5/5	.001	.0011	.0005	.0014
Cu	5/5	.026	.042	.0054	.0075
Cr	5/5	.005	.006	.011	.016
Pb	5/5	.039	.06	.00099	.025
Ni	1/5	.01	.01	.048	.919
Ag	ND	< .003	ND	.012	.084
Zn	5/5	.146	.27	.047	.150

- Criteria were calculated using a hardness of 40 mg/l. This value may be too conservative since recent monitoring data in other parts of the City show higher average hardness levels (personal communication, Jennie Goldberg, December 1990).

** Average of detected values.

1 Chronic criteria should not be exceeded during a 4-day average.

2 Acute freshwater criteria should never be exceeded.

ND = Not Detected

Urban Runoff Program showed that stormwater commonly exceeded water quality criteria for metals (Galvin & Moore, 1982). Table 3-2 summarizes metals and conventionals data for all storm events, as well as previous data from the watershed.

Organics data was determined for four of the five 1990 storm events. In three samples, no PAHs were detected. In the fourth, concentrations for both high and low molecular weight PAHs were lower than in the 1988 samples. Benzoic acid, a common chemical used as a plasticizer and food preservative, was also detected at low concentrations. Low levels of phthalate esters were detected in only one of the 1990 samples. Data on toxic organics is given in Table 3-3, both for current and previous sampling efforts.

TABLE 3-2. Conventional Pollutant and Metal Concentrations During Storm Events; Selected Storm Drains, Bitter Lake/ Haller Lake Drainage Basin

Constituent		Densmore Drain, Storm Samples			N 92nd & Stone Ave N, 1988 Storm Samples					N 92nd & Stone Ave N, 1990 Storm Samples						EPA Freshwater Criteria*		
		10/26/86	11/20/86	12/9/87	6/9/88	9/24/88	10/30/88	11/2/88		5/14/90	5/29/90	5/31/90	6/7/90	6/10/90				
Ortho Phosphorus (OrthoP)	(mg/l)	.078	.166															
Total Phosphorus (TP)	(mg/l)	.268	.206															
Ammonia (NH_3)	(mg/l)	.16	.06															
Nitrite (NO_2)	(mg/l)	.003	.027															
Nitrate (NO_3)	(mg/l)	.337	.126															
Total Kjeldahl Nitrogen (TKN)	(mg/l)	.44	.73															
Biochemical Oxygen Demand (BOD)	(mg/l)	< 25	18															
Fecal Coliform	(MPN/100 ml)	2400	4900															
Total Suspended Solids (TSS)	(mg/l)	54	77	13	42	61	108	94		33	38	21	10	24				
Oil & Grease (O/G)	(mg/l)	8.4	12									< 2		< 2				
Total Petroleum Hydrocarbons (TPH)	(mg/l)		11															
Fecal Coliform	(MPN/ 100 ml)	2400	4900															
									Ave(n)						Ave(n)		Chronic*	Acute*
Arsenic (As)	(ppm)	<.001	.004							<.05	<.05	<.05	<.05	<.05				
Cadmium (Cd)	(ppm)	.0004	.0017	.0003	<.003	<.002	.004	<.003	.004 (1)	.0011	.0018	.001	.0004	.0008		Cd	.0005	.0014
Copper (Cu)	(ppm)	.03	.026	.0140	.025	.021	.051	.031	.032 (4)	.038	.042	.02	.01	.02	.026 (5)	Cu	.0054	.0075
Chromium (Cr)	(ppm)	<.0005	.0045	.001	<.005	<.005	.012	.007	.0095 (2)	.005	.005	.005	.002	.006	.005 (5)	Cr	.011	.016
Lead (Pb)	(ppm)	.05	.066	.031	.026	.090	.140	.110	.09 (4)	.05	.06	.03	.014	.041	.039 (5)	Pb	.0009	.025
Nickel (Ni)	(ppm)	.004	<.001							<.01	.01	<.01	<.01	<.01	.01 (1)	Ni	.048	.919
Silver (Ag)	(ppm)	<.0003	<.0003							<.003	<.003	<.003	<.005	<.003		Ag	.012	.084
Zinc (Zn)	(ppm)	.098	.186	.064	.150	.130	.380	.230	.223 (4)	.18	.27	.11	.049	.12	.146 (5)	Zn	.047	.150

* A hardness of 40 mg/l was used to calculate relevant criteria
blank = not analyzed
MPN = mean probable number

TABLE 3-3. Toxic Organic Pollutant Concentrations During Storm Events; Selected Storm Drains, BitterLake/Haller Lake Drainage Basin

(Molecular Weight)	PAHs (ppb)	Densmore Drain, Storms				N 92nd & Stone Ave N, Storms					
		10/28/86	11/20/86	12/9/87	10/30/88	11/2/88	11/15/88	5/14/90	5/29/90	5/31/90	6/10/90
H	Benzo(a)Anthracene	.25	.38	.12	.35	.33	.24	–	–	–	–
H	Benzo(a)Pyrene	.30	.63	–	.39	.45	–	–	–	–	–
H	Benzo(b)Fluoranthene	.70	.71	–	.45	.48	–	–	–	–	–
H	Benzo(k)Fluoranthene	.50	.58	–	.68	.53	–	–	–	–	–
H	Chrysene	.60	.85	–	.73	.72	.51	–	–	–	–
H	Fluoranthene	1.20	1.40	.16	1.00	1.10	1.20	–	.71	–	–
L	Fluorene				–	–	1.70	–	–	–	–
L	Napthalene				.43	.22	.13	–	–	–	–
L	Phenanthrene	.70	.87	.12	.99	.81	3.50	–	.61	–	–
H	Pyrene	1.20	1.30	.16	.67	.87	.70	–	.54	–	–
L	Anthracene				–	.08	.09	–	–	–	–
	LPAH	.70	.87	.12	1.42	1.11	5.42		.61		
	HPAH	4.75	5.85	.44	4.27	5.33	2.65		1.25		
		5.45	6.72	.56	5.69	6.44	8.07				
	(Phthalates)										
	Butylbenzylphthalate			–	6.2	4.5	1.9	1.2	–	–	–
	Di-n-Octyl Phthalate			.32	–	–	–	–	–	–	–
	Diethylphthalate				.68	.53	–	1.0	–	–	–
	Dimethyl phthalate			.18	–	–	–	–	–	–	–
	Total Phthalates			.50	6.88	5.03	1.9	2.2			
	Phenol				–	–	1.10	–	–	–	–
	4-Methylphenol				–	–	–	–	–	–	–
	2-Methylphenol				.51	.21	.62	–	–	–	–
	Benzoic acid								17		

blank = not analyzed
– = not detected
H = high molecular weight
L = low molecular weight

From this data, it was concluded that major pollution sources were not likely in the watershed. Although metal levels were above chronic freshwater criteria, concentrations were low and could as easily be due to nonpoint sources of pollution such as roadway runoff business sources. It was also recognized that detecting changes that might occur due to the Source Control Project would be difficult due to the low baseline concentrations.

Wastewater Samples

Although not of immediate interest for this Source Control Project, a baseline of pollutant characteristics for wastewater from commercial land uses was established in cooperation with the Local Hazardous Waste Plan efforts. Figure 3-2 shows the sewerage subbasin boundary, which is very similar to the drainage subbasin boundary. Thirty 24-hour composite samples were collected and analyzed. Results are reported in Appendix C. In general, both metal and organic pollutants were low. Only one sample was above Metro's current discharge concentration limits for discharge to the sewer. This parameter was an oil and grease level (animal fat origin) of 291 ppm. The limit is 100 ppm. Presumably the source was domestic, since no restaurants were in business in the subbasin at the time of sampling.

The table in Appendix B lists the businesses tributary to the drainage and sewerage subbasins. Fewer businesses were in the sewerage subbasin than the drainage subbasin, as indicated in the table. This was due to the specific configuration of the local plumbing connections. This data also reinforced the conclusion that major pollution sources were not likely in the watershed.

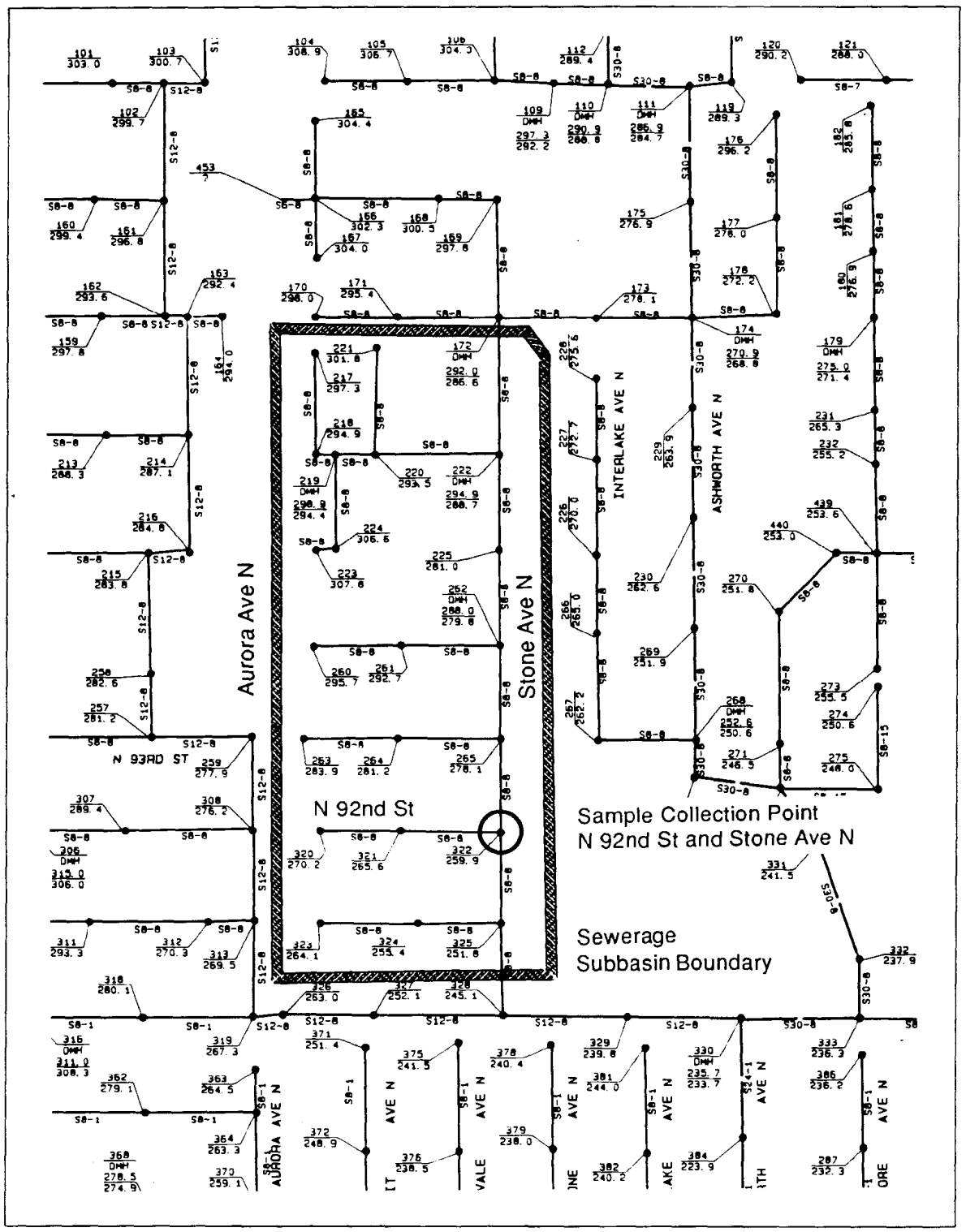


Figure 3-2. Sewerage Subbasin Boundary

SURVEY OF BUSINESSES IN THE DRAINAGE BASIN

Additional information about the businesses in the watershed was sought for two reasons. First, information about general waste management knowledge, attitudes, prevalence of recycling, and types of waste streams produced would be useful in designing a source control program for this particular watershed.

Secondly, an additional means for evaluating changes that might be brought about by the Source Control Project was desired, due to limitations of monitoring to detect changes, as noted previously. A questionnaire was designed to provide the desired information as well as to establish a baseline from which to measure future changes in knowledge and opinions.

Baseline Survey Design and Methods

A suggested telephone questionnaire had recently been prepared for the City of Seattle in connection with the Local Hazardous Waste Plan effort (Patmont & Statistics and Epidemiology Research, 1990). Where applicable, questions were adapted from that instrument. However, since the Source Control Project was focusing on wastes that might be washed into storm drains, a number of additional questions were also developed. Due to budgetary constraints, a mail-back survey was chosen rather than telephone interviews. Mail-back surveys are, however, subject to selection bias and are less apt to accurately represent the entire population in the sample area than a randomly selected phone survey (Patmont & Statistics and Epidemiology Research, 1990).

Survey questions covered the general areas listed below as well as asked about specific wastes handled by the business:

- General knowledge of waste management and fate of pollutants
- Attitudes and opinions about pollution control
- Changes in practices in the past year
- Reasons for making changes
- Best ways for learning about waste management

Survey of Businesses in the Drainage Basin

A postsurvey was also designed, which was identical to the baseline survey with a few changes which are discussed Section 4. The survey instruments are shown in Appendix D. The baseline survey was pretested by volunteer laboratory staff unfamiliar with the project.

Business addresses were found by searching a database purchased from Contacts Influential which included Standard Industrial Code (SIC) information. Business addresses were not field verified before mailing. A total of 450 questionnaires were sent out. Five were returned as not deliverable, and 93 were mailed back by respondents, for a return rate of 21 percent.

In addition, a comparison group of 100 businesses was selected from an area of West Seattle matched to the source control area in several important respects. The comparison area was typified by a major arterial strip development pattern, and the types of businesses were similar, based on SIC classification. Appendix B also provides data on businesses in the comparison group. A comparison group was included in the survey design to allow any changes in the general "baseline" level of awareness to be measured and accounted for in interpreting results of the postsurvey, to be administered after intensive source control efforts ended. The return rate for the comparison group was 15 percent, lower than for the source control area.

Responses to the baseline survey indicated a level of knowledge higher than expected. In order to check for selection bias, i.e., whether those having a higher level of knowledge returned surveys more frequently than the general population, a random sample of nonresponding businesses was chosen and interviewed by phone. Twenty-four businesses were interviewed. In addition, the eight questionnaires that had been returned anonymously were tallied separately and compared with those from the source control area.

Summary data for selected questions from the source control area, phone interviews, anonymous returns, and comparison group are given in Table 3-4. Although responses from those interviewed differed somewhat from mail-back respondents, substantial overlap existed. The responses from the mail-back sample fell within the 95 percent confidence

Table 3-4. Questionnaire Responses Summary, Baseline Case

	Aurora Area (n = 93)	Anonymous (n = 8)	Interview (n = 24)		Comparison Group (n = 15)
				(95 % CI)	
1.* Small businesses are exempt from most regulations about the kinds of wastes that can be discarded into the sewers and garbage. (correct response: No)	81%	63%	71%	(52 – 90%)	93%
2.* In the Seattle area, sewage treatment plants are able to give adequate treatment to all the various wastes produced by business and industry. (correct response: No)	60%	50%	63%	(43 – 83%)	87%
3.* Harmful or hazardous chemicals are only used by relatively large industries. (correct response: No)	87%	88%	92%	(81 – 100%)	93%
4.* Small businesses as a group contribute less than large businesses and industry to the overall waste loads handled by sewage treatment plants. (correct response: No)	42%	50%	50%	(29 – 71%)	53%
5.* It is sometimes hard to tell if a waste or product contains hazardous chemicals. (correct reponse: Yes)	68%	63%	79%	(62 – 96%)	80%
6.* It is against the law to allow oil to enter street drains in areas that have separate drains or sewers for rainwater and for sewage. (correct response: Yes)	85%	63%	71%	(52 – 90%)	87%
7.* Used oil, paint thinner, and antifreeze should not be poured onto the ground because they could pollute the groundwater. (correct response: Yes)	92%	100%	96%	(88 – 100%)	100%
8. My business recycles some of the wastes it produces or handles (either those that would go down the drain or into the garbage). (percent yes)	76%	75%	46%	(25 – 67%)	93%
18. In the past year, has your business made any changes in the way it disposes of wastes? (percent yes)	51%	47%	67%	(47 – 87%)	38%

* Questions 1 through 7 are percent correct response.
n = Number of observations in the sample.
CI = Confidence Interval

interval* of the random sample except for Question 8, regarding recycling. However, due to the small sample size, the confidence interval is quite large, and some selection bias cannot be ruled out.

A reduced frequency of recycling was seen in the random phone sample, from an average of 76 percent for the source control area to 46 percent in the random sample. This would imply that those who recycled might be more likely to mail back the survey than those who did not recycle. The anonymous returns were also somewhat different from the mail-back respondents, but were within the 95 percent confidence interval of the random sample, including their tendency to recycle. It was concluded that although some selection bias could not be ruled out, the mail-back respondents in the source control area adequately represented the North Aurora business population, within the rather large confidence interval seen—about plus or minus 20 percent.

Baseline Survey Findings

The average level of knowledge of respondents about general waste management questions was high. Items that respondents answered correctly most frequently were the following:

- Question 7. "Used oil, paint thinner, and antifreeze should not be poured onto the ground because they could pollute the ground water," 92 percent correct.
- Question 3. "Harmful or hazardous chemicals are <u>not</u> only used by large industries," 87 percent correct.
- Question 6. "It is against the law to allow oil to enter storm drains," 85 percent correct.
- Question 1. "Small businesses are <u>not</u> exempt from regulations governing the kinds of wastes that can be discarded into the sewers and garbage," 81 percent correct.

* The 95 percent confidence interval defines the range of uncertainty in the estimate. In essence, it means that if another sample were drawn, there would be only a 5 percent likelihood that the new sample would fall outside the confidence interval.

Questions respondents answered correctly less frequently included:

- Question 5. "It is sometimes hard to tell if a waste or product contains a hazardous chemical," 68 percent correct.

- Question 2. "Sewage treatment plants in the Seattle area cannot adequately treat all the various wastes produced by business and industry," 60 percent correct.

Lowest frequency of correct response was seen on Question 4. Less than half of respondents (42 percent) knew that as a group, small businesses do contribute as much to the overall loads handled by sewage treatment plants as large business and industry. Responses are summarized in Table 3-4.

In addition, Question 14 asked if respondents knew the current recommended method of disposal for all wastes produced by their companies, not just the hazardous ones. A total of 56 percent agreed or agreed strongly with the statement.

Attitudes about waste disposal were explored by three questions. Results were mixed, representing a wide range of opinion. Responses are summarized in Table 3-5. Question 10, "pollution control is good business-customers use 'environmentally friendly' establishments even if their prices are slightly higher," was agreed with or agreed with strongly by 55 percent of the respondents. Only 14 percent disagreed or disagreed strongly with the statement, and 31 percent neither agreed nor disagreed.

Question 11 asked if attention was paid to waste disposal only when required by regulations. A total of 51 percent either disagreed or disagreed strongly, while 27 percent agreed or agreed strongly, and 22 percent neither agreed nor disagreed.

Interestingly, attitudes toward government were generally positive. A majority (52 percent) disagreed or disagreed strongly with Question 13, that you'd get into trouble asking for information from a government staff person. Only 11 percent agreed or agreed strongly with the statement, and 37 percent neither agreed or disagreed.

TABLE 3-5. Baseline Survey: Attitudes About Waste Management

Question	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
10. Customers will use "environmentally friendly" establishments even if their prices are slightly higher. (% Agree, n = 92)	20	35	31	10	4
11. I pay attention to waste disposal only when required to by regulation. (% Disagree, n = 93)	4	23	22	33	18
13. Never ask for information about waste disposal from a government staff person—you'll just get into trouble. (% Disagree, n = 90)	1	10	37	35	17

n = sample size

Survey of Businesses in the Drainage Basin

Information was solicited about the best way for business operators to learn about waste management regulations (Question 17). When asked to choose among several suggested methods, the majority favored printed information, either as brochures and pamphlets or in trade or business journals. Calling an information hotline and onsite consultations with agency staff were also popular choices. Ratings were scored as the frequency with which a response was rated as best (1 or 2) on a scale of 1 to 5. Frequency of ratings are given in Table 3-6.

TABLE 3-6. Baseline Survey: Best Way to Learn About Waste Management

Method	Frequency (%)*
Printed information	60
Information in a trade or business publication	30
An information hotline	29
Onsite consultation with agency staff	27
Meetings and workshops	17
Articles in newspaper	20
Business associates	13
Onsite consultation with private specialists	14
Product supplier or waste hauler	15

* Total adds up to more than 100 percent because multiple responses were solicited.

Survey of Businesses in the Drainage Basin

Slightly less than half the respondents (46 percent) indicated that they made changes in waste management in the past year. Of that 46 percent, most (78 percent) indicated that they had begun recycling. Others indicated they had changed to less toxic products, changed disposal methods or used a hazardous waste service.

Reasons for adopting good waste management practices were identified in Question 19. When asked why a change in waste management might be made, concern for the environment was the most frequently given response (67 percent). Next most frequent were: if economically advantageous, concern for public image, concern about liability, and if new technology were available. Least frequently cited reasons were if disposal costs were higher and concern for government enforcement. In part these priorities reflect the fact that most businesses in the sample were small and many have not been regulated for pollution control purposes. Table 3-7 shows response frequencies.

TABLE 3-7. Baseline Survey: Why Changes in Waste Management Might Be Made

Response	Frequency (%)*
Concern for the environment	67
Economically advantageous	34
Concern for public image	28
Concern about liability	25
If new technology were available	23
Disposal costs higher	20
Concern for government enforcement	18

* Total adds up to more than 100 percent because multiple responses were solicited.

Survey of Businesses in the Drainage Basin

Question 20 asked under what conditions business owners would seek information or assistance with waste disposal problems. The most frequently indicated responses were: if there were changes in regulations that affected them (49 percent), if disposal rates for garbage and sewage went up (38 percent), if they thought they could save money (34 percent), and if assistance were given without mandatory requirements (33 percent). Table 3-8 shows responses.

TABLE 3-8. Baseline Survey: Under What Conditions Would You Like Information About Waste Management?

Response	Frequency (%)*
If changes in regulations	49
Save money	34
If given without mandatory requirements	33
Disposal rates for garbage and sewage increased substantially	31
If under enforcement or compliance order	21
Would like information now	12

n = 90

* Total adds up to more than 100 percent because multiple responses were solicited.

SOURCE CONTROL PROGRAM APPROACH

The University Regulator Source Control Project was undertaken to reduce the likelihood that pollutants from the north Aurora drainage area would adversely affect Lake Union after sewer separation was complete. The general project objectives given in Section 2 were refined into specific source control objectives based on identification of problems in the watershed. These objectives are as follows:

- Investigate whether cross-connections to the storm drainage system are a problem, and to work with the property owner to correct all problems found.
- Reduce the risk of spills from petroleum, gasoline, and other chemicals into the storm drainage system.
- Assist businesses to adopt good waste disposal practices and advise them about current regulations and acceptable disposal options.
- Encourage businesses to adopt housekeeping practices that avoid or minimize pollutants entering the storm drainage system.
- Encourage maintenance of oil collection sumps, oil/water separators, and storm drains.

The alternative approaches discussed in Section 1 were evaluated against these objectives, as well as long-term goals and implementation criteria. Only three of the alternatives discussed were judged to be applicable in small geographic areas such as the north Aurora watershed. These three were command and control regulation, technical assistance, and public awareness and education. A technical assistance approach was chosen as best meeting both short- and long-term source control objectives, as well as meeting implementation criteria. Some elements of public awareness were also adopted along with the basic technical assistance approach.

Command and control regulation also rated well against the objectives identified, but was difficult to apply in this situation since

Metro's authority for regulating discharges to the storm drainage system is not clear, as discussed previously. However, as part of the technical assistance approach, businesses were informed about current regulations concerning the discharge of pollutants to state waters. Thus, a regulatory context was included with the technical assistance approach.

Other strategies also were evaluated and may be useful in nonpoint pollution control projects in larger geographic areas. These include use of taxes, subsidies, certification programs, extending liability to include pollution damages, and development of markets. Certification programs, best applied on a citywide or regional scale, rated best when evaluated against specific and long-range source control objectives. Extending liability to include pollution damages also rated well when evaluated against the specific and long-range source control objectives. However, regulatory and legal impediments would have to be overcome, and political acceptance would probably have to be gained in order for the approach to be applied successfully.

Taxes, subsidies, market development, and public awareness strategies did not rate as well against the specific source control objectives identified above.

Details of the evaluation of these alternative approaches are presented in Appendix A.

SOURCE CONTROL PROGRAM ELEMENTS

Specific content of the program was guided by geographic surveys. These surveys were used to identify potential pollution-producing businesses, other nonpoint pollution sources in the basin, and to investigate water quality in the storm drainage system for signs of obvious pollution that might require followup training. Geographic surveys also allowed collection system connections to be investigated to verify that illicit connections were not a problem.

Technical Assistance Elements

The technical assistance portion of the outreach effort consisted of two aspects—site visits and direct mailings. Site visits were done for those

businesses that stored chemicals or petroleum products onsite or that produced liquid wastes. Direct mailings were made to all businesses, with additional targeted mailings to specific establishments. Site visits and direct mailings were chosen in part because onsite consultations and printed information were rated highly by survey respondents as good methods for learning about waste management. In addition, site visits were necessary to identify potential problems and for checking sewer connections. Outreach materials used during site visits are shown in Appendix E.

Site Visits. Businesses that were identified as having higher risks of generating pollutants to the storm drainage system (Table 2-1) were re-examined to decide which sites to visit. Of these, gasoline stations, auto repair shops, body shops, auto wrecking yards, and other companies which stored chemicals onsite were selected based on their potential for contributing pollutants to storm drains either actively or passively through rain runoff. These same shops were considered most likely to have shop sinks and floor drains that might be connected improperly. Eighty site visits were made between May and October 1990.

Site visits had three main objectives:

- Explain the sewer separation project, its purpose, and the future change of drainage outfall location.

- Check the condition of the onsite catch basins and storm drain connections, and verify that any shop sinks and floor drains were properly connected to the sanitary sewer.

- Examine the businesses' mode of operation and waste disposal practices, and make recommendations for improvement, if appropriate. Most recommendations were made both verbally and by followup letter.

Direct Mailing. A general mailing to inform all businesses in the drainage basin about the Source Control Project was done on two occasions. The first was a letter sent July 6, 1990. It included a pamphlet explaining the sewer separation project and the need for source control, and offered more information about waste disposal and no-fault

consultations. In addition, businesses were asked to change two practices: to sweep up dirt and litter instead of hosing off sidewalks and parking areas into storm drains, and to reduce the amount of soapy water that they allowed to run into the storm drains. No subsequent requests for consultations or additional information were received.

The second general mailing was sent in October 1990. It contained specific information about construction of the new storm drain. It also contained notice of two community meetings to receive comments and to provide further information about the CSO project design and construction.

Two targeted mailings were also done. One was to auto repair shops and others about proper cleaning of shop floors. An invitation was also extended to attend the Waste Information EXPO held at the Seattle Trade Center. None of the watershed businesses were among the list of registered attendees. There was a fee to attend.

The second mailing was to gas stations and businesses with fuel pumps concerning precautions to prevent spills from entering the storm drains.

In addition, auto shops were invited to a regional workshop sponsored by the Washington State Department of Ecology in June 1990. The workshop was about proper management of auto shop wastes. The workshop was on the Eastside, and attendance was sparse.

Public Awareness and Education Elements

General Articles. Two articles appeared in the local community newspaper about the University Regulator Project, one specifically on the source control portion of the Project. In addition, an article was prepared and printed in *The Manifold*, the publication of the Independent Auto Repair Trade of the Puget Sound Region, and in the *Aurora Avenue Merchant's Association Newsletter. The Manifold* article covered proper wastewater disposal from cleaning shop floors. A copy of these articles is included in Appendix E.

Awareness Raising. Storm drain stenciling of high traffic areas, including both sides of Aurora Avenue and major shopping areas, was

done in the summer. The message "Dump no pollutants, drains to lake" was stenciled in yellow traffic paint adjacent to catch basins. Stenciling was done with the assistance of the City of Seattle and the Surface Water Action Team, a group employing disadvantaged youth on water quality related projects.

SECTION 4
RESULTS AND EVALUATION

GENERAL WASTE MANAGEMENT FINDINGS

Based on the 80 site visits and on the geographic surveys conducted, the following summary is made. All businesses using solvent or generating used oil recycled those wastes, with only one exception. The one nonrecycling business began recycling solvent by the end of the project. Most other wastes were handled and disposed of properly. The few exceptions were brake fluid, which must now be handled by a hazardous waste hauler but at one time was allowed to be disposed of in the sanitary sewer, and batteries, which in a few cases were not recycled.

This is an impressive showing for proper waste handling and disposal practices. It should be kept in mind, however, that businesses were small, with relatively simple waste management problems. The one larger industry present, which had a liquid process waste stream, already had a Metro Industrial Waste Discharge Permit and was abiding by its provisions.

Those drain connections that could not be verified from the City of Seattle side sewer cards or by visual inspection were dyed or verified by sounding. However, most shops had no floor drains at all, and shop sinks were infrequent. One improper connection was found in more than 80 sites checked. At this site, a building had an inside drain with an oil collection sump that the owner believed to be connected to the storm drain system. The building was no longer used as a shop, however, but as office space, and the sump was inaccessible. This is a much different situation than that found in the Lander drainage basin of South Seattle, where numerous improper connections were found.

Housekeeping practices at many of these same businesses were, however, not as exemplary as their waste disposal practices. Since there seldom were floor drains, many shops rinsed floor wash water out into the parking lot or street where it would enter the storm drains. Vehicles were commonly washed on lots rather than at wash pads draining to the

sanitary sewer. The exceptions were the three large auto dealerships in the watershed who, at least by the end of the project, all had car wash and prep areas that drained to the sanitary sewer. Figure 4-1 shows a vehicle wash area at a dealership which was installed during the project. The following pages will discuss problems in more detail, along with solutions identified.

In addition to poor housekeeping practices, sometimes car work was done outside near storm drains which were not protected to prevent pollutant entry. Radiator rinsing (after antifreeze was drained), body work, and use of degreasers were the most harmful practices seen. These practices were observed, however, only at a few sites visited. Storage of oil, oily parts and chemicals, including old 55-gallon drums in areas unprotected from the rain was also common, as will be discussed under Site-Specific Problems.

Another common problem was the lack of maintenance of catch basins and oil water separators or sumps. This may in part be because a high proportion of business operators rented. Renters often felt it was not their responsibility to clean catch basins, sumps, or separators. In those cases, property owners were contacted and agreements reached to have neglected sumps cleaned.

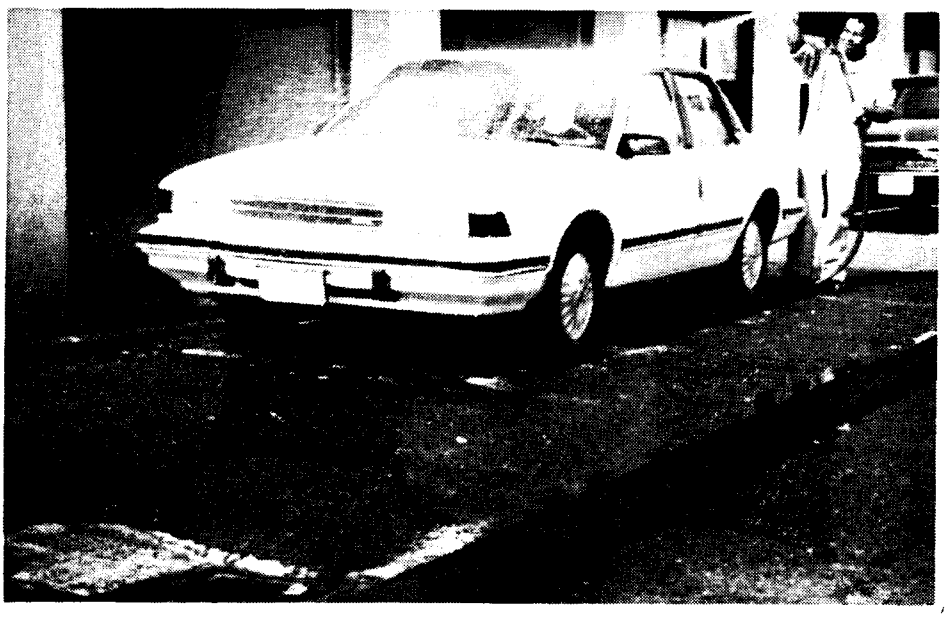


Figure 4-1. Vehicle Wash Area With Drain to Sanitary Sewer

GENERAL PROBLEMS AND SOLUTIONS IDENTIFIED

Three general problems were identified in the watershed which had potential for pollution of Lake Union. These problems are described below:

- Oily water from washing shop floors was often not handled properly, but rinsed out of the shop into street or parking lot drains. These pollutants then would enter the local storm drainage system. Oil and detergent would be carried to Lake Union after the separation project.

- Gasoline and other fuels spilled during vehicle fueling operations was a second source of potential pollutants to the storm drainage system. Although the quantity of pollutants was not likely to be as great as with shop floor wash water, gasoline is much more toxic than oil.

- The drainage area is characterized by many new and used car dealers. In the summer, cars are washed frequently, and the soapy wash water runs into the storm drainage system. Soap is highly toxic to aquatic life. The same properties that makes soap able to remove dirt and grime also makes it able to bind to lipids in biological membranes. Fish are particularly vulnerable since respiration takes place through the gills, characterized by thin cell membranes to permit oxygen diffusion into the body. Discharge of soapy water into Lake Union from this source is of concern.

Failure to clean catch basins and oil sumps or separators was also a problem. When requested, most shop owners had the cleaning done. However, without a reminder, yearly cleaning is unlikely to take place. This problem is not, however, considered as important as the three identified. This is because addition of good spill control practices will prevent pollutants from entering the storm drain, averting most of the potential damage. All active oil/water separators and oil sumps were connected to the sanitary sewer. Although yearly maintenance is

probably necessary to meet discharge limits to the sanitary sewer, pollution risks to storm drains is minimal.

The first two general problems—floor wash water disposal and chronic small spills from fueling stations—were addressed similarly. First detailed information was collected about current practices. Shops had dealt with cleaning floors in different ways, some of which were acceptable in terms of their pollutant effect on the storm drainage system. "Ideal" alternatives were also identified by talking with regulatory staff and the Metro Transit Environmental Compliance Specialist (personal communication, Debbie Mundt, Dave Waddell, 1990). These alternatives for disposing of floor wash water and preventing gas spills were then reviewed with area business leaders and City of Seattle Drainage and Wastewater Utility staff for feedback as to practicality. Suggestions were incorporated, and final recommendations were sent by personal letter to all businesses known or having the potential to contribute to the problem.

The letters identified the problem; listed acceptable alternatives; and in the case of fuel stations, offered limited assistance from the City; and included a list of suppliers of spill control materials. Voluntary adoption of these practices was solicited. Letters are reproduced in Appendix E.

The third general problem, that of soap in the storm drainage system, was more complex. The sanitary lines along Aurora Avenue North are only 8-inch-diameter lines, and are undersized for current flows. Due to this constraint, the City was unable to endorse a recommendation to have all car wash water diverted to the sanitary sewer, which would be the most straightforward, albeit expensive, solution. In order to determine more precisely the amount of the actual risk to Lake Union from soap, fish bioassays were done on eight typical car wash soaps to determine the range of toxicity associated with these soaps. To decide which soaps to test, an inventory was taken of car dealers along Aurora Avenue. The Washington Toxics Coalition, which was working on a similar study for the Local Hazardous Waste Plan, then determined to the extent possible, the chemical ingredients of the soaps. Based on the identified ingredients, eight soaps were selected for testing. Two were available only from commercial vendors, two from auto supply shops, two were common household liquids, and two were marketed at Puget Consumers Co-op as environmentally safe.

General Problems and Solutions Identified

Table 4-1 lists the products being tested and known chemical ingredients. Information on two soaps tested previously are also listed. All products with the exception of Dr. Bronner's soap are detergents, employing various surface-active agents (surfactants) to achieve removal of dirt. Dr. Bronner's is a pure castile soap, characterized by sodium and potassium salts of fatty acids.

TABLE 4-1. Soaps Selected for Fish Bioassay Testing

Name	Constituents
Hi Suds 206	Sodium alpha olefin sulfonate Sodium lauryl ethoxysulfate Lauric diethanolamide
ESP	Ethylene glycol monobutyl ether Sodium metasilicate Sodium dodecylbenzene sulfonate
Armor All	Sodium dodecylbenzene sulfonate
Simple Green	Butyl cellusolve = ethylene glycol Monobutyl ether Nonionic surfactants (alkayl polyether alchohol)
Lemon Joy	Anionic and nonionic surfactants Ethyl alchohol Stabilizing agents Perfume
Crystol White Octagon	Alkyl aryl sulfonate Ethoxylated alchohol sulphate Sodium sulfate Ethanol Organic foam builders
Ecover	Coconut oil based surfactant
Dr. Bronner's soap	Sodium & K salts of fatty acids
Believe	Tetra sodium EDTA Alkli metasilicate
Xotox	No information

General Problems and Solutions Identified

Bioassay information will be evaluated and recommendations made to businesses during the next year. The hope is that a product with a low enough toxicity will be identified so that even in dry weather, use of the soap would not pose a problem in Lake Union. Although bioassays results have recently become available, evaluation of impact to Lake Union will be completed later in 1991. There are also problems to be worked out with regulatory agencies regarding wording of any recommendation, since all soaps are currently defined as pollutants.

Least toxic detergents are Believe (Johnsons Wax), Xotox (Ecology Technology), Simple Green (Sunshine Makers, Inc.), and ESP (ZEP Manufacturing). Ecover, marketed as environmentally safe, and Joy were the most toxic. Appendix F contains complete bioassay information for both fish tests and for Microtox, a bacterial assay. Good agreement between the two assays was seen, making Microtox a promising method to use in future studies, since it costs less than fish bioassay.

Usually an engineering solution to a problem such as posed by soapy water is possible. It involves diverting low flows to the sanitary sewer on a permanent basis. However, in the north Aurora watershed, there is permanent base flow in the drainage system. Thus, low-flow diversion would result in significant flows of clean water into the sanitary sewer, contrary to the purpose of the sewer separation project. Thus in this case, low-flow diversion is not considered a viable option for dealing with the soap problem.

SITE-SPECIFIC PROBLEMS

In addition to the general problems noted, there were several site-specific problems identified during site visits. At about 25 percent of the sites visited, improvements in waste management were recommended either to meet future water quality requirements or to lessen the possibility of future spills or leaks. It is notable that, with a few exceptions, these recommendations were fine-tuning recommendations, and did not involve extensive modifications not already planned by the business. In one case, a large oil/water separator was installed to help control oily discharges. Although perhaps precipitated by the Source Control Project, the owner had decided to take this action before the site visit was made.

However, one site exhibited major water quality problems, both in terms of chronic pollutant load and spill potential. On this site, car bodies were sanded and accumulated grit was allowed to be washed into the storm drainage system. A water sample from the catch basin onsite showed metals from 10 to 100 times above water quality standards. Solvents were also stored without berming. In one portion of the storage area, the asphalt was already deteriorated from chronic spills.

Table 4-2 summarizes recommendations made and notes which are known to have been implemented before December 1, 1990. As is apparent from the table, about half the businesses acted quite promptly on the recommendations. This level of responsiveness toward making recommended changes is comparable to that seen in the Lander Source Control Project (True, 1989).

Some sites are of potential interest under the newly issued EPA NPDES stormwater permit requirements that the City of Seattle will be addressing in the future. The regulations specifically include auto wrecking yards and large vehicle fleet maintenance yards as uses to be inventoried. The City of Seattle's Haller Lake vehicle maintenance shops, Aurora Auto Wrecking, Lincoln Auto Wrecking, All Volvo Auto Wrecking, and Rick's Auto Wrecking are the relevant businesses. Improvements in runoff collection and treatment have recently been made at the City shops and Lincoln Auto Wrecking. Aurora Auto Wrecking installed an oil/water separator connected to the sanitary sewer over 2 years ago, and All Volvo Auto Wrecking is in the process of making housekeeping changes to minimize oil discharge. The yard drains at this location do, however, connect to the sanitary sewer.

The last company, Rick's Auto Wrecking, was the only business unwilling to allow a site visit. This particular site appears to have no internal storm drains. The site will be referred to the Washington State Department of Ecology for possible inspection.

Other Standard Industrial Codes (SICs) are identified by the new regulations as being of concern (Part 122.26 b[14]). Table 4-3 lists businesses from the source control area with these SICs and indicates which were visited. Those not visited were not identified during the geographic surveys as having potential for pollutant inputs to storm drains, or likely to have shop sinks or floor drains. A complete list of all sites visited is given in Appendix G.

TABLE 4-2. Evaluation of Site Visits

Date	Business Name	Change Recommended	Done?
5/10	Phelps Tire Co.	Keep tire shreds swept up. (Found to leach zinc.)	Yes
7/26	Lincoln Auto Parts	Were installing oil/water separator. Separate oily/drippy work, drain to separator.	Yes Yes
8/20	C.A.R.S. Inc.	Clean catch basins. Replumb sink to sanitary. Roof and berm work area. Install pre-treatment system.	Yes Consultant hired
8/20	University Mechanical Contractors	Berm used oil tank Remove old drums. Store useful drums properly.	
8/21	Pioneer Builders Supply	Clean oil out of storm drain.	
8/23	Japan Auto/Ed Garneau	Clean oil/water separator. Cover to prevent rain water entry, illicit dumping	Yes Yes
8/29	McCalls Heating Oil	Use concrete rather than asphalt for resurfacing. Cover & berm used oil storage.	
8/30	Seattle Parks & Recreation	Dispose of old wastes. Consolidate chemical storage, and berm. Provide spill clean up materials at gas pumps.	Yes Yes
9/10	Ratelco	Sweep up flaking zinc paint from storm drain area.	Yes
9/13	AAA Automotive	Recycle batteries. Only clean water in storm drains.	Ongoing

TABLE 4-2. Evaluation of Site Visits (continued)

Date	Business Name	Change Recommended	Done?
9/13	My Mechanic	Recycle solvent. Clean up oil spills promptly. Connect sink to sanitary sewer.	Yes Ongoing
9/13	Andy's Collision	Prevent paint and dust from entering storm drain when working outside.	Ongoing
10/10	Nordic	Provide spill tray when dispensing solvents.	
10/15	WA Natural Gas	Clean oil/water separator.	Yes
10/15	S & S Sign	Cover and berm used oil area. Cover, berm, and provide concrete floor in solvent dispensing area.	 Yes
10/15	Honda Masters	Clean oil/water sump.	Yes
10/22	Superior Tire	Clean catch basins. Clean oil/water sump. Limit work outside shop to dry work.	Yes Ongoing
10/26	Mundy Company	Move used oil tank to concrete pad, cover and berm.	
11/2	Laurelhurst Fuel	Move used oil tank to concrete pad, cover and berm.	
11/9	All Volvo	Segregate drippy, oily work from dry work. Cover & berm messy area.	 Ongoing

TABLE 4-3. Businesses in SIC Categories Specified in 40 CFR Part 122

Company Name	Address	SIC
Korea Central Daily News/The	13749 Midvale Ave N	2711
Ellipsis	936 N 89th St	2741
Puget Sound Printers	11726 Aurora Ave N	2752
Photo Litho Company	1114 N 97th St	2752
Kenlake Northwest Label & Print	950 N 98th St	2759
Master Press Incorporated	1200 N 96th St	2796
Seattle Glass Block Windows	12633 Stone Ave N	3231
Jennings Manufacturing Inc	930 N 127th St	3231
B & D Sheet Metal Company	1111 N 98th St	3444
Buser Ornamental Iron Works*	1110 N 143rd St	3446
Ratelco*	1113 N 100th St	3449
West Coast Industries Inc	1111 N 92nd St	3545
British Car Shoppe*	1119 N 100th St	3711
Terries Auto Service*	1107 N 98th St	3711
Unocal*	130th & Stone Ave N	3714
Circle K*	12248 Aurora Ave N	3714
Arco AM/PM Minimart*	N 105 & Aurora Ave N	3714
Pyrocom Company	924 N 143rd St	3823
Custom Contact Lenses Inc	312 N 85th St	3851
Neon Broker	11728 Aurora Ave N	3993
S & S Sign Company*	13190 Stone Ave N	3993
Public Storage	11512 Aurora Ave N	4225

* Visited during Source Control Project.

EVALUATING EFFECTIVENESS

Determining project effectiveness by direct stormwater sampling is expected to be difficult. This is because pollutant levels are already low and because runoff from parking lots and roadways contributes the same kind of pollutants as present in businesses such as auto shops, making it difficult to attribute changes in concentrations to changes in business practices. In addition, two practices of concern—rinsing floor wash water and car wash soap into the street or storm drains—probably occur primarily in nonrainy weather, making it even more difficult to measure effects by sampling storms. Followup storm sampling is, however, scheduled to be repeated in January and February 1991 for the commercial subbasin sampled at the beginning of the project.

Because of this difficulty, two other measures of effectiveness are presented. One is a modified benefit/cost approach. The other measure is a comparison of the followup survey to the baseline survey.

Evaluating Benefits of the Program

The cost of the first year of the University Regulator Source Control Project was $53,000, including stormwater monitoring costs. Most of the cost was staff labor. The benefits of the project consist mainly in the prevention of future problems. These include both improved housekeeping practices (for reduction of chronic discharge of oil, gasoline, and detergents) and improved storage practices (for prevention of spills).

The monetary value of avoiding pollutant stress to ecosystems is difficult to evaluate. Instead, it will be assumed that the one site that had major pollution problems continues to operate as it had in the past. In this scenario, highly contaminated sediment and poor solvent storage practices persist undiscovered for a 3-year period. At that point, a 55-gallon drum of solvent is spilled and enters Bitter Lake via the drainage system. The chronic sediment contamination problem is discovered after the spill when regulatory agencies visit the site.

The scenario assumes that the effects of the source control project will persist through this 3-year period, with small additional expenditures for a semiannual newsletter to the business community informing them of storm drain construction progress and updating information about waste disposal. The total 3-year cost of the source control project

will therefore be estimated at $58,000 (1990 dollars). The cost to clean up the spill and sediment contamination occurring if the source control project were not conducted in 1990 will then be compared to the cost of the project.

Drainage from the site in question is via a local drainage ditch and a piped drainage system that discharges directly into Bitter Lake. Bitter Lake is surrounded by a large city park, swimming beach, community center, a major retirement home complex, and several apartment buildings, condominiums, and single-family homes. The storm drain enters at the northern end of the lake. Land use in the area surrounding the outfall is predominantly single-family residences. The park and swimming beach are at the southern part of the lake.

The scenario involves both the spillage of 55 gallons of solvent via the drainage system to the lake and the cleanup of sediment highly contaminated with metals from car paint, which routinely entered the storm drains. This scenario treats the probability of a solvent spill as .33 per year per business (once in 3 years). This is a rather high probability, even for a poorly managed site. Costs will therefore be estimated using a typical spill probability derived from spill data in Lake Union*. This spill probability for a 3-year time period is .186 per business.

A solvent spill into the lake would very likely kill fish, taint surviving fish with undesirable flavors, foul shoreline sands, and cause health and safety exposure problems to lake residents and users. These impacts are likely to result in nonmonetary costs, such as odor and aesthetic impacts, loss of recreational opportunity including fishing and swimming, and perhaps extended closure of some private beach areas.

However, this analysis will focus primarily on estimating the cleanup cost of the spill and chronic sediment contamination problems. The two aspects of the cleanup scenario will be evaluated in turn.

---

* From March 1990 to March 1991, 62 spills known not to be from vessels were reported in Lake Union (Suzanne Winters, personal communication, March 1990). There are approximately 1,000 businesses in the watershed that handle petroleum products that might spill into the Lake (Debbie Mundt, personal communication, March 1990), for an average spill frequency of .062 per year per business (or once in 16 years). For a 3-year period the probability of a spill would be .186 per business.

Solvent Spill Cleanup. Cost of cleaning up the hypothesized solvent spill is estimated based on the cost of cleaning up a recent spill into Hicks Lake in South King County. In this spill, a small amount of oil contaminated with degreaser entered the lake. The amount of oil spilled was not known, but was considerably less than 55 gallons. An area of 20 feet near the outfall was contaminated, as well as 150 feet on both sides of the lake, for a total of 320 feet of contaminated shoreline. Cleanup was done by a small crew without mechanical equipment. The cost was approximately $5,000 and took 2 days (personal communication, Chempro, 1991). The cleanup cost of contaminated shoreline was approximately $16.00 per foot.

A spill of 55 gallons of solvent into Bitter Lake is assumed to contaminate about 25 percent of the shoreline. If the prevailing southerly wind pattern occurred at the time of spill, the solvent would remain in the northern portion of the lake and would not contaminate the public beach to the south. Since southerly winds occur over half the time in the Puget Sound area (Puget Sound Air Pollution Control Authority, 1989), this assumption is adopted for the cleanup scenario. Assuming that solvent is not significantly more difficult to clean up than oil, the per-unit cost of cleanup in Hicks Lake can be applied to Bitter Lake. Using booms and sorbent pads, the cleanup would remove floating solvent and minimal amounts of contaminated sand.

The affected shoreline area of Bitter Lake is estimated to be about 1,125 feet*. Cost of cleanup of the solvent spill would thus be $17,600. In addition, the piped portion of the drainage system would need to be cleaned since solvent would adhere to the pipe and sediment, recontaminating the lake during the next rainfall. The cost of this cleanout is estimated at $5,926, which includes disposal of the contaminated sediments from the drain pipe cleaning. The total cost of spill cleanup is estimated to be $23,526. Specifics are given in Table 4-4.

* Bitter Lake has a linear shoreline of 4,541 feet and an area of 19.4 acres (Tom Higgins, personal communication, March 1991).

TABLE 4-4. Cost of Solvent Spill Cleanup (all costs are 1990 dollars)		
Solvent cleanup from shoreline		$17,600
Drain line cleaning	($550/day)	1,100
Disposal of drain line sediments (1 ton)		
Truck & driver	($62/hr)	620
Loader	($250/hr)	2,000
Crew	(3 @ $225/person/day)	675
Laboratory testing		1,000
Regulatory approvals	($60/hr)	480
Landfill cost	($51.25/ton)	51
Total Cost of Cleanup		$23,526
Expected Cost (x .186)		$4,376

Using the spill frequency for a 3-year period of .186 per business, which was derived from Lake Union data, the expected cost from a spill for the business identified is (.186)($23,526) or $4,376 for the 3-year period. This calculation of expected cost makes three simplifying assumptions.

- Spills reported for Lake Union are from business rather than other sources.
- All spills that occur are reported.
- All business sites have the same probability of having a spill.

The first assumption may overestimate the frequency of spills if many nonbusiness spills occurred. The second and third assumptions tend to underestimate the probability of spills, particularly for poorly managed sites.

Metal-Contaminated Sediment Cleanup. If sediment and stormwater contaminated with high levels of metals continued to be washed off the

site for three years, extensive areas of Bitter lake would be contaminated. It is conservatively estimated than 100 cubic yards of sediment would be sufficiently contaminated so that removal or remediation would be required. It is assumed that without the source control project, the probability of this contamination occurring is 100 percent. Several cleanup methods of contaminated sediment are possible, including dredging and disposal, capping contaminated sediment without removal, and biological treatment in place (bioremediation). Neither capping nor bioremediation is a good choice in this scenario. Capping of sediments is not considered feasible since chronic buildup of excess sediments occurs at the inlet pipe over time and periodic removal is necessary (personal communication, Charles Cox, 1991). Capping would aggravate this maintenance problem. Bioremediation of metal contamination in an aqueous environment has not yet been successfully developed. Thus, dredging of contaminated sediments is the cleanup method evaluated.

Cleanup consists of five elements:

(1) The extent and location of the contaminated sediment is determined, and an overall cleanup plan submitted for approval to the Departments of Ecology and Fisheries and the Seattle King County Health Department.

(2) The dredging operation is conducted. In addition to removal of sediments, stockpiling of the spoils is necessary to permit excess water to drain from spoils and to reduce turbidity of the water before it is disposed of in the sanitary sewer. Dredge-decant water is typically not allowed to reenter the lake. The contaminated spoils are tested to determine the leachable metal content level and to check for other contaminants.

(3) Loading, transport, and disposal of the contaminated sediment to Cedar Hills landfill or a hazardous waste landfill (location dependent upon the test results) is accomplished.

(4) The drainage pipe is cleaned of all sediment. To do this, the pipe outfall is isolated from the lake and plugged. Water-jet cleaning, from the outfall back up the line to a manhole on North 137th Street, is required.

(5) Restoration is required for damage resulting from heavy equipment operation near or on residential property. Damage can include cracked cement pads, fractured retaining walls and utilities, and damaged landscaping. Clean sand is also replaced in dredged shoreline areas to maintain stability of the beach area.

Costs of these steps are estimated in Table 4-5. Equipment and labor prices used to develop the cost estimates are given in Table 4-6. The total cleanup cost for dredging and disposing of 100 cubic yards of contaminated sediment is estimated at $52,600 if the sediment is not hazardous waste. If metal concentrations are high enough for the sediment to be classified as hazardous waste, an additional $46,000 in disposal costs would be incurred, and the total cleanup cost would be about $98,600.

Total Cleanup Scenario Costs. The total cost of the cleanup scenario, including both the solvent spill and the sediment cleanup, would be $57,000, and could possible be as high as $103,000 if the sediment was highly contaminated and classified as hazardous waste. This does not include harder-to-quantify costs resulting from lost resources or recreational opportunities, health and safety or expenses risks, resulting from the spill and deposition of contaminated sediments in the lake.

These cleanup costs will be avoided because this site was identified as a problem and improper waste disposal practices halted as a result of technical advice supplied during the source control project. The site in question has stopped outdoor car body sanding, which prevents contaminated sediment from being discharged to the storm drains, and is in the process of installing a pretreatment system before discharge of water to the sanitary sewer. Solvent storage practices are also improved, so that the likelihood of a spill is significantly reduced.

TABLE 4-5. Cost Estimates for Cleanup of 100 Cubic Yards of Metal-Contaminated Sediment (all costs are 1990 dollars)

Task 1. Sediment Testing and Disposal Plan		
Labor:		
Field crew of three (2 days)	$1,350	
Professional staff (16 hours)	960	
Agency approvals (48 hours)	2,880	
Equipment rental (2 days):		
Boat	250	
Dredge	50	
Permit fees	1,500	
Laboratory testing (10 @ $500, 3 @ $1,000)	8,000	
Task 1 Subtotal		**$14,990**
Task 2. Dredging		
Labor:		
Crew of three (5 days)	$3,375	
Equipment:		
Dredge and operator (5 days)	4,205	
Pump (5 days)	500	
Supplies	500	
Laboratory testing (4 @ $1,000)	4,000	
Task 2 Subtotal		**$12,125**
Task 3. Loading, Transport, & Disposal of Sediment		
Labor:		
Crew of three (3 days)	$2,025	
Equipment:		
Loader (3 days)	6,000	
Truck and driver (3 days)	1,488	
Supplies, Protective Equipment	1,500	
Disposal at Cedar Hills landfill		
Transport (included above)		
Tipping fee ($51/ton)	8,619	
Task 3 Subtotal, nonhazardous waste		**$19,632**
Disposal at Arlington, Oregon		
Transport ($1,165 trip)	11,650	
Disposal fee ($255/ton)	43,095	
Task 3 Subtotal, hazardous waste		**$65,758**

TABLE 4-5. Cost Estimates for Cleanup of 100 Cubic Yards of Metal-Contaminated Sediment (all costs are 1990 dollars) (continued)

Task 4. Cleaning Storm Drain		
Equipment:		
Water jet and operator (2 days)	$1,100	
Truck and driver (2 days)	496	
Laboratory testing (1 @ $500)	500	
Disposal:		
Transport (included above)		
Tipping fee	51	
Task 4 Subtotal		**$2,147**
Task 5. Restoration		
Labor:		
Crew of three (4 days)	$2,700	
Clean sand	500	
Supplies	500	
Task 5 Subtotal		**$3,700**
Tot Cost, Nonhazardous Waste		**$52,594**
Total Cost, Hazardous Waste		**$98,720**

TABLE 4-6. Labor and Equipment Costs Used in Cleanup Cost Estimate (all costs are 1990 dollars)

Equipment	
Loader*	$250/hour
Truck and driver**	62/hour
Jet cleaner and operator*	550/day
Vactor truck and operator*	700/day
Crane and operator*	841/day
Pump	100/day
Manpower	
Laborer	225/day
Regulatory agency staff	60/hour
Laboratory Testing	
Metals, petroleum hydrocarbons and organic base/acid/neutrals	1,000/sample
Solvents	250/sample
Landfill Costs	
Cedar Hills disposal fee	51/ton
Arlington, Oregon	
Disposal fee (metal contaminated sediment)	225/ton
Transport	1165/trip

Conversions: 100 cubic yards of sediment = 169 tons
1 truck holds 10 cubic yards

* Based on 1990 chargeout costs, City of Seattle, Drainage and Wastewater Utility.

** Based on construction Bluebook values, 1990. (Myers-Browne, personal communication, February 1991).

Evaluating Effectiveness

Thus, avoiding the need for the cleanup scenario hypothesized is viewed as a direct benefit of the University Regulator Source Control Project. This benefit, valued at $57,000, is almost equal to the cost of $58,000 to conduct the technical assistance and outreach program, along with followup for a 3-year period. In some watersheds, particularly industrial ones, more than one significant problem may be found, making the benefits of conducting source control projects more pronounced. In addition, the benefits from preventing other smaller, incremental problems are gained. Even though not evaluated in monetary terms, preventing water quality problems associated with nonpoint pollution has direct benefits to the receiving waters, and the enjoyment of those waters by citizens of the region.

Considering the avoidance of future cleanup costs and possible foreclosure of recreational, aesthetic and health amenities, the University Regulator Source Control Project is considered to have been worthwhile.

Measure of Effectiveness From Survey

In addition to the benefit/cost approaches, a baseline survey/post-survey strategy was adopted as another avenue for evaluating the project. The postsurvey was administered at the end of November, after the technical assistance and public awareness aspects of the project were completed. A total of 500 questionnaires were sent out, 50 more than for the baseline survey. The additional firms were identified during geographic surveys and were not on the original database from Contacts Influential. Thirty questionnaires were returned as undeliverable primarily because of business turnover, and 85 were mailed back, for a return rate of 17 percent. Response from the 100 businesses in the comparison group in West Seattle was again solicited, with 14 returning surveys, for a 14 percent return rate.

Responses from the north Aurora area postsurvey were analyzed as a whole as well as for the subsample of returns from businesses visited during the outreach effort. (Recall that these businesses had a higher potential for contributing pollutants to the storm drains.) Eighty business sites were visited during the course of the project, of which 23 returned surveys, for a return rate of 29 percent in the subsample—significantly

higher than for the whole Aurora sample (90 percent confidence level*). Only about 35 percent of businesses responding to the postsurvey had also returned baseline surveys.

Questions in the postsurvey were worded the same as in the baseline survey, with the following exceptions. One additional choice was added to Question 17, which asked if businesses had made changes in waste management practices in the last year. Change of waste storage practices was added. Question 5 from the baseline survey, "It is sometimes hard to tell if waste products contain hazardous chemicals" was eliminated in the postsurvey. The question was eliminated because several staff members indicated that the answer was disputable.

Two questions were added to the postsurvey, Questions 14 and 15. They both concerned the perception of risks by business operators, both to their own establishments and to the environment. These questions were added to gain information to be used in future source control projects.

Response frequencies for each question from the postsurvey were compared to frequencies seen in the baseline survey administered in April 1990. These frequencies were then compared to see if changes had occurred. A difference in frequency of correct response could be due to a number of factors, including chance. A statistical technique (the difference in two population proportions [Wonnacutt & Wonnacutt, 1984]) was used to determine if changes were due simply to chance, or to other factors. Table 4-7 compares data from the two surveys. Statistical calculations are given in Appendix D.

Limitations in Interpreting Survey Results. Evaluating changes brought about by intervention programs is difficult. This is not only because effecting the change is difficult, but also because the measurement process is also fraught with difficulties. Care is required in interpreting results. A before/after mail-back survey was used to evaluate changes in knowledge, attitudes, and actions which might result from technical assistance to targeted businesses over a 7-month period. This evaluation scheme has

* The 90 percent confidence level means that there is 90 percent certainty that the increase was not simply due to chance.

Table 4-7. Survey Comparison, Baseline and Postsurvey

		Baseline n = 93	Whole Aurora Area Sample n = 85				Visited Subgroup n = 23			
	Questions Measuring Knowledge (correct response in parenthesis)	Score (%)	Score (%)	Direction of Change	Sig? 95%	Sig? 90%	Score (%)	Direction of Change	Sig? 95%	Sig? 90%
1.	Small businesses are exempt from most waste disposal regulations. (No)	81	76	↓	N	N	87	↑	N	N
2.	Sewage treatment plants can adequately treat all the various wastes produced by industries. (No)	60	72	↑	N	Y	61	↑	N	N
3.	Harmful or hazardous chemicals are only used by large industries. (No)	87	82	↓	N	N	87	0	–	–
4.	Small businesses as a group contribute less than large business and industry to the waste loads of sewage treatment plants. (No)	42	38	↓	N	N	43	↑	N	N
6/5.*	It is against the law to allow oil to enter storm drains. (Yes)	85	87	↑	N	N	87	↑	N	N
7/6.*	Used oil, paint thinner, and antifreeze should not be poured onto the ground because they could pollute the groundwater. (Yes)	92	96	↑	N	N	97	↑	N	N
14/13.*	I know the recommended disposal methods for all wastes my company produces. (Yes)	56	62	↑	N	N	61	↑	N	N
	Questions Measuring Attitudes									
10/9.*	Customers will use "environmentally friendly" establishments even if their prices are slightly higher. (% Agree)	52	60	↑	N	N	56	↑	N	N
11/10.*	I pay attention to waste disposal only when required to by regulation. (% Disagree)	51	66	↑	Y	Y	65	↑	N	N
13/12.*	Never ask for information about waste disposal from a government staff person—you'll just get into trouble. (% Disagree)	52	68	↑	Y	Y	78	↑	Y	Y

n = sample size
↑ - Increase; ↓ = Decrease
* The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.
N = no; Y = yes

Table 4-7. Survey Comparison, Baseline and Postsurvey (continued)

	Baseline n = 93	Whole Aurora Area Sample n = 85				Visited Subgroup n = 23			
Questions About Changes in Practice	Score (%)	Score (%)	Direction of Change	Sig? 95%	Sig? 90%	Score (%)	Direction of Change	Sig? 95%	Sig? 90%
8/7.* My business recycles some of its wastes. (Yes)	76	72	↓	N	N	87	↑	N	N
12/11.* Its common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down the drain. (% Disagree)	51	60	↑	N	N	61	↑	N	N
18/17.* In the past year, has your business made changes in the way its disposes of waste? (% Yes)	46	52	↑	N	N	64	↑	N	Y
change method of disposal?	28	28	0			21	↓		
recycle more?	78	88	↑			86	↑		
use less toxic product?	25	35	↑			50	↑		
change storage practices (added)		28	NA			50	NA		
use hazardous waste disposal service?	28	30	↑			57	↑		
change practices?	8	12	↑			14	↑		
other?									
19/18.* Why might you make changes in waste management?									
concern for the environment	67	80	↑			86	↑		
economically advantageous	34	37	↑			41	↑		
concern about public image	28	34	↑			41	↑		
concern about liability	25	37	↑			59	↑		
new technology available	23	27	↑			36	↑		
high disposal costs	20	22	↑			23	↑		
concern about government enforcement	18	33	↑			64	↑		

n = sample size
↑ - Increase; ↓ = Decrease
* The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.
N = no; Y = yes

Table 4-7. Survey Comparison, Baseline and Postsurvey (continued)

Questions About Information Delivery	Baseline n = 93 Score (%)	Whole Aurora Area Sample n = 85 Score (%)	Direction of Change	Sig? 95%	Sig? 90%	Visited Subgroup n = 23 Score (%)	Direction of Change	Sig? 95%	Sig? 90%
17/16.* What is the best way for you to learn about waste management regulations on a scale of 1 to 5, with 1 being best. (% 1 or 2)									
printed information	100	100				100			
trade/business newsletter	50	62				81			
newspaper	33	35				19			
business associate	22	29				25			
meetings		38				44			
onsite consultation with agency staff	45	67				69			
onsite consultation with private specialist	23	48				63			
product suppliers/waste haulers		42				50			
information hot line	48	60				56			
other									

n = sample size

- The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.

inherent difficulties which need to be considered before conclusions can be drawn. The most important of these difficulties are:

- The design of the survey itself
- Selection bias, which is inherent in most mail-back surveys
- Contemporaneous effects; that is, effects occurring at the same time the program of interest is operating

First, the survey instrument itself should measure the changes, or surrogates for the changes, that the program is designed to remedy or effect. For instance, if less water pollution is the desired outcome, specific polluting actions, or factors affecting those actions, should be measured. In addition, a reader should not be lead by the question; that is, should not be able to tell what answer may be desired from the wording of the question. Another problem is in determining whether responses are honest or whether the respondent simply felt they ought to answer a certain way. This might be the case when asked about reasons for making waste management changes. Respondents may have felt it necessary to indicate "concern for the environment" whether or not they felt such concern.

Secondly, mail-back surveys invariably are subject to selection bias; that is, the group responding is not chosen randomly but self-selected by those choosing to mail back responses. It is possible that those returning the survey may be more interested in the subject matter, be more cooperative, or have other traits that make the sample biased, or unrepresentative of the whole population of interest. By drawing a random sample of businesses not returning the survey and interviewing them by phone, it was concluded that the mail-back sample could be used to represent the larger business community of interest. However, because the random sample was small, confidence limits for the sample were broad. Thus, some amount of selection bias was probably present in the survey samples (both baseline and postsurveys).

The third major problem with evaluation of a rather complex system such as a business community relates to the fact that other factors and events also occur at the same time the program of interest is being carried out. These other factors may influence or have an effect on the

same variables the primary program is trying to influence. For instance, 1990 saw the 20th anniversary of Earth Day, with much media attention to environmental problems. If awareness of the specific items asked in the survey was increased because of this publicity, the evaluation technique employed would also measure whatever change was caused by Earth Day publicity.

A problem similar to this is referred to as a maturation effect. Over time, the population of interest can become more informed, and the general baseline level of knowledge can increase. Use of a control group or a comparison group can be used to detect general changes over the time of the study. Use of the comparison group in West Seattle was done to detect and control for this source of error. Additional sources of error could be due to businesses entering and leaving the area during the outreach program.

Another source of bias in a before/after survey is that respondents, because of their increased familiarity with the survey, tend to do better on the postsurvey. About 35 percent of responses to the postsurvey were from businesses that had also responded to the baseline survey. Though not a high percentage, some increase in tendency to more frequent correct responses might be attributed to this effect.

Comparison Group Analysis. To detect whether there might be a general increase in base-level knowledge and awareness about waste management practices among Seattle area business operators during the 7-month site visit period, a comparison group in West Seattle was evaluated with the same survey and postsurvey as used in the source control area. Unfortunately, the return rate was low, 15 and 14 for the baseline and postsurveys, respectively.

Table 4-8 shows that for the questions testing knowledge of general waste management regulations and fate of pollutants, there was not a general increase in the frequency of correct responses in the comparison group. In fact, all scores decreased, with decreases being statistically significant in some cases. Six of 14 postsurveys were returned from businesses which had also returned surveys in the baseline survey. Eight were from businesses responding for the first time.

Table 4-8. Comparison Group Responses, Baseline and Postsurvey

	Questions Measuring Knowledge (correct response in parenthesis)	% Correct Response: Before n = 15	% Correct Response: After** n = 14	Trend	Significant? 95%	Significant? 90%	Significant? 80%
1.	Small businesses are exempt from most waste disposal regulations. (No)	93	64	Decrease	N	Y	Y
2.	Sewage treatment plants can adequately treat all the various wastes produced by industries. (No)	87	50	Decrease	Y	Y	Y
3.	Harmful or hazardous chemicals are only used by large industries. (No)	93	79	Decrease	N	N	N
4.	Small businesses as a group contribute less than large business and industry to the waste loads of sewage treatment plants. (No)	53	43	Decrease	N	N	N
6/5.*	It is against the law to allow oil to enter storm drains. (Yes)	87	79	Decrease	N	N	N
7/6.*	Used oil, paint thinner, and antifreeze should not be poured onto the ground because they could pollute the groundwater. (Yes)	100	86	Decrease	N	N	N
14/13.*	I know the recommended disposal methods for all wastes my company produces. (Yes)	67	64	Decrease	N	N	N

n = sample size
* The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.
** Six repeats, eight first-time responders.
N = no; Y = yes

Table 4-8. Comparison Group Responses, Baseline and Postsurvey (continued)

		% Correct Response		Trend	Significant?		
	Questions Measuring Attitudes	Before n = 15	After** n = 14		95%	90%	80%
10/9.*	Customers will use "environmentally friendly" establishments even if their prices are slightly higher. (% Agree)	73	79	Increase	N	N	N
11/10.*	I pay attention to waste disposal only when required to by regulation. (% Disagree)	60	71	Increase	N	N	N
13/12.*	Never ask for information about waste disposal from a government staff person—you'll just get into trouble. (% Disagree)	60	64	Increase	N	N	N
	Questions About Changes in Practice						
8/7.*	My business recycles some of its wastes. (Yes)	93	71	Decrease	N	N	Y
12/11.*	Its common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down the drain. (% Disagree)	47	71	Increase	N	N	Y
18/17.*	In the past year, has your business made changes in the way its disposes of waste? (Yes)	38	55	Increase	N	N	N

n = sample size
* The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.
** Six repeats, eight first-time responders.
N = no; Y = yes

Table 4-8 also shows that there was an increase in the number of businesses in the comparison group reporting changes in waste management practices, from 38 percent in the baseline to 55 percent in the postsurvey. This trend is not, however, statistically significant at even the 80 percent level of confidence. Two other questions concerning changes in waste management practices were asked. Question 12/11* stated, "It is common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down street or sidewalk drains." The number of comparison group respondents disagreeing or disagreeing strongly with the statement increased from 47 percent to 71 percent, significant at the 80 percent level of confidence. Interestingly, a decrease in the proportion of respondents saying they recycled at least part of their business waste occurred. In the baseline survey, 93 percent of respondents said they recycled, and in the postsurvey only 71 percent said they recycled. This decrease tested significant at the 80 percent confidence level.

In summary, it seems unlikely that a general increase in knowledge about the waste management questions asked took place between April and November 1990. Nor does there appear to be a general trend toward increased recycling during that time period. There may, however, be an increase in the number of businesses making waste management changes, but this trend cannot be stated with more than 80 percent confidence. This trend should be considered plausible rather than established.

North Aurora Area Analysis.

Knowledge of Waste Management. Seven questions in the survey asked about general knowledge of waste management practices and the fate of pollutants. For three questions, respondents did slightly worse on the postsurvey than on the baseline survey. These questions are:

- Question 1. "Small businesses are exempt from most waste disposal regulations," (correct answer is "No"), decreased from 81 to 76 percent.

* The split numbering refers to the question numbers on the baseline and postsurveys. Since Question 5 was deleted on the postsurvey, the same questions have different numbers in the two instruments.

- Question 3. "Harmful or hazardous chemicals are used only by large industries," (correct answer is "No"), decreased from 87 to 82 percent.

- Question 4. "Small business as a group contribute less than large businesses and industry to the waste loads of sewage treatment plants," (correct answer is "No"), decreased from 42 to 38 percent.

For four of the questions, the respondents did slightly better on the postsurvey. These questions were:

- Question 2. "Sewage treatment plants can adequately treat all the various wastes produced by industries," (correct response is "No") increased from 60 to 72 percent.

- Question 6/5. "It is against the law to allow oil to enter storm drains," (correct answer is "Yes") increased from 85 to 87 percent.

- Question 7/6. "Used oil, paint thinner, and antifreeze should not be poured onto the ground because they could pollute the groundwater," (correct answer is "Yes") increased from 92 to 96 percent.

- Question 14/13. "I know the recommended disposal methods for all wastes my company produces," (tallied frequency of "Yes" responses) increased from 56 to 62 percent.

However, only one of these tendencies was statistically significant at the 90 percent level of confidence. This was Question 2, "Sewage treatment plants can adequately treat all the various wastes produced by industries," which increased from 60 to 72 percent. None of the questions which showed decreases in the number of correct responses, nor the other three questions showing increases in the proportion of correct responses, were significant at the 90 percent confidence level.

Responses were also compared for the subgroup visited during the project. Although all questions except Question 3 showed a slight tendency toward increased proportion of correct responses, none were significantly different from the baseline survey at a 90 percent level of confidence. Question 3, "Harmful or hazardous chemicals are only used by large industries," showed the same response as the baseline sample.

Discussion: The only question that clearly demonstrated improved level of knowledge was Question 2, "Sewage treatment plants can adequately treat all the various wastes produced by industries." More respondents in the postsurvey knew this statement was false (from 60 percent to 72 percent). Information about wastes that should never be discharged to the sanitary sewer was included on the general project flyer entitled, *"Are you pouring water quality down the drain?"* The flyer was distributed along with the July 6, 1990 letter to all businesses in the basin and is included in Appendix E.

However, a similar increase was not seen in the visited group. The same pamphlet, and in some cases an additional fact sheet about restricted wastes, was distributed to visited sites. Even though the increase in the postsurvey was significant at the 90 percent level of significance, it seems possible that the higher frequency of correct response may have been a sampling fluke, since a similar increase could not be demonstrated in the visited group. It may also be, however, that the visited group results were a fluke, and the project did contribute to the improved level of knowledge.

Attitudes Relevant to Waste Management. Three questions were about the attitudes or opinions of business owners about various waste management issues. Slightly more than half (52 percent) of the baseline respondents agreed or agreed strongly with Question 10/9, "Customers will use environmentally friendly establishments even if their prices are slightly higher." In the postsurvey, 60 percent of respondents indicated they agreed or agreed strongly with the statement. The increase was not statistically significant at the 90 percent level.

Respondents disagreed with the other two statements in this category. These were as follows:

- Question 11/10. "I pay attention to waste disposal only when required to by regulations" (disagreeing or disagreeing strongly increased from 51 to 66 percent).

- Question 13/12. "Never ask for information about waste disposal from a government staff person—you'll just get into trouble" (disagreeing or disagreeing strongly increased from 52 percent to 68 percent).

Both these increases were statistically significant at the 95 percent level of confidence. The visited group showed the same increases in response for these two questions, but the increase for Question 11/10 was only significant at the 90 percent level of confidence.

Discussion: Responses to Question 13/12, "Never ask for information about waste disposal from a government staff person—you'll just get into trouble" was disagreed with more frequently by both the whole Aurora postsurvey sample and the visited group as well. Both increases (from 52 percent to 68 percent for the whole sample and to 78 percent in the visited group) were significant at the 95 percent level of confidence. The comparison group also showed an increasing number of respondents disagreeing with this statement, but not by a statistically significant amount (60 to 64 percent). Thus, it appears that the message that government can be approachable and is willing to help businesses with waste disposal problems was successfully communicated to businesses in the drainage basin.

Changes in Practices. Three questions on the surveys asked about changes in recycling or other waste management practices, and one question asked about motives for these changes. The questions asked and responses are indicated below:

- Question 8/7. "My business recycles some of its waste" (tallied as percent "Yes") decreased from 76 to 72 percent.

- Question 12/11. "It's common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down the drain" (disagreeing or disagreeing strongly) increased from 51 to 60 percent.
- Question 18/17. "In the past year, my business made changes in the way it disposes of waste" (percent "Yes") increased from 46 to 52 percent.

As indicated in Table 4-7, none of these changes were statistically significant at the 90 percent level of confidence. They do, however, mirror the tendencies seen in the comparison group. In the comparison group, there was a decreasing percentage saying that they recycled waste, an increasing percentage disagreeing that it was common to wash litter from sidewalks or parking lots down storm drains, and an increasing percentage saying that they made changes in waste management.

Considering just the visited group, an increase in frequency of changes in waste management from 46 to 64 percent was reported. This increase is significant at the 90 percent level of confidence. The types of changes made were also scored for frequency of response. Table 4-9 compares results for the baseline survey, the whole sample postsurvey, and the postsurvey visited group.

TABLE 4-9. Types of Changes Made (%)*

	Baseline (%)	Postsurvey Whole Aurora Area (%)	Visited Group (%)
Changed disposal method.	28	28	21
Recycled waste.	78	88	86
Changed to less toxic product.	25	35	50
Changed waste storage practices.	–	28	50
Used hazardous waste disposal service.	28	30	57
Changed practices.	8	12	14

* Number making change indicated ÷ total number making changes. Total is greater than 100% because multiple responses were solicited.

Evaluating Effectiveness

The most frequently cited change was increased recycling. Of those in the postsurvey who said they made changes, 88 percent of the whole Aurora sample and 86 percent of those in the visited group said they began recycling, compared to 78 percent in the baseline survey. Note that these figures only apply to those stating that they made changes, not to the Aurora area sample as a whole. More than one response was permissible for this question, making statistical analysis difficult, but it is apparent from inspection that the visited group made more changes in storage practices, changed to less toxic products, and began using a hazardous waste hauling firm more frequently than is characteristic of the whole Aurora sample.

Reasons for making changes were also asked (Question 19/18). The postsurvey showed changes in the relative frequency with which some reasons were cited, as can be seen from Table 4-7. For both the baseline and postsurveys, concern for the environment was the most frequent response given, increasing from 67 percent to 80 percent. The postsurvey showed that concern for liability was somewhat more important than in the baseline survey (tied for second place in the postsurvey versus fourth place in the baseline). Concern for enforcement was also more of a concern, rising from last place (seventh in the baseline) to fourth place in the postsurvey.

Again, the visited group showed differences from the whole sample in their motives for making changes. The visited group shares concern for the environment as the primary reason given for making changes (86 percent). However, concern for enforcement is cited next most frequently (64 percent), followed by concern for liability (59 percent). Concern about public image and changes made for reasons of economic advantage are given equal weight, both cited with a frequency of 41 percent.

Discussion: The visited group indicated they made changes in waste management proportionately more than for the whole Aurora sample. They also more frequently made changes to less toxic products, changed storage practices, and began to use hazardous waste haulers. These are generally the types of recommendations given to businesses during onsite consultations. Although other sources of influence cannot be ruled out, it seems likely that the outreach effort positively influenced the number of changes made by the visited group.

It should be recognized that the businesses that were not visited had few or no occasions to modify waste management practices since they do not produce liquid wastes nor store chemicals onsite. The visited group had, conversely, more occasions to make changes.

There also appears to be a distinction in factors that motivate firms to make changes in waste management practices, depending on whether or not they produce wastes. Although both the whole sample and the visited group cite concern for the environment as the primary reason they would make changes, firms that produce liquid wastes or store chemicals were much more apt to be concerned about enforcement than other firms (64 percent versus 33 percent). It is understandable that those who have a higher potential of polluting would be more concerned about enforcement than those who have little or no potential. Concern about liability, public image, and economic advantage are also cited more frequently by the visited group than for the whole Aurora sample.

Learning About Waste Management. Question 17/16 (Table 4-7) asked respondents to rate the best methods for them to learn about waste management regulations and practices. Responses were evaluated by calculating the relative frequency with which an item was rated either 1 or 2—the two highest scores—on a scale of 1 to 5. For instance, in the postsurvey, 52 respondents rated printed information—as 1 or 2. The next highest rating was trade journals, with 32 respondents rating it 1 or 2. Thus, the relative ratings for printed information and trade journals are 52/52 (or 100 percent) and 32/52 (or 62 percent). Using this system, the top four items are the same as in the baseline survey. These items include printed information (a clear first choice), information in trade or business journals, an information hotline, and onsite consultation with agency staff, although the order of the last three items varies somewhat between the surveys. The lowest rated sources of information are from business associates and newspapers. Onsite consultation with a private professional, product suppliers and meetings were rated of intermediate preference. However, the visited group rated onsite consultation with a private professional higher, ranking fourth in frequency cited, higher than calling an information hotline.

Discussion: These rankings by business operators reflect the fact that small businesses have limited ability to make time for meetings offsite, and prefer either reading about requirements from a reliable source (trade

journals are favored over newspapers) or consulting with specialists onsite. Calling an information hotline also appears to be a favored mode of information acquisition.

There was a distinction made between consulting with an agency versus a private specialist. This question tested whether agency specialists were viewed as less knowledgeable than private sector specialists. This does not appear to be the case, either for the whole sample (67 percent preferring consultation with an agency staff person to 48 percent preferring consultation with a private specialist) or for the visited group (69 percent preferring agency staff to 63 percent preferring a private specialist). The cost to hire a private specialist may have also influenced the ratings.

Perception of Risk. Two questions in the postsurvey asked how businesses perceived risks, both to business liability and to the environment, due to commonly encountered situations with potential to cause water pollution. Question 14 asked business operators to rank specified on a scale of 1 to 5 practices or situations based on their opinion of the potential liability to businesses. Question 15 asked that the same practices be rated based on risks posed to the environment. The five situations addressed are summarized in Table 4-10, along with the results. Responses were tabulated by tallying the frequency with which respondents identified a situation as a major risk or a definite risk (a ranking of 1 or 2).

Respondents perceived spills or discharges of oil or solvent, fuels, and antifreeze to be of greatest potential risk, both in terms of business liability and to the environment. However, in most cases respondents more frequently rated the risks to the environment as greater than the risks to business liability. The most serious risk was perceived to be oil or solvent leaking into the ground. Risk to the environment was rated a major or definite risk by 93 percent of the respondents for such leaks, whereas risk to business liability was judged to be a major or definite risk by only 85 percent. Respondents regarded dispensing solvents or fueling vehicles in areas draining directly to storm drains as almost as great a risk, with 90 percent rating the risk to the environment as a major or definite risk. For antifreeze release to storm drains, likelihood of major or definite risk to the environment was perceived by 87 percent of respondents, while risk to business liability was perceived by only 82 percent.

TABLE 4-10. Perceived Risk From Common Pollution-Prone Situations (frequency of response in % and 95% confidence interval)

Situation	Business Liability Risk (Question 14)		Environmental Risk (Question 15)		Business Liability Risk (Question 14)	Environmental Risk (Question 15)
	Whole Aurora (n=84)	Visited Group (n=23)	Whole Aurora (n=84)	Visited Group (n=23)	Comparison Group	
Allowing oil or solvent to leak into ground.	85 (77-93)	78	93 (86-99)	83*	83	91
Dispensing solvent or fueling vehicles in area draining directly to storm drains.	83 (75-91)	74*	90 (83-97)	83	83	100
Storing liquid wastes in an unpaved area without a roof.	73 (63-83)	70	71 (61-81)	65	67	82
Washing detergents or soapy water into storm drains.	36 (26-46)	35	52 (41-63)	48	42	45
Letting antifreeze drain into storm drains.	82 (74-90)	74	87 (80-94)	87	67	91

n = sample size
* Significantly lower than score of whole Aurora sample at 95 percent level of confidence.

Evaluating Effectiveness

Lack of storage precautions for liquid wastes was rated less frequently as a major or definite risk, both in terms of liability (73 percent) and environmental risk (71 percent). This is also the only situation for which risk to the environment was not judged to be higher than the risk to business liability.

Respondents perceived washing soap or detergents into storm drains as having the lowest risks. However, risks to business liability from discharging detergents into the storm drain were perceived much less frequently as major than were risks to the environment (36 percent versus 52 percent). This difference is statistically significant at the 95 percent confidence level.

Discussion: Business owners regarded washing soaps and detergents into storm drains as a less risk-prone problem, both in its impact on the environment as well as to business liability, than the other situations identified. During the site visits and area surveys, few business owners felt there was a threat to liability for discharging detergents and soaps. Indeed, analysis of the actual impact of soaps on the ecology of Lake Union has not yet been done. If it is found to be a concern, survey results indicate it would be important to provide information about the adverse environmental effects of detergents and soaps in any future program to control discharges.

Dispensing solvents or fueling vehicles near storm drain outfalls was rated almost as frequently as leaking tanks as a major or definite risk, both to the environment and to business liability. Control of leaking tanks has been addressed very aggressively by national and state legislation. Most business operators in the visited group know about the underground tank regulations—some were affected by them. However it is a common practice to fuel vehicles and dispense solvents near storm drains. In fact, all gas stations and many businesses visited have fueling stations near enough to storm drains so that even small spills would enter these drains. This was one of the three general problems addressed by this Source Control Project.

Awareness of the potential risk appears high, even though a less concerted regulatory effort has been placed on controlling fuel spills into storm drains. Since perception of risk was also high in the comparison group, it seems reasonable to conclude that the potential seriousness of

fuel or solvent spills into storm drains is realized by many business owners. In this case, knowledge of the risk has not brought about effective structural controls for controlling spills, at least in the north Aurora drainage area. Such structural controls could consist of re-plumbing to divert drainage to the sanitary sewer and providing oil/water separators to catch small spills. These controls are not currently required by regulatory agencies, though the Department of Ecology may soon make a recommendation to local governments to adopt such controls as part of stormwater management programs. The management practices identified in this project (see Appendix E) offer a lower-cost approach to deal with the problem.

There is a tendency for the visited group (businesses typically dealing with these pollution-prone situations) to perceive the risks as lower than the whole sample, both to business liability and to the environment. In most cases the tendency was not statistically significant; that is, the score for the visited group falls within the 95 percent confidence interval for the whole Aurora sample. In two cases—risk to business liability from dispensing fuel or solvent near storm drains, and the risk to environment from leaking oil or solvent tanks—the lower rating was, however, significant (95 percent confidence level). It seems reasonable that business operators who encounter these situations frequently would tend to view the risk as less serious than those who do not. It is well known that perception of risk can be influenced by whether the risk is familiar or not (National Research Council, 1989). It could also be the case that these business operators are better aware of instances that might be liability concerns, and these instances are fewer or less severe than they appear to those who simply are observers of the problems.

General Conclusions from Survey.

Level of Knowledge. For most questions, level of knowledge was already high in the source control area as measured by the baseline survey. A statistically significant increase in knowledge occurred only for one question. The question showing change was Question 2 regarding the ability of sewage treatment plants to adequately treat all the various wastes produced by business and industry. Since a statistically significant improvement was not also seen in the visited group, the extent to which the improvement is simply a sampling fluke rather than attributable to information distributed during the project can be questioned.

Evaluating Effectiveness

Attitudes. Attitudes about the accessibility of agency staff to provide assistance about waste management problems was improved during the 7 months of technical assistance to targeted businesses. Both the whole sample as well as the visited group significantly increased the frequency with which they disagreed with the statement "Never ask for information about waste disposal from a government staff person—you'll just get into trouble."

The outreach effort had purposely moved away from a command and control approach, which relies on strict interpretation of regulations, in favor of a technical assistance approach. Information was provided to all businesses in the area about waste recycling and other actions to prevent pollutants from escaping into the environment. Additional specific information was sent to firms targeted as likely to have specific problems. It seems likely that this project influenced businesses to look more positively at government as a source of information about problems they might encounter. This result appears more tenable since the comparison area showed no significant increase in warming of attitudes toward government.

In the postsurvey, the whole Aurora sample also disagreed more frequently to the statement, "I pay attention to waste disposal, but only when required to by regulations," from 51 to 66 percent. Letters sent to businesses did emphasize that good pollution control has advantages to the business owner in reducing liability for future spills and enforcement action, as well as environmental benefits. Attributing the change to the project cannot be done with certainty because of the nonspecific nature of the information provided, and because other co-occurring factors may have also influenced the change.

Waste Management Practices. Improvements were made in waste management practices during the outreach effort. For the whole sample, the increase (from 46 to 52 percent) was not statistically significant. In the visited group, the increase (from 46 to 64 percent) was significant at the 90 percent level of confidence. The comparison group did show an increase also, but it was not statistically significant. Besides the University Regulator Source Control Project, there are other factors that could account for changes in practices. One could be requirements of the Seattle Fire Department for hazardous materials storage, and another could be the activity of vendors selling various waste management products or

services. The survey is not able to distinguish among these alternative explanations. The outreach effort cannot, however, be ruled out as an influencing factor.

Information Transfer. The survey also provided information useful for future outreach projects. Specifically, reasons for making changes in waste management (Question 19/18) and best methods of learning about waste management regulations (Question 17/16) were informative. It is notable that the primary motive for making changes is out of concern for the environment. Businesses that manage chemical or petroleum wastes also cite concern about enforcement, liability concerns, concerns about public image, and economic advantages as important motives.

The highest-ranked methods for learning were printed information, articles in business or trade journals, onsite consultation with specialists, and information hotlines. Meetings, newspapers, and business associates were poorly rated as effective methods.

Risk Perception. Spills or leaks of oil or solvent, fuel, and antifreeze were perceived to be the highest-risk situations, both to the environment and to business liability. In these cases, risk to the environment was rated as greater than the risk to business liability.

DISCUSSION AND RECOMMENDATIONS

The north Aurora watershed is characterized by low pollutant concentrations in stormwater samples, including fairly low fecal coliform levels, a large number of commercial land uses, and a high level of knowledge and awareness among business owners about the effects of waste on the environment. However, geographic surveys and site visits revealed poor housekeeping practices which contributed a chronic source of pollutants and a potential for future spills.

Based on the one improper connection found in over 80 sites visited, the area is considered to have a low rate of illicit connections. The reason for this may be because the local storm drainage system is totally separate from the sanitary sewers, with wet weather overflows from the storm drain flowing into Green Lake—a sensitive receiving water. Age of

buildout (predominantly 1960s) may also explain the lack of problems often experienced in older areas.

The north Aurora area is considered typical of many commercial areas of Seattle. The high level of knowledge revealed by the survey may have been due to the ability to "guess" the correct response from wording of the survey questions. However, there are other factors that probably contribute to a high level of waste management knowledge in this area, such as:

- Many shops are owned by landlords who are knowledgeable about environmental regulations and requirements. In one case, a particular level of professionalism is demanded by the landowner as a condition of continued tenant occupancy. Indeed, when problems were found and changes recommended, landowners were valuable allies in encouraging change.

- The area is actively inspected by the Seattle Fire Department. In addition to the fact that all but one business recycled solvents, all businesses had good solvent and flammable storage arrangements. Some business owners reported that the Department conducts two to three inspections per year.

- Product and service suppliers are also a dynamic force who bring information with their product and service lines. This influence can be positive if the information delivered is accurate; however, there is also a potential for spreading misinformation. An example is a common misperception found among auto shop owners that detergents labeled biodegradable were safe to discharge to the natural or storm drainage system.

- Unlike industrial areas, businesses in the watershed are located in proximity to residential communities and draw their customers from the general public. This proximity to the residential community may provide business with public scrutiny and encourage them to take more care in managing wastes.

These factors are probably also operating in many other watersheds, both in the City and at suburban locations.

Specific Recommendations for Followup

Two of the three general problems identified in the watershed—those of inappropriate disposal of floor wash water and lack of spill control near fueling and solvent transfer areas—were dealt with during the project. However, it is likely that problems corrected by adopting better operating practices will revert if not encouraged.

- It is recommended that the City of Seattle provide signs free of charge to all businesses with fuel tanks or pumps, which warn of fuel spillage dangers. Providing labor to post the signs would make it more likely signs would be displayed.

- It is also recommended that Metro and the City jointly publish a newsletter containing specific information about construction progress of the new storm drain, and reinforce the need for proper fueling precautions and floor washing waste disposal.

Further, information about toxicity of soaps should be conveyed to the businesses, and the following undertaken:

- It is recommended that Metro evaluate the impact on Lake Union of dry weather soap use in the watershed. A recommendation for dealing with the problem should be coordinated with the City of Seattle and the Department of Ecology. In the interim, businesses should be encouraged to use one of the least toxic soaps identified, such as Believe, Xotox, Simple Green, or ESP.

- If soap toxicity presents a risk to Lake Union, Metro should work with the City of Seattle to allow dry weather wash water to be disposed of in the sanitary sewer. Car dealers and body shops should be contacted about diversion of soap to the sanitary sewer.

Discussion and Recommendations

General Recommendations

Site Visits. Although the level of knowledge and awareness in the north Aurora area appears high, several practices with pollution consequences were noted. Indeed, several times obvious problems were overlooked by business operators. Onsite visits provide the ability to identify risk-prone practices that might not be detectable any other way. They also offer an opportunity to personalize government and build credibility. Business operators were generally not enthusiastic about site visits; however, they could see why precautions were requested and that it was to their advantage to reduce the risk of spills. Site visits are time-consuming, but are effective for technical assistance programs. The fact that business operators rated onsite consultation highly further supports this recommendation.

Concurrent Outreach to Business and Community. In Metro's initial approach to the University Regulator Source Control Project, it was planned that outreach to the community as well as the business operators would be pursued. Community outreach efforts were to be conducted at the same time as the business outreach. Due to staffing constraints, outreach to the community was delayed. Delays are a reality, but it is recommended as most effective if outreach to both groups occur during the same time period. Opportunities for reinforcement of messages are gained by timing both efforts simultaneously. For instance, most business operators frequent community services such as grocery stores, restaurants, post offices, and libraries. Brochures and posters in these localities aimed at the community would also be seen by those who work in the watershed, reinforcing messages delivered by letter or personal visit.

Single Watershed Efforts. Watershed-by-watershed source control efforts have distinct advantages in connection with sewer separation projects. They are in a small enough area so that illicit connections can be sought and individual sources and problems identified. Despite these advantages and the positive results from this outreach effort, it should be recognized that working with only a single watershed has drawbacks. Outreach strategies that involve voluntary gatherings, such as meetings, workshops, or tours, are difficult to apply successfully on a small scale since attendance would be sparse. Indeed, all workshop and meeting opportunities offered during the Source Control Project were as part of larger programs drawing on citywide or countywide participation.

A similar problem occurs in writing articles for trade or business journals. The area covered by these journals is large, and this information will reach a very small number of businesses in one particular watershed. Since the audience of the journals is usually regional, it becomes more efficient to target a regional audience rather than a local one.

In addition, opportunities inherent in other pollution control approaches, such as incentives in the form of certification programs or subsidies, are lost since they are usually not appropriate on a very small scale. (See Appendix A for more details.) Source control projects conducted over a broader area have the flexibility of adopting a wider range of pollution control strategies than do single-watershed approaches.

SUMMARY AND CONCLUSIONS

The University Regulatory Source Control Project was conducted in a commercial/residential watershed that lacked outward signs of pollution. Stormwater samples did not show high levels of fecal coliform bacteria or other pollutants, which would indicate a lack of improper connections to the storm drainage system. Wastewater samples from a portion of the subbasin also showed low pollution levels. A mail-back survey was sent to area businesses to determine their knowledge, attitudes, and actions concerning general waste management. The survey showed a higher-than-expected level of awareness of the fate of pollutants and waste management.

Even so, low strength, chronic pollution problems from multiple sources were found in the watershed, and one significant pollution source was identified and corrected. A technical assistance approach was successful in remedying at least half of the problems identified during site visits. This compared favorably with a command and control approach used in the Lander Separation Project, which was able to correct a similar proportion of problems identified within the same time frame (True, 1989).

An evaluation showed the potential costs, associated with failure to identify and clean up the one major pollution source identified, very nearly equaled the cost of conducting the source control project. Cleanup costs of a spill scenario for this site, involving a 55-gallon solvent spill and the chronic discharge of metal-contaminated sediment for 3 years, is estimated to cost about $57,000. The cost of the source control project,

with minimal followup for 3 years, is estimated at $58,000. The determination was made on the basis of estimated cleanup costs only, and did not consider harder-to-quantify intangible costs such as health risks, loss of recreational opportunity, or tainting of fish resources. Benefits from preventing smaller, nonpoint sources of pollution were not estimated due to difficulty in quantification. Those benefits are central, however, to preventing degradation of lakes and streams, and the crux of successful nonpoint pollution control projects.

A followup survey, administered after technical assistance and public information efforts were completed, showed a warming of attitudes toward government as a source of information about disposal problems.

Businesses that were visited onsite during the project showed an increase in actions taken to improve waste management from 46 percent to 64 percent (90 percent confidence level). However, the whole sample showed an increase from 46 percent to only 52 percent, which is not statistically significant, and cannot be distinguished from chance variation.

Businesses preferred to learn about waste management from printed material, onsite consultations, and information hotlines rather than meetings.

Regarding risks, businesses surveyed regarded spills of oil, fuel, and antifreeze to have the highest environmental risk of problems identified in the watershed. In general, businesses rated risks to the environment as greater than risks to business liability.

APPENDIX A

EVALUATION OF POTENTIAL STRATEGIES FOR CONTROLLING NONPOINT SOURCES OF WATER POLLUTION

APPENDIX A
EVALUATION OF POTENTIAL STRATEGIES FOR CONTROLLING NONPOINT SOURCES OF WATER POLLUTION

CONTROL OF NONPOINT POLLUTION AT THE SOURCE

Controlling the damages from nonpoint pollution can be done in one of two basic ways. Polluted water can be treated (either passively using gravity or actively with energy-intensive methods) or controls can be exerted at the source to prevent pollutants from getting into the water in the first place. The latter method, called source control, is generally considered the least-cost method of pollution control. It is also most protective of the resource, a fortuitous combination, making source control a prime focus of nonpoint pollution control efforts (U.S. EPA, 1987; Thomas, 1987).

Nonpoint pollution consists of small contributions from a large number of sources. Therefore, for source control to be successful, a large number of contributors must change their behaviors or actions. In order for change to occur, however, some basic preconditions are necessary. Ryan (1989) has found that change is more likely to result from programs that have addressed three conditions:

- Behavior is more likely to change if there is awareness and acknowledgment that actions are causing or contributing to a pollution problem.

- Behavior is more likely to change if acceptable alternative actions can be identified, especially if these alternatives cause minimal disruption.

- Behavior is more likely to change if there is a belief that the actions will make a difference in solving the problem identified.

These preconditions are important to consider in developing source control projects where behavioral changes are involved. Within this broad

perspective, each particular source control initiative has specific objectives, depending on the overall project goals and the particular characteristics of the watershed involved. For instance, source control projects might emphasis pollutants discharged to the sanitary sewer, the municipal solid waste stream, or that contribute to air pollution. The source control project carried out in conjunction with the University Regulator Combined Sewer Overflow Control Project will be used as a specific example for the rest of this analysis. The University Regulator Project was primarily concerned with pollutants that would be contributed to the natural storm drainage system.

SPECIFIC OBJECTIVES FOR THE UNIVERSITY REGULATOR PROJECT

The University Regulator Source Control Project was carried out in the north Aurora watershed, an urban watershed of North Seattle which is characterized by a mix of commercial business and residential land uses. Five specific pollution control objectives were identified as important for achieving source control in this watershed. These objectives are as follows:

- Cross-Connections. Identify and correct cross-connections (plumbing connections) where sanitary flows might be incorrectly connected to the storm drainage system.

- Risk of Spills. Reduce the risk of spills of chemicals and petroleum products to storm drains.

- Waste Disposal Options. Encourage adoption of good waste disposal options, particularly for liquid or petroleum wastes.

- Housekeeping Practices. Encourage adoption of good housekeeping practices that reduce transfer of pollutants to the storm drains.

- Routine Maintenance. Encourage routine maintenance of catch basins and oil sumps and separators.

Though these objectives are not atypical, it should be noted they are specific to the north Aurora watershed after the major causes of nonpoint pollution had been identified. In general, objectives can be expected to be different for different areas since the causes of nonpoint problems are likely to be different.

EVALUATION OF ALTERNATIVE STRATEGIES FOR ACHIEVING POLLUTION CONTROL

Section 1 of the text identifies eight major alternatives with potential to reduce water pollution from nonpoint sources. Five alternatives are classified as economic incentives. These alternatives are listed as follows:

- Command and control regulation
- Taxes*
- Direct subsidies*
- Certification programs*
- Technical assistance programs*
- Extending liability to include pollution damages*
- Development of waste management markets
- Provision of public awareness and education

Table A-1 lists the five specific objectives identified for the University Regulator Source Control Project and compares the expected performance of all eight alternatives. Cost considerations are evaluated at the bottom of the table. Costs include four aspects: costs to the business, costs to administer, costs to enforce, and any social inefficiency costs likely to result from the alternative.

The extent to which alternatives meet objectives are rated 0, 1, or 2. Those alternatives that are not applicable or with little or no potential to achieve the objective are assigned a value of "0", those with moderate potential assigned a "1", and those with good potential assigned a "2". All objectives are counted at full value with the exception of maintenance, which is weighted at half the value.

---

* Categorized as economic incentives.

TABLE A-1. University Regulator Source Control Project Evaluation of Source Control Objectives of Alternatives

Program Objectives (Benefits)	Command and Control	Incentives					Market Develop-ment	Aware-ness/ Education
		Taxes	Subsidies	Certifica-tion	Technical Assistance	Liability		
Cross-connections identified	NA	NA	NA	NA	NA	NA	NA	NA
Risk of spills reduced	1	0	0	1	1	2	NA	1
Good waste disposal practices	2	0	1	2	1	1	1	1
Good housekeeping adopted	0	0	0	2	1	1	NA	0
Oil sumps maintained (X 0.5)	0.5	NA	1	0.5	0	0.5	NA	0
Total Benefits	3.5	0	2	5.5	3	4.5	1	2
Program Costs								
Business costs	High	High	Low	Mod	Mod	High	Low	Low
Administering costs	High	Low	High	High	High	Low	Mod	Mod
Enforcement costs	High	Mod	[illegible]	High	Low	High	NA	NA
Social efficiency costs	High	Mod	Mod	Mod	Mod	High	Mod	NA
Overall Costs	High	Mod	Mod	Mod	Mod	High	Mod	Mod

0 = little or no potential
1 = moderate potential
2 = good potential
NA = not applicable

Cross-Connections

Identification of cross-connections is a major project objective, but the techniques to identify cross-connections are fairly technical and constrained. Investigating plumbing connections at specific sites, in conjunction with determining water chemistry and fecal coliform concentrations is an effective method for investigating cross-connections. Since this technique can be pursued irrespective of the source control strategy employed, it was rated as not applicable (NA) in Table A-1.

Risk of Spills

Risk of spills can be addressed by all the alternatives with the exception of developing markets that are at present incomplete. Command and control regulation is expected to be only moderately effective in controlling spills, mainly because of the practical limits of enforcement. Provision of public awareness and education is also considered moderately effective in reducing the risk of spills, even though it relies on voluntary compliance. Two of the economic incentives—taxing wastes and providing direct subsidies for correct waste handling—are considered to have little potential for reducing the risk of spills. Both certification and technical assistance programs are likely to have a moderate effect. Overall, extending liability for spill damages is considered to be most effective in reducing the likelihood of spills, since it would reach all parties and provide the correct incentives to adopt controls.

Waste Disposal Practices

Adoption of good waste disposal practices can be addressed to some extent by all the alternatives. The command and control approach and use of a certification program are considered the most likely to ensure good disposal practices are adopted. Both alternatives involve personal contact with a fairly large number of firms; thus, the likelihood of compliance is relatively high. At the same time, these two alternatives have high enforcement costs. Taxing wastes is considered least likely to result in good disposal options being adopted by businesses. Other alternatives, including subsidies, technical assistance, extending liability to include pollution damages, providing education, and developing complete

markets are considered to have a moderate potential to affect waste management practices.

Housekeeping Practices

Another aspect of achieving source control of nonpoint pollutants to the storm drainage system is by the adoption of good housekeeping practices by businesses in the watershed. In particular, pollutants from cleaning floors or waste storage areas need to be kept from entering the storm drainage system. Market development is not considered relevant to this objective. Four other alternatives are judged to have little potential to address housekeeping issues, including command and control regulation, public awareness and education, taxing wastes, or providing subsidies. A certification program is considered the most likely to achieve this objective, with technology transfer programs and the extension of liability likely to have moderate effect in encouraging good housekeeping practices.

Routine Maintenance

The last source control objective is for routine maintenance of catch basins and oil sumps and separators. This objective is somewhat less important than the previous ones, and is weighted by a factor of 0.5 to reflect this. Development of markets that are not yet complete, and taxes are not considered applicable to achieving this objective. Subsidies are most likely to be successful; and command and control, certification programs, and the extension of liability are moderately likely to achieve the objective. Technology transfer and provision of public awareness are likely to have little or no potential to encourage maintenance.

ALTERNATE STRATEGIES EFFECTIVENESS RATINGS

An overall score is determined by adding the scores for each objective (times the weight, if applicable) for each alternative (see Table A-1). The rankings so arrived at reflect the extent to which the alternative is likely to meet the immediate pollution control objectives if applied in a fairly optimal environment.

Likewise, an overall cost is determined for the eight alternatives by averaging the four cost components. The respective rankings of alternatives, and their relative overall costs, are given below:

Rating	Alternative Strategy	Cost
5.5	Certificate program	Moderate
4.5	Extension of liability	High
3.5	Command and control regulation	High
3.0	Technology transfer program	Moderate
2.0	Awareness and public education	Moderate
2.0	Providing subsidies	Moderate
1.0	Developing markets	Moderate
0	Taxing wastes	Moderate

From the rankings, a certification program is the best alternative, considering both the high rating in meeting the source control objectives and the moderate cost. Extending liability for pollution damages is the second best alternative. However, there are other factors that come directly to bear on the practicality of implementing any of these alternatives.

ADDITIONAL CRITERIA FOR EVALUATING ALTERNATIVES

In addition to the consideration of the potential to meet program objectives and overall costs, other factors come into play in evaluating the best alternative strategy to achieve source control. The most obvious include factors directly affecting implementation, but achieving long-range objectives and the inclusion of social acceptance criteria are also relevant. These factors are considered below and summarized in Tables A-2 and A-3.

Implementation Objectives

Implementation concerns are considered apart from the evaluation of program objectives and costs. This is because an agency might not simply choose the strategy that is easiest to adopt, but might choose to invest energy in removing impediments or overcoming other obstacles, such as political acceptance, if the source control benefits of the approach are expected to be significant. Including implementation considerations with the evaluation of objectives blurs distinctions and makes important tradeoffs less obvious.

TABLE A-2. Geographic Implications of Source Control Strategies

Source Control Strategy	Suitable for Single Watershed	Suitable for Larger Area
Command and Control Regulation		
State water quality regulations	Yes, by referral	State
Discharge restrictions to the sanitary sewer	In some cases	In some cases
Economic Incentives		
Tax on pollution	No	County, Region, State
Subsidies		
Challenge grants	Maybe	County, Region, State
Reducing/waiving fees	No	Fee Area
Certification program	No	City, County
Technical assistance	Yes	City, Region, State
Tradeable permits	In some cases	Region or State
Extending liability	No	State
Market Development	No	County + or State
Public Awareness and Education	Yes	County

TABLE A-3. Evaluation of Additional Objectives

Criteria	Command and Control	Incentives					Market Develop-ment	Aware-ness/ Education
		Taxes	Subsidies	Certifica-tion	Technical Assistance	Liability		
Implementation criteria								
Regulatory impediments?	minor	yes	no	no	yes	yes	yes	no
Scale—single watershed?	yes	no	no	yes	no	no	no	yes
Thorough coverage?	yes	tar	tar	tar	tar	yes	tar	no
Long-term success criteria								
Responsibility	no	no	yes	yes	no	yes	no	yes
Basis for judgment	no	yes	yes	no	yes	yes	NA	??
Alternative actions	no	no	no	yes	no	??	NA	??
Social acceptance objectives								
Political support	yes	no	yes	yes	no	no	no	yes
Trades support	no	no	yes	yes	yes	no	yes/no	yes
Neighborhood support	yes	yes	yes	??	no	yes	no	yes

tar = targeted
?? = uncertain
NA = not applicable

Considerations relative to implementation of the alternatives are of critical importance. No matter how favorable an alternative looks in terms of benefits and cost, unless it can be implemented it cannot achieve objectives. In some cases, regulatory impediments exist and would prevent adoption of an alternative without modification of statutory language. For the eight alternatives identified in this paper, three have no regulatory impediments. These include certification and technical assistance programs, and provision of public awareness and education. Minor impediments exist with application of a command and control approach, mainly related to delegation of authority. Providing taxes, subsidies, extending liability, or developing markets all entail some degree of legal or regulatory impediment or requirement that would have to be addressed before the alternative could be applied.

Some alternatives are sensitive to the geographic scale upon which they are applied, and work well only if applied to a fairly broad area. Certain public awareness and education techniques, such as public service announcements, are an example. Since the message is disseminated over a regional area, the technique may not be efficient if meant to be applied only to a local community. Table A-2 provides information about the alternatives and the geographic scales for which they are suitable. In the University Regulator Source Control Project, a very local scale of application is desired, since the watershed is only one of about 50 within the Seattle City limits. Strategies applicable to single, small watershed areas include:

- Enforcement of State Water Quality regulations
- Technical assistance programs
- Public awareness and education programs

Thoroughness of coverage is also a consideration in evaluating the implementation of alternative source control strategies. Techniques that cast a wide net may be appropriate for regional application, but may fail to involve enough pollution sources to achieve objectives if applied on a very local scale. Both public awareness efforts and certification programs exhibit this sensitivity. Some programs would be targeted only at certain types of pollutants or activities. Alternatives most likely to be specifically targeted include taxes, subsidies, and development of markets. Thus, those alternatives would need to be applied in conjunction with other approaches if a variety of businesses or nonpoint pollution sources were to also be addressed.

In small watershed areas, thoroughness of coverage is important. Extending liability to include pollution damages and the command and control alternative have the most thorough potential coverage. Other alternatives would likely be targeted to a particular kind of nonpoint pollution source. These include taxes, subsidies, certification and technical assistance programs, and development of markets that are incomplete. Awareness and education effects are not considered to have thorough coverage. In fact, one of the difficulties of education efforts is often the inability to reach those most needing to receive the information or message.

Long-Term Success Objectives

Another dimension to be considered in evaluating a source control strategy is the potential for long-term success of the program. In dealing with nonpoint sources, where numerous small pollution sources comprise the problem, repeating the intervention is particularly difficult and time consuming. If a source control program can provide sufficient information and motivation to have long-lasting effects, the more likely it is that water quality benefits will be realized.

Long-term success objectives that are identified for the University Regulator Source Control Project include the following:

- Encourage responsibility for actions.
- Provide information about consequences of actions as a basis for independent decisions.
- Offer information about attributes of viable alternatives to pollution.

Of the eight alternatives, the ones that best encourage long-term success are the technology transfer and certification programs. Extending liability to include pollution damages also performs well against long-term success criteria.

Social Acceptance Objectives

Lastly, support or opposition by political or community groups, and trade organizations, can make a great deal of difference in the success

of implementing a source control strategy. Attitudes of certain groups can be altered over time and with effort, so these objectives should perhaps be considered in terms of coalitions to be built rather than static scores. At the present time, there is probably support for a certification program. Business groups, political groups, and the general public are all fairly favorable to the alternative. Other alternatives would likely have fewer groups in support, but no alternative is likely to be opposed by all groups.

OVERALL EVALUATION OF ALTERNATIVES

Since the University Regulator Source Control Project must be implemented on a single-watershed basis, only three alternatives are really applicable: command and control regulation, a technology transfer program, and provision of public awareness and education. Considering immediate source control objectives only, a technical assistance approach is judged to be slightly less effective overall. It is somewhat less effective in ensuring that good waste disposal practices are adopted than a command and control approach. However, it is considered more effective in achieving changes in housekeeping practices. This is because housekeeping measures are more difficult to enforce and regulate due to ambiguities in the regulation, whereas waste disposal regulations are quite specific. It is also easier to regulate problems perceived as important than those not so perceived, particularly where enforcement is difficult. The command and control approach could be more effective in providing maintenance of catch basins and oil sumps and oil/water separators. Technical assistance is not likely to provide maintenance incentives. Public awareness and education, the other approach implementable on a single-watershed basis, does not meet pollution control objectives as well as the other two alternatives.

When long-term objectives are considered, a technical assistance approach has advantages in providing a basis for independent judgment, in identifying important components of actions, and in encouraging responsibility for a business' own actions. The extent to which command and control and public awareness meet the long-term objectives is uncertain.

In general, support from interest groups is fairly good for all three alternatives. None of the three have major regulatory impediments,

although command and control regulation requires judicious representation of the extent of Metro's authority. Expected coverage using the command and control and the technology assistance program are good; public awareness is expected to be less thorough in coverage.

Considering both immediate and long-term objectives, a technical assistance program was judged to be the best alternative given the geographic constraints of the University Regulator Source Control Project. However, neither technical assistance nor command and control regulation clearly dominate in all objectives. Which is considered best depends in large part which objectives are most important for a particular project.

SUMMARY AND CONCLUSIONS

"Would you tell me, please, which way I ought to go from here?"
"That depends a good deal on where you want to get to."
– Lewis Carroll

This analysis has explored alternatives for conducting a specific source control project dealing with nonpoint water pollution via storm drains in a commercial/residential watershed. In addition to specific pollution control objectives arising from the particular circumstances of the project, other objectives were found to be important. These involved implementation concerns, long-range pollution control goals, and social and political considerations. In the University Regulator Project, only alternatives applicable to a single-watershed approach could be pursued. In this case, both technical assistance and command and control regulation offered particular advantages.

In source control projects not restricted to a small geographic area, a certification program and extension of liability for pollution damages have potential to meet both short- and long-term program objectives. Implementation and political and social considerations differ and need to be evaluated as factors in an overall decision. For each source control project, pollution control objectives can be expected to be somewhat different. Thus, no approach is likely to be clearly dominant in all nonpoint water pollution control efforts. Indeed, in some cases a mix of approaches may be superior than a single approach, particularly if there are many different kinds of sources present.

In examining the objectives developed in the University Regulator Project, some interesting tradeoffs are revealed. First, it appears that some alternatives are better at meeting shorter-term project objectives, whereas others are better at meeting more sustained, long-term objectives. It is interesting that alternatives which focus more intensely on modifying current behavior could, in the long-run, perform more poorly at encouraging acceptance of individual responsibility for pollution management. This balance between short-term results and long-term sustainability is an important consideration for many source control efforts, and needs to be carefully weighted. This tradeoff provides another argument that a mix of alternatives may be the best overall approach.

Another set of tradeoffs is in the scope or thoroughness of coverage expected with a particular alternative, which is also related to cost. Alternatives which are less costly tend to provide less thorough coverage. In some applications thoroughness may not be important, but in others, all sources, or all of a particular subset, may need to be identified.

Social acceptance objectives point to the fact that in most cases, a convergence of support by all groups is not likely. Of particular interest is industry support. When professional or trade organizations are ready to assist in addressing pollution problems, more weight might be attached to this group than the others. In some cases, political support could be of prime importance, especially if removal of regulatory impediments is necessary to implement an approach.

Thus, in addition to criteria specifically related to project objectives, considerations of implementation, long-range goal attainment, and social acceptance are also important. Unfortunately, alternatives that are strong in some objectives are weak in others, and may involve difficult tradeoffs. One possible solution is to select a mix of alternatives that will address multiple objectives. In the University Regulator Source Control Project, long-term behavior changes and ensuring an understanding of the actions affecting the future drainage system were judged to be equally important with attaining short-term changes. Thus, a technical assistance approach was chosen over a command and control strategy. The alternative or mix of alternatives chosen for achieving source control does indeed depend on where you want to get to.

APPENDIX B

BUSINESS INFORMATION

Businesses in the Commercial Subbasin Sampled at North 92nd Street and Stone Avenue North

* AAA Automotive
* AAA Spraying
* Acme Auto Electric
* All Volvo Auto
* Andy's Collision Auto Body
  Astaire Dance Studio
  Aurora Collision
  Aurora Auto Service
* Aurora Auto Wrecking
* Aurora Tavern
  B & D Sheet Metal Company
  Baleno
* Bekins Moving & Storage
* Bill's Wheel House
  British Car Shoppe
  Burgermaster
* Car Store
  Clary's Transmission Service
  Community Correction
  Contract Floor Covering
  Crow Roofing
  Crowe Building Specialties
* Crown Motel
* Dang Hair Design
  Dillon Company Inc.
  E & E Contractors
  Emerald Cut
  Evergreen Painting Company
  F & F Auto Repair
* Geisha Inn
  Grund & Company Inc.
* House of Pizza
  Infocus
* Installation specialists
  Japan Auto
  KC's Restaurant
  Kemi-K Products
* Kenlake Northwest Label & Print
* Klose IN Motel
  L. Hoyt Motors
  Lang Towing
  Lundquist Furniture
  Master Press Inc.
  May Co.
  McAbee Construction
* McPherson's Realty Warehouse
  Medalia's Auction
  Mind Technologies
* My Mechanic Automotive
  Nelson Electric
  Nordic Services
  North End Distributing
  Northwest Brake Shop
* Northwest Metal Salvage
  Olson Lumber Company
  Peugot, Etc.
* Photo Litho Company
  Pioneer Builder's Supply
  Ratelco
  Seafair Inn
  Sound Business Forms
  Sound Insurance Agency
* Standard Brands Paint
  TCI Cablevision
  Terries Auto Service
* Uniforms Plus
  Unlimited Tile
  West Coast Industries
  Wilcox Company Inc
  Wright Outboard Marine Co.

• Business is in the stormwater drainage basin, but outside of the sewerage basin sampled to characterize commercial wastewater.

Businesses in the North Aurora Drainage Basin (Contacts Influential, 1990)

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
A Aardvark Auto Wrecking	12521 Stone Way N	Seattle	WA	98133	5093	0
A-1 Clutch Engine & Tire	8401 Aurora Ave N	Seattle	WA	98103	7538	-0-
AAA Automotive	937 N 96th St	Seattle	WA	98103	7538	-0-
AAA Heating Service	406 N 127th St	Seattle	WA	98133	1711	0
AAA Recreation Services Inc	12715 Aurora Ave N	Seattle	WA	98133	7519	5561
AAA Spraying	P.O.Box 33066 Bitterlake Stn	SEATTLE	WA	98133	-0-	-0-
ABBEY PARTY RENTS	1310 131ST AVE NORTH	SEATTLE	WA	98133	-0-	-0-
AC Electric Service	320 N 100th St	Seattle	WA	98133	1731	0
Acme Auto Electric Inc	9015 Aurora Ave N	Seattle	WA	98103	7539	-0-
Acme Weatherization	922 N 128th St	Seattle	WA	98133	1793	0
Advance Properties	11715 Greenwood Ave N	Seattle	WA	98133	6531	6552
Al's Auto Supply	10342 Aurora Ave N	Seattle	WA	98133	5531	0
Al's Glass	10201 Aurora Ave N	Seattle	WA	98133	5231	5039
All Styles Barber Shop	13201 Aurora Ave N	Seattle	WA	98133	7241	0
All Video	10318 Aurora Ave N	Seattle	WA	98133	7841	0
All Volvo Auto	930 N 95th St	Seattle	WA	98103	5015	-0-
Allstate Insurance Companies	10002 Aurora Ave N	Seattle	WA	98133	6411	0
Alpine Custom Buildings Inc	929 N 130th St	Seattle	WA	98133	1542	0
AM PM Mini Mart	950 N 85th St	Seattle	WA	98103	5411	5541
American Academy Of Wine	8307 Linden Ave N	Seattle	WA	98103	8299	-0-
Ampac Tours International Inc	8610 Aurora Ave N	Seattle	WA	98103	4725	-0-
ANDY'S COLLISION AUTOBODY	931 NORTH 96TH STREET	SEATTLE	WA	98103	7532	-0-
ANETTE'S GALLERY	14300 GREENWOOD AVE N	SEATTLE	WA	98133	5945	-0-
Animal Medical Center	13510 Aurora Ave N	Seattle	WA	98133	742	0
Appliance Service Station Inc	12546 Aurora Ave N	Seattle	WA	98133	7623	5722
Arbiter Antique Appraisers Inc	9248 Evanston Ave N	Seattle	WA	98103	5932	-0-
ARCO AM/PM	14424 GREENWOOD AVE. N	SEATTLE	WA	98133	5541	-0-
ARCO AM/PM MINIMART	NORTH 105TH ST & AURORA AVE N	SEATTLE	WA	98133	3714	-0-
Around The Sound	323 N 105th St	Seattle	WA	98133	7629	0
Assn Tavern Owners Of WA	1155 N 130th St	Seattle	WA	98133	8611	0
Astaire Dance Studio Inc/Fred	9871 Aurora Ave N	Seattle	WA	98103	7911	-0-
AT & T Company	10000 Aurora Ave N	Seattle	WA	98133	5999	0
Auntie M's Cuts For Kids	1410 N 80th St	Seattle	WA	98103	7231	-0-
Aurora Auto Service	1115 N 94th St	Seattle	WA	98103	7538	-0-
Aurora Auto Wrecking Inc	9217 Aurora Ave N	Seattle	WA	98103	5932	5531
AURORA AVENUE MERCHANTS ASSOC.	951 NORTH 100TH STREET	SEATTLE	WA	98133	-0-	-0-
Aurora Cinema I II & III	13000 Linden Ave N	Seattle	WA	98133	7832	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Aurora Cleaning Center	13260 Aurora Ave N	Seattle	WA	98133	7215	7216
Aurora Collision	9120 Aurora Ave N	Seattle	WA	98103	7538	-0-
Aurora Discount Cars	12222 Aurora Ave N	Seattle	WA	98133	5521	0
Aurora Family Restaurants	8800 Aurora Ave N	Seattle	WA	98103	5812	-0-
Aurora Firestone	12553 Aurora Ave N	Seattle	WA	98133	5531	7538
Aurora Flower Shop	8808 Aurora Ave N	Seattle	WA	98103	5992	-0-
Aurora Grocery	8958 Aurora Ave N	Seattle	WA	98103	5411	-0-
Aurora Motor Inn	8820 Aurora Ave N	Seattle	WA	98103	7011	-0-
AURORA MOTORS	10712 AURORA AVE NORTH	SEATTLE	WA	98133	5521	-0-
Aurora Oriental Market	13254 Aurora Ave N	Seattle	WA	98133	5411	0
Aurora Plumbing & Electric	14330 Aurora Ave N	Seattle	WA	98133	5211	5074
Aurora Tavern	9505 Aurora Ave N	Seattle	WA	98103	5813	-0-
Aurora Teriyaki Restaurant	13134 Aurora Ave N	Seattle	WA	98133	5812	5813
Aurora Veterinary Hospital	8821 Aurora Ave N	Seattle	WA	98103	742	-0-
Autofind	8201 Aurora Ave N	Seattle	WA	98103	5521	-0-
Autos Limited	8101 Aurora Ave N	Seattle	WA	98103	5521	-0-
AUTOVIA	8610 AURORA AVE NORTH	SEATTLE	WA	98103	5531	-0-
B & D Sheet Metal Company	1111 N 98th St	Seattle	WA	98103	3444	-0-
Bears & Balloons	10416 Aurora Ave. North	Seattle	WA	98133	-0-	-0-
Bekins Moving & Storage Co	9401 Aurora Ave N	Seattle	WA	98103	4214	5541
Bell & Company Inc	1130 N Northgate Way	Seattle	WA	98133	6411	0
BELLA LUNA	14053 GREENWOOD AVE N	SEATTLE	WA	98133	5812	-0-
Bethany Community Church	8023 Green Lake Dr N	Seattle	WA	98103	8661	-0-
Beverly Enterprises Reg Trng	10509 Stone Way N	Seattle	WA	98133	8249	0
Biddle & Crowther Company	910 N 137th St	Seattle	WA	98133	5047	0
Big Elephant Geraniums	8808 Aurora Ave N	Seattle	WA	98103	181	182
Bill's Wheel House	9411 Aurora Ave N	Seattle	WA	98103	5521	-0-
Binyon Optometrists	10000 Aurora Ave N	Seattle	WA	98133	8042	0
Bitter Lake Vista Apartments	715 N 130th St	Seattle	WA	98133	6513	0
Black Angus Motor Inn	12245 Aurora Ave N	Seattle	WA	98133	7011	0
Blackbourn Services	13500 Linden Ave N	Seattle	WA	98133	7629	7359
Blanchet High School	8200 Wallingford Ave N	Seattle	WA	98103	8211	-0-
Blockbuster Videos	13500 Aurora Ave. N.	Seattle	WA	98133	7841	-0-
Blumenthal Uniform Company Inc	10219 Aurora Ave N	Seattle	WA	98133	5699	0
Bob's Boats & Motors	12015 Aurora Ave N	Seattle	WA	98133	5551	0
Body Firm	847 NE Northgate Way	Seattle	WA	98133	7991	0
BOTTING MECHANICAL CONTRACTORS	13549 AURORA AVE NORTH	SEATTLE	WA	98133	1711	-0-

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Boyer Electric	830 A North 127th St.	Seattle	WA	98133	-0-	-0-
Brennan Lighting	14032 Aurora Ave N	Seattle	WA	98133	5063	5719
Brentwood Square Apartments	13433 Greenwood Ave N	Seattle	WA	98133	6513	0
BRISTOL MARINE	12015 AURORA AVE N	SEATTLE	WA	98133	5551	-0-
BRITISH CAR SHOPPE	1119 NORTH 100TH	SEATTLE	WA	98103	3711	-0-
Broadview-Thompson Elementary	13052 Greenwood Ave N	Seattle	WA	98133	8211	0
Brown Bear Car Wash	11710 Aurora Ave N	Seattle	WA	98133	-0-	7542
Budget Video	306 N 125th St	Seattle	WA	98133	7841	0
Bug-Aid	14045 Midvale Ave N	Seattle	WA	98133	7538	0
Bullseye Tavern	8615 Aurora Ave N	Seattle	WA	98103	5812	5813
Buns Master Bakery	13020 Aurora Ave N	Seattle	WA	98133	5461	0
Burg/The	14303 Aurora Ave N	Seattle	WA	98133	5812	0
Burger King	13241 Aurora Ave N	Seattle	WA	98133	5812	0
Burgermaster/The	9820 Aurora Ave N	Seattle	WA	98103	5812	-0-
Burgess Industries Company Inc	10721 Midvale Ave N	Seattle	WA	98133	3441	0
Buser Ornamental Iron Works	1110 N 143rd St	Seattle	WA	98133	3446	0
Business Systems Northwest	8253 Bagley Ave N	Seattle	WA	98103	5112	-0-
C & M Escrow Inc	1155 N 130th St	Seattle	WA	98133	6531	0
Campbell & Associates/Scott	1155 N 130th St	Seattle	WA	98133	6411	0
CAR TUNES	14355 Aurora Ave N	Seattle	WA	98133	5735	5731
CARS	14323 Greenwood Ave N	Seattle	WA	98133	7532	0
Cars to Go	12721 Aurora Ave N	Seattle	WA	98133	5521	0
CASH & CARRY	13102 STONE AVE NORTH	SEATTLE	WA	98133	5411	-0-
Cellar Wineshop/The	14411 Greenwood Ave N	Seattle	WA	98133	5921	0
Chec Medical Centers	8313 Aurora Ave N	Seattle	WA	98103	8011	-0-
Check Express	13028 Aurora Ave N	Seattle	WA	98133	6099	0
Childbirth Education Assn	14310 Greenwood Ave N	Seattle	WA	98133	8099	0
China Dragon Restaurant	10119 Aurora Ave N	Seattle	WA	98133	5812	5813
Christ The King School	415 N 117th St	Seattle	WA	98133	8211	0
CHRISTIAN CHURCH	10529 ASHWORTH AVE NORTH	SEATTLE	WA	98133	8661	-0-
Christian Church-Univ Phlsphy	10529 Ashworth Ave N	Seattle	WA	98133	8661	8299
Christian Conciliation Service	424 N 130th St	Seattle	WA	98133	8322	0
CIRCLE K	12248 AURORA AVE NORTH	SEATTLE	WA	98133	3714	-0-
CITY LIGHT NORTH SERVICE CENTE	1300 NORTH 97TH STREET	SEATTLE	WA	98103	-0-	5541
Citywalk Apartments	1130 N 115th St	Seattle	WA	98133	6513	0
Clary's Transmission Service	9700 Aurora Ave N	Seattle	WA	98103	7537	-0-
Clean & Handy	8610 Aurora Ave N	Seattle	WA	98103	7349	-0-

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Coastal Coatings Inc	13749 Midvale Ave N	Seattle	WA	98133	1721	1799
Coastal Tank Cleaning	13749 Midvale Ave N	Seattle	WA	98133	4493	0
Cochran Electric Company Inc	12500 Aurora Ave N	Seattle	WA	98133	1731	5541
Cody Thompson & Associates	1155 N 130th St	Seattle	WA	98133	8721	0
Colbeck & Company	6534 48th Ave. N.E.	Seattle	WA	98115	-0-	-0-
Colonial Roofing Company	1115 N 140th St	Seattle	WA	98133	1761	0
COLUMBIA BAPTIST CONFERENCE	925 N 130th St	Seattle	WA	98133	8661	0
Community Correction	9620 Stone Ave N	Seattle	WA	98103	8322	-0-
Connector World Supply Inc	312 N 104th St	Seattle	WA	98133	5065	0
Continental Engineering Co	13533 Aurora Ave N	Seattle	WA	98133	8711	0
Contract Floor Covering Inc	1111 N 98th St	Seattle	WA	98103	5713	-0-
Cool Creations	7908 E Green Lake Dr N	Seattle	WA	98103	5812	-0-
CORRY'S FINE DRY CLEANING	14419 GREENWOOD AVE N	SEATTLE	WA	98133	7216	-0-
Court Reporting Inst & Agency	929 N 130th St	Seattle	WA	98133	7338	0
Credithrift Of America Inc	14333 Aurora Ave N	Seattle	WA	98133	6141	0
Crest Motel & Trailer Park	14115 Aurora Ave N	Seattle	WA	98133	7011	7033
Crow Roofing & Sheet Metal Inc	9500 Aurora Ave N	Seattle	WA	98103	1761	5541
Crowe Building Specialties Inc	9620 Stone Ave N	Seattle	WA	98103	5039	-0-
Crown Motel	9541 Aurora Ave N	Seattle	WA	98103	7011	-0-
Custom Contact Lenses Inc	312 N 85th St	Seattle	WA	98103	3851	-0-
Custom Masonry & Stove	8922 Corliss Ave N	Seattle	WA	98103	1741	-0-
Cuttin' Loose On Green Lake	7906 E Green Lake Dr N	Seattle	WA	98103	7231	-0-
Cycle Leather Wear	10311 Aurora Ave N	Seattle	WA	98133	5651	0
Cyndy's House Of Pancakes	10507 Aurora Ave N	Seattle	WA	98133	5812	0
Cyphers Attorney/R Wayne	10302 Midvale Ave N	Seattle	WA	98133	8111	0
Dang Hair Design	9851 Aurora Ave N	Seattle	WA	98103	7231	-0-
Dansco Indoor Garden Center	315 N 105th St	Seattle	WA	98133	5261	0
Davis Warburton Appliance	10101 Aurora Ave N	Seattle	WA	98133	5722	-0-
Day & Night Towing	8700 Aurora Ave N	Seattle	WA	98103	7549	-0-
Dillon Company Incorporated/J	9414 Stone Ave N	Seattle	WA	98103	1711	-0-
Discount Glass	10718 Aurora Ave N	Seattle	WA	98133	1793	7536
DISTRIBUTION RESOURCES Inc	12645 STONE AVE NORTH	SEATTLE	WA	98133	-0-	-0-
Dizard Masonry Incorporated	12633 Stone Ave N	Seattle	WA	98133	1741	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Dr. Morrison DDS	235 NORTH 143RD	SEATTLE	WA	98133	8021	-0-
Dunkin Donuts	13201 Aurora Ave N	Seattle	WA	98133	5461	0
Earthworks Landscaping Servics	938 N 128th St	Seattle	WA	98133	782	0
ECONOLUBE N TUNE	12248 Aurora Ave. North	SEATTLE	WA	98133	7538	-0-
EDELSTEIN	11711 STONE AVE NORTH	SEATTLE	WA	98133	2434	-0-
Edwards Automotive Service Inc	950 N 128th St	Seattle	WA	98133	7538	0
Elias Companies/The	1833 N 105th St	Seattle	WA	98133	6411	0
Elliott Bay Bicycles	7904 E Green Lake Dr N	Seattle	WA	98103	5941	-0-
Ellipsis	936 N 89th St	Seattle	WA	98103	2741	-0-
Emerald City Autobody Sales	14044 Aurora Ave N	Seattle	WA	98133	5521	7532
Emerald City Electric & Lightg	10719 Stone Ave N	Seattle	WA	98133	5063	0
EMERALD INN MOTEL	8512 Aurora Ave N	Seattle	WA	98103	7011	-0-
Employee Support Systems Co	1833 N 105th St	Seattle	WA	98133	7389	0
Evergreen Painting Company	8516 Interlake Ave N	Seattle	WA	98103	1721	-0-
Evergreen Washelli Memorial Pk	11111 Aurora Ave N	Seattle	WA	98133	6553	5541
Evich & Hansen Attorneys	1116 N Northgate Way	Seattle	WA	98133	8111	0
Excel Properties	7850 E Green Lake Dr N	Seattle	WA	98103	6531	-0-
Exxon Self Serve Station	8408 Aurora Ave N	Seattle	WA	98103	5541	5411
Eyes Rite	14000 Aurora Ave N	Seattle	WA	98133	8042	0
F & F Auto Repair	1115 N 94th St	Seattle	WA	98103	7538	-0-
Factory Direct Draperies Inc	8300 Aurora Ave N	Seattle	WA	98103	5714	-0-
Farmers Insurance Group	1155 N 130th St	Seattle	WA	98133	6411	0
Feola CPA/Ronald S	8610 Aurora Ave N	Seattle	WA	98103	8721	-0-
First Interstate Bank Of WA	13273 Aurora Ave N	Seattle	WA	98133	6021	0
Fish Bowl	14040 Aurora Ave N	Seattle	WA	98133	5812	-0-
FLEET REPAIR SERVICE	14315 1/2 AURORA AVE. N	SEATTLE	WA	98133	7538	-0-
Flowers & Gifts By J	10334 Aurora Ave N	Seattle	WA	98133	5992	5947
Food Giant	13201 Aurora Ave N	Seattle	WA	98133	5411	-0-
Foss Homes	13023 Greenwood Ave N	Seattle	WA	98133	8051	0
Four Freedoms House Of Seattle	747 N 135th St	Seattle	WA	98133	6513	0
Fraker DDS/Ross	8120 Green Lake Dr N	Seattle	WA	98103	8021	-0-
Frantic Art	13518 Burke Ave N	Seattle	WA	98133	5719	0
Fraser's Auto Sales	8601 Aurora Ave N	-0-	-0-	-0-	-0-	-0-
Fraser's Auto Sales	8715 Aurora Ave N	Seattle	WA	98103	5521	-0-
Freeman & Associates/George	11728 Aurora Ave N	Seattle	WA	98133	8721	0
Futon Factory	13555 Aurora Ave N	Seattle	WA	98133	5712	0
Gallery Racquet Club	11616 Aurora Ave N	Seattle	WA	98133	7997	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Garfield Auto Parts Inc	14315 Aurora Ave N	Seattle	WA	98133	5013	5531
Geisha Inn	9613 Aurora Ave N	Seattle	WA	98103	7011	-0-
GEMINI SHAREWARE	10329 AURORA AVE. N.	SEATTLE	WA	98133	5734	-0-
Georgian Motel	8801 Aurora Ave N	Seattle	WA	98103	7011	-0-
Gibraltar Savings FA	1155 N 130th St	Seattle	WA	98133	6035	0
Gillmore Insurance	13201 Aurora Ave N	Seattle	WA	98133	6411	0
Goldmark	10325 Aurora Ave N	Seattle	WA	98133	5944	0
Goodhue Homes/Nellie	1707 N 125th St	Seattle	WA	98133	8361	0
Gordon Skoog Construction	830 B North 127th St.	SEATTLE	WA	98133	-0-	-0-
Gordon's Tape Recordng Service	13100 Stone Ave N	Seattle	WA	98133	7389	0
Grace Lutheran Church	11051 Phinney Ave N	Seattle	WA	98133	8661	0
Granite Curling Club	1440 128th Ave North	Seattle	WA	98133	7997	-0-
Grapevine Hair Fashions	11203 Greenwood Ave N	Seattle	WA	98133	7231	0
Great Escape Travel	10002 Aurora Ave N	Seattle	WA	98133	4724	0
Green Lake Motel	8900 Aurora Ave N	Seattle	WA	98103	7011	-0-
Greenlake Jake's	7918 E Green Lake Dr N	Seattle	WA	98103	5812	5813
Greenlake Medical Center	8118 Green Lake Dr N	Seattle	WA	98103	8011	-0-
Greenlake Realty	8204 Green Lake Dr N	Seattle	WA	98103	6531	-0-
Greenwood Boys & Girls Club	8635 Fremont Ave N	Seattle	WA	98103	8641	-0-
Greenwood Chamber Of Commerce	208 NORTH 85TH	Seattle	WA	98103	8611	-0-
Greenwood Furniture Refinishng	10001 Aurora Ave N	Seattle	WA	98133	7641	0
Greenwood Park Care Center	13333 Greenwood Ave N	Seattle	WA	98133	8051	0
Greenwood Restoration-Uphlstry	10001 Aurora Ave N	Seattle	WA	98133	7641	0
Grund & Company Inc	1115 N 97th St	Seattle	WA	98103	1721	-0-
Hair Sensations	10002 Aurora Ave N	Seattle	WA	98133	7231	0
Halcyon Mobile Park	12215 Ashworth Ave N	Seattle	WA	98133	6515	0
Haller Lake Baptist Church	14054 Wallingford Ave N	Seattle	WA	98133	8661	0
Handy Andy Rent A Tool Inc	10711 Aurora Ave N	Seattle	WA	98133	7353	7513
Hansen Bros Transfr-Storage Co	10750 Aurora Ave N	Seattle	WA	98133	4214	4213
Harvison DDS/James C	11046 Greenwood Ave N	Seattle	WA	98133	8021	0
Hawley's Northend Taxi	1133 N 85th St	Seattle	WA	98133	4121	0
He Rae Deung Restaurant	930 N 130th St	Seattle	WA	98133	5812	5813
Helene Madison Pool	13401 Meridian Ave N	Seattle	WA	98133	7999	0
Hello Belly	10002 Aurora Ave N	Seattle	WA	98133	5812	0
HERB HANSON	-0-	-0-	-0-	-0-	-0-	-0-
Herman's Auto Repair	14309 Midvale Ave N	Seattle	WA	98133	7538	0
Hertz Penske Truck Rntl & Lsng	10750 Aurora Ave N	Seattle	WA	98133	7513	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Highland Auto Glass Inc	14101 Aurora Ave N	Seattle	WA	98133	5013	0
HIGHLAND UNOCAL	14056 GREENWOOD AVE NORTH	SEATTLE	WA	98133	5541	-0-
Highlands Pharmacy	14409 Greenwood Ave N	Seattle	WA	98133	5912	0
Hill Fuel Company/Denny	9000 Aurora Ave N	Seattle	WA	98103	5211	5261
Holiday Pharmacy	13510 Aurora Ave N	Seattle	WA	98133	5912	0
Home Service Plumbing	922 NW 85th St	Seattle	WA	98103	1711	-0-
HONDA MASTERS	8951 AURORA AVE NORTH	SEATTLE	WA	98103	7538	-0-
Hoover Company/ The	13250 Aurora Ave N	Seattle	WA	98133	5722	0
Horta Food Services Inc	948 N 127th St	Seattle	WA	98133	5149	5148
House Of Pizza	9019 Aurora Ave N	Seattle	WA	98103	5812	5813
Hoyt Motors	9016 Aurora Ave N	Seattle	WA	98103	5521	-0-
Hungry Steer	1200 N Northgate Way	Seattle	WA	98133	5812	0
In Focus Optical	13520 Aurora Ave N	Seattle	WA	98133	5995	0
Infocus	747 N 90th St	Seattle	WA	98103	7379	-0-
INGRAHAM HIGH SCHOOL	1819 NORTH 135TH STREET	SEATTLE	WA	98133	-0-	-0-
Intrust	1833 N 105th St	Seattle	WA	98133	6531	0
Ivar's Seafood Bar	13448 Aurora Ave N	Seattle	WA	98133	5812	0
IVERSON CENTER	424 N 130th St	Seattle	WA	98133	8322	0
Jack In The Box	8502 Aurora Ave N	Seattle	WA	98103	5812	-0-
James Finance Company/Lee	917 N 130th St	Seattle	WA	98133	6141	0
James Realtors/Richard	10002 Aurora Ave N	Seattle	WA	98133	6531	0
Japan Auto Service	9400 Aurora Ave N	Seattle	WA	98103	7538	-0-
JED Chem Dry	13100 Stone Ave N	Seattle	WA	98133	7217	0
Jennings Manufacturing Inc	930 N 127th St	Seattle	WA	98133	3231	0
Jet Color Lab	953 N 128th St	Seattle	WA	98133	7384	0
Jim's Body Works	10019 Aurora Ave N	Seattle	WA	98133	7532	0
Johnson DDS/Rich C	907 N 130th St	Seattle	WA	98133	8021	0
Jorgensen Dental Laboratory	14310 Greenwood Ave N	Seattle	WA	98133	8072	0
K-Mart Discount Stores	13200 Aurora Ave N	Seattle	WA	98133	5311	0
Karelsen Custom Boats Inc	8516 Wallingford Ave N	Seattle	WA	98103	3732	-0-
Karin's Beauty Supplies Inc	8316 Aurora Ave N	Seattle	WA	98103	5999	5087
KC's Restaurant	9710 Aurora Ave N	Seattle	WA	98103	5812	5813
Kelly's Motel	8816 Aurora Ave N	Seattle	WA	98103	7011	-0-
Kemi-K Products Inc	9622 Aurora Ave N	Seattle	WA	98103	5087	5169
Kenlake Northwest Label &Print	950 N 98th St	Seattle	WA	98133	2759	0
Kentucky Fried Chicken	13248 Aurora Ave N	Seattle	WA	98133	5812	0
Kitchen & Bath Designs	14018 Aurora Ave N	Seattle	WA	98133	7389	1521

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Klose In Motel	9309 Aurora Ave N	Seattle	WA	98103	7011	-0-
Korea Central Daily News/The	13749 Midvale Ave N	Seattle	WA	98133	2711	0
LA BAGUETTE	620 NORTH 85TH	SEATTLE	WA	98103	5461	-0-
LA BAGUETTE	620 NORTH 85TH	SEATTLE	WA	98103	5461	5461
Lake & Company Realtors	7801 Green Lake Dr N	Seattle	WA	98103	6531	-0-
Lancer Realty & Investments	10554 Aurora Ave N	Seattle	WA	98133	6531	0
Lang Towing Inc	9200 Aurora Ave N	Seattle	WA	98103	7549	-0-
Larry's Markets Inc	10008 Aurora Ave N	Seattle	WA	98133	5411	0
Larsen Nautical Clocks-Instrmt	315 N 145th St	Seattle	WA	98133	5063	0
Las Margaritas	14356 Aurora Ave N	Seattle	WA	98133	5812	0
LAURELHURST FUEL CO	7040 26th Ave. N.E.	SEATTLE	WA	98115	-0-	-0-
Lee's Automotive	13281 Aurora Ave N	Seattle	WA	98133	7538	5541
Lifestyle 2000	10002 Aurora Ave N	Seattle	WA	98133	7299	0
Lincoln Auto Salvage	12220 Aurora Ave N	Seattle	WA	98133	5015	5093
Living Well Lady Fitness Ctrs	13022 Aurora Ave N	Seattle	WA	98133	7991	0
Londo Creative Jewelry/Charles	7810 E Green Lake Dr N	Seattle	WA	98103	5944	-0-
Love Pantry	10333 Aurora Ave N	Seattle	WA	98133	5947	0
LUNDQUIST FURNATURE	-0-	-0-	-0-	-0-	-0-	-0-
LVI Environmental Services Inc	12532 Aurora Ave N	Seattle	WA	98133	1799	0
MacReady TBA North	12200 Aurora Ave N	Seattle	WA	98133	5013	0
Mail Shop	13510 Aurora Ave N	Seattle	WA	98133	7389	4215
Mama's Own Pizza & More	10330 Aurora Ave N	Seattle	WA	98133	5812	0
Mandarin Gate	10000 Aurora Ave N	Seattle	WA	98133	5812	5813
Marilyn's Salon	747 N 135th St	Seattle	WA	98133	7231	0
Marshall's One Hour Cleaning	310 N 125th St	Seattle	WA	98133	7216	0
Master Press Incorporated	1200 N 96th St	Seattle	WA	98133	2796	0
May Co/W L	9801 Aurora Ave N	Seattle	WA	98103	5722	-0-
McAbee Construction	9510 Stone Ave N	Seattle	WA	98103	1542	-0-
McCall Heating Company	631 N 95th St	Seattle	WA	98103	5983	5541
McPHERSON'S REALTY WAREHOUSE	945 96TH AVENUE NORTH	SEATTLE	WA	98103	-0-	-0-
Medalia Floral	13414 Corliss Ave N	Seattle	WA	98133	5992	0
Medalia's Auction	1112 N 98th St	Seattle	WA	98103	5999	-0-
Mercury Cleaners	608 N 105th St	Seattle	WA	98133	7216	0
Meridian Excavating & Wrecking	911 N 141st St	Seattle	WA	98133	1794	1795
Metropolitan Beauty School	13201 Aurora Ave N	Seattle	WA	98133	7231	0
Michelle Apartments/The	940 N 98th St	Seattle	WA	98103	6513	-0-
Michelle Renee Hair Design	7910 E Green Lake Dr N	Seattle	WA	98103	7231	-0-

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Miller & Company/Greg	10908 Whitman Ave N	Seattle	WA	98133	5087	0
Miller Beauty Supply	10907 Aurora Ave N	Seattle	WA	98133	5087	0
Miller Co/Charles A	8739 Evanston Ave. N.	Seattle	WA	98103	1521	0
Mind Technologies Inc	9620 Stone Ave N	Seattle	WA	98103	8742	-0-
MONTESSORI FOR KIDS	14410 GREENWOOD AVE. N.	SEATTLE	WA	98133	8351	-0-
Moore's Body Shop Inc	1110 N 140th St	Seattle	WA	98133	7532	0
Morris Incorporated/Robert C	1155 N 130th St	Seattle	WA	98133	6411	0
My Mechanic Automotive	933 N 96th St	Seattle	WA	98103	7538	-0-
Nagle Real Estate Inc/John P	929 N 130th St	Seattle	WA	98133	6531	0
National Cargo Bureau	1155 N 130th St	Seattle	WA	98133	4785	0
National Trailer Park	912 N 125th St	Seattle	WA	98133	6515	7033
Nautilus Northwest	13555 Aurora Ave N	Seattle	WA	98133	7997	0
Nelson Electric Inc	9615 Stone Ave N	Seattle	WA	98103	1731	-0-
Neon Broker	11728 Aurora Ave N	Seattle	WA	98133	3993	0
NEW BEGINNINGS	14326 GREENWOOD AVE N	SEATTLE	WA	98133	8322	-0-
New Seattle Motel/The	12059 Aurora Ave N	Seattle	WA	98133	7011	0
Nites Inn	11746 Aurora Ave N	Seattle	WA	98133	7011	0
Nordic Services Inc	9618 Midvale Ave N	Seattle	WA	98103	1521	1542
North End Distributing	1137 N 96th St	Seattle	WA	98103	5181	-0-
North End Stanley Door Inc	12714 Aurora Ave N	Seattle	WA	98133	5031	5211
North Park Grocery	10217 Aurora Ave N	Seattle	WA	98133	5411	0
North Seattle Chrysler Plymth	13733 Aurora Ave N	Seattle	WA	98133	5511	0
Northgate Baptist Childcare	10510 Stone Ave N	Seattle	WA	98133	8351	0
Northgate Rehabilitation Ctr	10509 Stone Ave N	Seattle	WA	98133	8361	0
Northwest Brake Shop Inc	9406 Aurora Ave N	Seattle	WA	98103	7539	-0-
Northwest Digital Systems	10303 Aurora Ave N	Seattle	WA	98133	5734	0
NORTHWEST METAL SALVAGE	9607 AURORA AVE NORTH	SEATTLE	WA	98103	5093	-0-
Northwest Progressive Care Ctr	1545 N 120th St	Seattle	WA	98133	8051	0
Novus Windshield Repair Co	8401 Aurora Ave N	Seattle	WA	98103	7536	-0-
Oak Tree Cinemas	10006 Aurora Ave N	Seattle	WA	98133	7832	0
Oak Tree Cleaners	10002 Aurora Ave N	Seattle	WA	98133	7216	0
Oak Tree Terrace	910 N 104th St	Seattle	WA	98133	6513	0
Oak Tree Village Maytag Lndry	10002 Aurora Ave N	Seattle	WA	98133	7215	0
Oaktree Dentists	10004 Aurora Ave N	Seattle	WA	98133	8021	0
Olson Lumber Company	9300 Aurora Ave N	Seattle	WA	98103	5211	-0-
Olympic Lincoln Mercury Inc	13001 Aurora Ave N	Seattle	WA	98133	5511	7532
One-O-One Auto Body	10059 Aurora Ave N	Seattle	WA	98133	7532	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Osberg Construction Company	1132 N 128th St	Seattle	WA	98133	1611	0
Pacific Coast Network	929 N 130th St	Seattle	WA	98133	7377	0
PACIFIC CONSOLIDATED SERVICES	1318 NORTH 128TH	SEATTLE	WA	98133	-0-	-0-
Pacific Linen	13510 Aurora Ave N	Seattle	WA	98133	5719	0
Pacific Rainer Roofing Inc	10735 Stone Ave N	Seattle	WA	98133	1761	5541
Pacific Window Incorporated	938 N 127th St	Seattle	WA	98133	5231	0
Paradise Motors Auto Sales	12207 Aurora Ave N	Seattle	WA	98133	5521	4226
Paris Plumbing	314 N 117th St	Seattle	WA	98133	1711	0
Parker Paint	14333 Aurora Ave N	Seattle	WA	98133	5231	0
Parn's Yiu Mien	308 N 125th St	Seattle	WA	98133	5812	5813
Pay 'N Pak Stores	13501 Aurora Ave N	Seattle	WA	98133	5211	5231
Pay Less Drug Stores Inc	13201 Aurora Ave N	Seattle	WA	98133	5912	5331
Peddlers Restaurant	7850 E Green Lake Dr N	Seattle	WA	98103	5812	5813
PEKING PALACE	14314 Greenwood Ave N	Seattle	WA	98133	5812	0
Petosa's Market & Deli	14415 Greenwood Ave N	Seattle	WA	98133	5411	5812
PEUGOT ETC	9406B Aurora Ave N.	SEATTLE	WA	98103	7538	-0-
Phelps Tire Company	10702 Aurora Ave N	Seattle	WA	98133	7534	5531
Photo Litho Company	1114 N 97th St	Seattle	WA	98103	2752	-0-
Pierre's Hyundai Aurora Inc	14005 Aurora Ave N	Seattle	WA	98133	5511	0
Pioneer Builders Supply Inc	1145 N 98th St	Seattle	WA	98103	5033	-0-
PJ'S DOG WASH	10701 AURORA AVE NORTH	SEATTLE	WA	98133	752	-0-
Precision Foreign Car Service	8219 Aurora Ave N	Seattle	WA	98103	7538	-0-
Preservative Paint Company	12012 Aurora Ave N	Seattle	WA	98133	5231	5198
Price Savers	13550 Aurora Ave N	Seattle	WA	98133	5399	5141
Primewest Financial Ltd	1155 N 130th St	Seattle	WA	98133	6163	0
Pro Staff	902 North 127th	SEATTLE	WA	98133	-0-	-0-
Pro-Staff Heating & Air Condng	902 N 127th St	Seattle	WA	98133	1711	0
Public Storage	11512 Aurora Ave N	Seattle	WA	98133	4225	0
Puetz Evergreen Golf Range Inc	11762 Aurora Ave N	Seattle	WA	98133	5941	7992
Puget Snd Masonry Restoration	10745 Stone Ave N	Seattle	WA	98133	1741	5541
Puget Sound Blood Center	10357 Stone Ave N	Seattle	WA	98133	8099	0
Puget Sound Printers	11726 Aurora Ave N	Seattle	WA	98133	2752	0
Pyrocom Company	924 N 143rd St	Seattle	WA	98133	3823	5063
Quality Rentals	13032 Aurora Ave N	Seattle	WA	98133	7359	0
Rainbow Motors	12801 Aurora Ave N	Seattle	WA	98133	5521	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Ranson Enterprises	1833 N 105th St	Seattle	WA	98133	8331	0
RATELCO	131ST & STONE	SEATTLE	WA	98133	-0-	-0-
RATELCO	1113 NORTH 100TH	SEATTLE	WA	98103	3449	3499
Reeder Chiropractic Center	10000 Aurora Ave N	Seattle	WA	98133	8041	0
Rent-A-Center	13248 Aurora Ave N	Seattle	WA	98133	7359	0
Rest Inn	11502 Aurora Ave N	Seattle	WA	98133	7011	0
Rex Pub & Grill/The	12534 Aurora Ave N	Seattle	WA	98133	5813	5812
Ricardo Roofing	919 N 102nd St	Seattle	WA	98133	1761	0
Rich's Custom Upholstery	10003 Aurora Ave N	Seattle	WA	98133	7641	0
Richard's Business Machines	10509 Aurora Ave N	Seattle	WA	98133	5044	0
Rickshaw Restaurant	322 N 105th St	Seattle	WA	98133	5812	5813
Roberts Home Appliance/Jack	10326 Aurora Ave N	Seattle	WA	98133	5722	0
Rodeside Broiler	12531 Aurora Ave N	Seattle	WA	98133	5812	5813
Rodeside Lodge	12501 Aurora Ave N	Seattle	WA	98133	7011	0
Rory Dental & Technical Art	907 N 130th St	Seattle	WA	98133	8072	0
Ross Stores Inc	13201 Aurora Ave N	Seattle	WA	98133	5651	0
Ruben's Cleaners	14305 Greenwood Ave N	Seattle	WA	98133	7216	7219
S & S Sign Company	13190 Stone Ave N	Seattle	WA	98133	3993	0
Saldin Quality Plantmates	11201 Greenwood Ave N	Seattle	WA	98133	5193	0
Salon Apercu	1402 N 80th St	Seattle	WA	98103	7231	-0-
Salvage Broker	13760 Aurora Ave N	Seattle	WA	98133	7389	5093
Sandwich Isles/The	13258 Aurora Ave N	Seattle	WA	98133	5812	5813
Schuck's Auto Supply	14320 Aurora Ave N	Seattle	WA	98133	5531	0
Schwaben Motors Incorporated	10729 Aurora Ave N	Seattle	WA	98133	7538	0
Scott Hendrickson DDS	235 NORTH 143RD	SEATTLE	WA	98133	8021	-0-
Seaco Realty	10512 Aurora Ave N	Seattle	WA	98133	6531	0
Seafair Motel	9100 Aurora Ave N	Seattle	WA	98103	7011	-0-
Seafirst Bank	10310 Aurora Ave N	Seattle	WA	98133	6021	0
Seal's Motel	12035 Aurora Ave N	Seattle	WA	98133	7011	0
Seattle Beauty Supply	10000 Aurora Ave N	Seattle	WA	98133	5087	0
Seattle Cycle Center	10203 Aurora Ave N	Seattle	WA	98133	5571	0
Seattle Engineering Dept Yard	12555 Ashworth Ave N	Seattle	WA	98133	4952	5541
Seattle Fireplace Shop	13728 Aurora Ave N	Seattle	WA	98133	5719	0
Seattle Glass Block Windows	12633 Stone Ave N	Seattle	WA	98133	3231	0
SEATTLE GOLF CLUB	210 Northwest 145th	Seattle	WA	98133	7992	5541
Seattle Surgical Repair	10726 Aurora Ave N	Seattle	WA	98133	7699	0
Seattle Vacuum	14022 Aurora Ave N	Seattle	WA	98133	5722	7699

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Seattle Vocational Services	11728 Aurora Ave N	Seattle	WA	98133	8331	0
Seattle Yamaha Kawasaki	12230 Aurora Ave N	Seattle	WA	98133	5571	0
Secret Garden	7900 E Green Lake Dr N	Seattle	WA	98103	5942	-0-
Seven-Eleven Food Stores	13417 Roosevelt Way NE	Seattle	WA	98133	5411	0
Shakey's Pizza Parlor	12020 Aurora Ave N	Seattle	WA	98133	5812	5813
Signal Systems Incorporated	10109 Aurora Ave N	Seattle	WA	98133	1731	0
Silk Interiors	11201 Greenwood Ave N	Seattle	WA	98133	7389	0
Silo Stores	10409 Aurora Ave N	Seattle	WA	98133	5731	5722
Simonetti's	12255 Aurora Ave N	Seattle	WA	98133	5812	5813
Sir Real Espresso	12700 Aurora Ave N	Seattle	WA	98133	5812	0
Sixty Minute Tune Up	8401 Aurora Ave N	Seattle	WA	98103	7538	-0-
Skoog Gordon Construction Inc	12532 Aurora Ave N	Seattle	WA	98133	1521	1542
Song's Painting Company	10059 Aurora Ave N	Seattle	WA	98133	1721	0
Sound Business Forms	9600 Stone Ave N	Seattle	WA	98133	5112	0
Sound Insurance Agency	9627 Aurora Ave N	Seattle	WA	98103	6411	-0-
Sound Motors Inc	9400 Aurora Ave N	Seattle	WA	98103	7538	-0-
SOUND STEEL SERVICE	1210 North 107th St.	Seattle	WA	98133	5051	-0-
Sound Truck Equipment Inc	14325 Aurora Ave N	Seattle	WA	98133	5013	0
Sound View Properties Inc	14700 Greenwood Ave N	Seattle	WA	98133	6531	0
Speedy Auto Glass	8901 Aurora Ave N	Seattle	WA	98103	7536	-0-
Sportscaster/The	13738 Aurora Ave N	Seattle	WA	98133	5813	0
SRO Video	10002 Aurora Ave N	Seattle	WA	98133	7841	0
Standard Brands Paint Company	9701 Aurora Ave N	Seattle	WA	98103	5231	-0-
Starbucks Coffee & Tea	10002 Aurora Ave N	Seattle	WA	98133	5812	5499
State Farm Insurance Companies	1401 N 80th St	Seattle	WA	98103	6411	-0-
Stephens & Co/C	10301 Stone Ave N	Seattle	WA	98133	5023	0
Sun Hill Motel	8517 Aurora Ave N	Seattle	WA	98103	7011	-0-
SUPER BO CHINESE BUFFET	13025 AURORA AVE NORTH	SEATTLE	WA	98133	5812	-0-
Superior Bathrooms & Kitchens	2341 N 122nd St	Seattle	WA	98133	1751	0
Superior Tire Service	12200 Aurora Ave. N.	SEATTLE	WA	98133	7538	-0-
Sure Fit Service Centers	10526 Aurora Ave N	Seattle	WA	98133	7532	0
Takeda Landscape Design	312 N 103rd St	Seattle	WA	98133	781	0
Tan Duc Grocery	10005 Aurora Ave N	Seattle	WA	98133	5411	0
Target Insurance Services	1155 N 130th St	Seattle	WA	98133	6411	0
TCBY Yogurt	10000 Aurora Ave N	Seattle	WA	98133	5812	0
TCI Cablevision	1125 N 98th St	Seattle	WA	98103	4841	-0-
Terminix International Inc	11728 Aurora Ave N	Seattle	WA	98133	7342	0

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
TERRIES AUTO SERVICE	1107 NORTH 98TH	SEATTLE	WA	98103	3711	-0-
That Added Touch	308 N 100th St	Seattle	WA	98133	5812	0
The Car Store	9117 Aurora Ave N	Seattle	WA	98103	5521	-0-
Thirsty's Beverages	13034 Aurora Ave N	Seattle	WA	98133	5499	5921
Thomas Lighting Sales	958 N 127th St	Seattle	WA	98133	5063	0
Tobin Dental Laboratory	1201 N 145th St	Seattle	WA	98133	8072	0
Trailer Haven	11724 Aurora Ave N	Seattle	WA	98133	6515	0
TRANSMISSION FACTORY	10538 AURORA AVE NORTH	SEATTLE	WA	98133	7537	-0-
Travelers III Tavern	8904 Aurora Ave N	Seattle	WA	98103	5813	-0-
Tricoter	12004 Aurora Ave N	Seattle	WA	98133	5949	0
Trinity Technology	8610 Aurora Ave N	Seattle	WA	98103	5734	-0-
Tsing Tao	13744 Aurora Ave N	Seattle	WA	98133	5812	5813
TSING TAO RESTAURANT	13744AURORA AVE NORTH	SEATTLE	WA	98133	5812	-0-
TVS Audio Video	927 N 128th St	Seattle	WA	98133	5731	0
U-Haul Truck Rental	10711 Aurora Ave N	Seattle	WA	98133	7513	7519
Underwater Sports	10545 Aurora Ave N	Seattle	WA	98133	5941	0
Uniforms Plus	9891 Aurora Ave N	Seattle	WA	98103	5699	-0-
United Transmission North	1201 N Northgate Way	Seattle	WA	98133	7537	0
University Mechanical Cntrctrs	1300 N 130th St	Seattle	WA	98133	1711	5541
University Moving & Storage	905 N 128th St	Seattle	WA	98133	4214	4213
University Savings Bank	14500 Greenwood Ave N	Seattle	WA	98133	6035	0
Unlimited Tile Company	9632 Midvale Ave N	Seattle	WA	98103	1743	-0-
UNOCAL	130TH & STONE AVE. NORTH	SEATTLE	WA	98133	3714	-0-
US Slo-Pitch Softball	510 N 84th St	Seattle	WA	98103	7999	-0-
Van's 105	602 N 105th St	Seattle	WA	98133	5813	0
Vancouver Tavern	13754 Aurora Ave N	Seattle	WA	98133	5813	0
Versatile Vending Sales	11740 Aurora Ave N	Seattle	WA	98133	5962	0
Vic's Insurance Center	8610 Aurora Ave N	Seattle	WA	98103	6411	-0-
Viewland Day Care Center	12024 Greenwood Ave N	Seattle	WA	98133	8351	0
Vivian's Apparel	13030 Aurora Ave N	Seattle	WA	98133	5621	0
Volume Shoe Source	13244 Aurora Ave N	Seattle	WA	98133	5661	0
WA AUTOMOTOVE WHOLESALERS ASSO	936 NORTH 143RD	SEATTLE	WA	98133	-0-	-0-
WA NATURAL GAS	P.O.BOX 1869	SEATTLE	WA	98111	4924	5541
Wallingford Grocery	9257 Wallingford Ave. N.	Seattle	WA	98103	5411	-0-
Wally World Resorts Inc	1155 N 130th St	Seattle	WA	98133	7033	0
Walt's Construction	9257 College Way N	Seattle	WA	98103	1521	-0-

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC	sic2
Walt's Radiator & Muffler	10735 Aurora Ave N	Seattle	WA	98133	7539	7533
Walter's Engine Works	10017 Aurora Ave N	Seattle	WA	98133	7538	0
WARREN INSURANCE AGENCY	11728 Aurora Ave N	Seattle	WA	98133	6411	0
Washington Limousine	8016 Ashworth Ave N	Seattle	WA	98103	4119	-0-
WASHINGTON NATURAL GAS	13330 STONE AVE NORTH	SEATTLE	WA	98133	4923	-0-
Washington School Of Insurance	13100 Stone Ave N	Seattle	WA	98133	8249	0
Washington State Liquor Store	13231 Aurora Ave N	Seattle	WA	98133	5921	0
Way West Motel	8600 Aurora Ave N	Seattle	WA	98103	7011	-0-
Weaco Construction	13528 Corliss Ave N	Seattle	WA	98133	1521	0
Weiskind Bros	10314 Aurora Ave N	Seattle	WA	98133	5722	0
Wells Custom Golf Shop/Tom	8914 Aurora Ave N	Seattle	WA	98103	5941	-0-
Wendel's License & Services	13201 Aurora Ave N	Seattle	WA	98133	7389	0
West Coast Grocery Company	1334 N 131st St	Seattle	WA	98133	5141	0
West Coast Industries Inc	1111 N 92nd St	Seattle	WA	98103	3545	-0-
WESTERN HOMES	P.O. Box 33524	Seattle	WA	98133	-0-	-0-
Western States Leasing Co	10735 Stone Ave N	Seattle	WA	98133	7359	0
Westlund Buick GMC Inc/Warren	12800 Aurora Ave N	Seattle	WA	98133	5511	0
Westminster Manor	14701 Dayton Ave N	Seattle	WA	98133	8361	0
Wicker Attorney/S Edward	11728 Aurora Ave N	Seattle	WA	98133	8111	0
Wilcox Company Inc/Al	1227 N 97th St	Seattle	WA	98103	1796	-0-
Windermere Real Estate	10004 Aurora Ave N	Seattle	WA	98133	6531	0
Winkelman True Value Hardware	14401 Greenwood Ave N	Seattle	WA	98133	5251	0
Wiseman Appliance-TV Store/Al	13030 Aurora Ave N	Seattle	WA	98133	5722	5731
World Wide Video	12700 Aurora Ave N	Seattle	WA	98133	7841	0
Wright Outboard Marine Co	1201 N 96th St	Seattle	WA	98103	5088	-0-

Appendix B

Businesses in the West Seattle Comparison Area

WEST SEATTLE LIST - UNIVERSITY REGULATOR

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC_1	SIC2
Alki Lumber & Hardware	4422 36th Ave SW	Seattle	WA	98126	5251	5182
Animal Clinic Of Roxbury	9608 30th Ave SW	Seattle	WA	98126	742	
Appraisal Service	7900 35th Ave SW	Seattle	WA	98126	6531	
Ava DC/Toivo A	5940 35th Ave SW	Seattle	WA	98126	8041	
Avalon Day Care	3025 SW Avalon Way	Seattle	WA	98126	8351	
B & D Unfinished Furniture	4449 35th Ave SW	Seattle	WA	98126	5712	
Berg Equipment & Scaffolding	2328 Harbor Ave SW	Seattle	WA	98126	7353	
Bob's Auto Tops & Upholstering	3602 SW Alaska St	Seattle	WA	98126	7532	
Braseth Construction Co Inc	6335 35th Ave SW	Seattle	WA	98126	1542	1542
Brown Insurance/Lonne	8951 Westwood Village Mall SW	Seattle	WA	98126	6411	
Burger King	4022 SW Alaska St	Seattle	WA	98126	5812	
Checkmate Cleaners	3503 SW Morgan St	Seattle	WA	98126	7216	
Complete Auto Repair	7617 35th Ave SW	Seattle	WA	98126	7538	
Crossland Savings	9153 Westwood Village Mall SW	Seattle	WA	98126	6035	7699
De Paul Mount St Vincent/The	4831 35th Ave SW	Seattle	WA	98126	8051	
Dearborn Lumber Company	4422 36th Ave SW	Seattle	WA	98126	5031	
Division Nine Painting	2287 Harbor Ave SW	Seattle	WA	98126	1721	
Doug's Service	6058 35th Ave SW	Seattle	WA	98126	7538	
Doyle Automotive Service Inc	4607 37th Ave SW	Seattle	WA	98126	7538	
Duane's Super Service	3295 SW Avalon Way	Seattle	WA	98126	5541	7538
Elliott Bay Distributing Co	3310 Harbor Ave SW	Seattle	WA	98126	5181	
Elliott Tire Inc	4441 Fauntleroy Way SW	Seattle	WA	98126	7534	
Enchanted World Day Care Centr	2207 California Ave SW	Seattle	WA	98126	8351	
Eng DDS/R Craig	9639 28th Ave SW	Seattle	WA	98126	8021	
Food Giant	9050 Westwood Village Mall SW	Seattle	WA	98126	5411	
Foreign Car Workshop	4603 37th Ave SW	Seattle	WA	98126	7538	
Fred Meyer	2601 SW Roxbury St	Seattle	WA	98126	5399	5211
Garlic Press Incorporated/The	9024 Westwood Village Mall SW	Seattle	WA	98126	5719	
Gary's Electric	9447 35th Ave SW	Seattle	WA	98126	1731	
Groucho's Broiled Burgers	3508 SW Avalon Way	Seattle	WA	98126	5812	5046
GT Towing Service	3252 Harbor Ave SW	Seattle	WA	98126	7549	
Hair Hut	2601 SW Roxbury St	Seattle	WA	98126	7231	
Hair Shoppe/The	9405 35th Ave SW	Seattle	WA	98126	7231	
Hans VW Parts	6302 35th Ave SW	Seattle	WA	98126	5531	
Happiness Hair Clinic	9400 35th Ave SW	Seattle	WA	98126	7231	
Hegge's Chevron/Ted	7580 35th Ave SW	Seattle	WA	98126	5541	
High Point Market	3401 SW Graham St	Seattle	WA	98126	5411	
Highpoint Neighborhood House	6564 32nd Ave SW	Seattle	WA	98126	8361	
Holland Place	8985 Westwood Village Mall SW	Seattle	WA	98126	5812	7629
House Of Kleen	4425 Fauntleroy Way SW	Seattle	WA	98126	7216	7216
Huling Brothers Mazda	4545 Fauntleroy Way SW	Seattle	WA	98126	5511	
Inn Of West Seattle	3512 SW Alaska St	Seattle	WA	98126	7011	
Jacobson Seaway Marina	2940 SW Avalon Way	Seattle	WA	98126	5551	
Jeans Express	9012 Westwood Village Mall SW	Seattle	WA	98126	5651	
Jerry's Exxon	2851 SW Roxbury St	Seattle	WA	98126	5541	7538

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC_1	SIC2
John's Deli	7500 35th Ave SW	Seattle	WA	98126	5812	5813
Knock Out Auto Repair	3600 SW Alaska St	Seattle	WA	98126	7538	
Kruse Construction Co/Gordon	5611 Delridge Way SW	Seattle	WA	98126	1542	
Larry's Markets Inc	2645 SW Roxbury St	Seattle	WA	98126	5411	
Lee's Custom Tailoring	8986 Westwood Village Mall SW	Seattle	WA	98126	5699	
Mary & John's Restaurant	7350 35th Ave SW	Seattle	WA	98126	5812	5813
Midas Muffler & Brake Shop	4457 Fauntleroy Way SW	Seattle	WA	98126	7533	
Ochsner Cars/Bob	4518 Fauntleroy Way SW	Seattle	WA	98126	5511	
Olympus Press Inc	3416 SW Webster St	Seattle	WA	98126	2752	
Paradise Garden Service	5643 30th Ave SW	Seattle	WA	98126	782	
Pay 'N Save Drug Stores Inc	9071 Westwood Village Mall SW	Seattle	WA	98126	5912	
Pet Care Center	2950 SW Avalon Way	Seattle	WA	98126	742	
Purdy Company Of Illinois/The	2929 SW Florida St	Seattle	WA	98126	5093	
Quality Auto Rebuild	4623 36th Ave SW	Seattle	WA	98126	7532	
Radio Shack	9055 Westwood Village Mall SW	Seattle	WA	98126	5734	
Red Baron	9157 Westwood Village Ct SW	Seattle	WA	98126	5812	5813
Ridzenieks Contractor/Karlis A	3830 37th Ave SW	Seattle	WA	98126	1521	
Roxbury Auto Parts & Service	2839 SW Roxbury St	Seattle	WA	98126	5531	
Roxbury Clinic	2656 SW Roxbury St	Seattle	WA	98126	8031	
Roxbury Texaco	2805 SW Roxbury St	Seattle	WA	98126	5541	
Roxbury Village Management	9455 27th Ave SW	Seattle	WA	98126	6513	
Safelite Auto Glass	4480 Fauntleroy Way SW	Seattle	WA	98126	7536	
Salty's On Alki	1936 Harbor Ave SW	Seattle	WA	98126	5812	
Sea Galley Restaurant	2500 SW Barton St	Seattle	WA	98126	5812	
Seacrest Auto Marine	2503 Harbor Ave SW	Seattle	WA	98126	3732	
Seacrest Boat House	1660 Harbor Ave SW	Seattle	WA	98126	5941	5331
Seafirst Bank	9131 Westwood Village Ct SW	Seattle	WA	98126	6021	
Seattle Skindiving Supply	1661 Harbor Ave SW	Seattle	WA	98126	5941	
Seven-Eleven Food Stores	8856 35th Ave SW	Seattle	WA	98126	5411	
Seven-Eleven Food Stores	2419 Harbor Ave SW	Seattle	WA	98126	5411	
Shakey's Pizza Parlor	3500 SW Avalon Way	Seattle	WA	98126	5812	
Sharon's Westwood Florist	8943 Westwood Village Mall SW	Seattle	WA	98126	5992	
Shirley's Hair Design	9033 35th Ave SW	Seattle	WA	98126	7231	
Smith Concrete & Masonry	3616 SW Dakota St	Seattle	WA	98126	1741	
Smith's Automotive Inc/Tom	3616 SW Oregon St	Seattle	WA	98126	7538	
Softrend Services	6022 37th Ave SW	Seattle	WA	98126	8742	
Southwest Cleaners	7910 35th Ave SW	Seattle	WA	98126	7216	
Southwest Saws & Mowers	4447 35th Ave SW	Seattle	WA	98126	7699	
Stokes Construction/A H	7126 31 S SW	Seattle	WA	98126	1521	
Stovers Kitchens Inc	4600 37th Ave SW	Seattle	WA	98126	5812	
Sudden Printing	4151 Fauntleroy Way SW	Seattle	WA	98126	2752	
Swedish Automotive/The	4451 35th Ave SW	Seattle	WA	98126	7538	
Tom's Auto Machine	3616 SW Oregon St	Seattle	WA	98126	7538	
Transitional Resources	2970 SW Avalon Way	Seattle	WA	98126	8361	
U-Haul Company	6343 35th Ave SW	Seattle	WA	98126	7513	
Video Tech Services	7908 35th Ave SW	Seattle	WA	98126	5731	
Walter's Hair Design & Gifts	9002 Westwood Village Mall SW	Seattle	WA	98126	7231	
Weller's Pharmacy	6313 35th Ave SW	Seattle	WA	98126	5912	

Appendix B

COMPANY NAME	ADDRESS	CITY	ST	ZIP	SIC_1	SIC2
West Fuel Company	4455 35th Ave SW	Seattle	WA	98126	5983	
West Seattle Auto Parts	4505 38th Ave SW	Seattle	WA	98126	5531	7538
West Seattle Auto Rebuild	4501 38th Ave SW	Seattle	WA	98126	7532	
West Seattle Brake Service	4464 37th Ave SW	Seattle	WA	98126	7539	
West Seattle Cleaners	4528 Fauntleroy Way SW	Seattle	WA	98126	7216	
West Seattle Eye Clinic	4615 35th Ave SW	Seattle	WA	98126	8011	
West Seattle Gull	9050 35th Ave SW	Seattle	WA	98126	5541	5411
West Seattle Herald	3500 SW Alaska St	Seattle	WA	98126	2711	
West Seattle Mobil	4580 Fauntleroy Way SW	Seattle	WA	98126	5541	
West Seattle Optical Inc	4611 35th Ave SW	Seattle	WA	98126	5995	
West Seattle Recycling Ctr YMCA	2964 SW Avalon Way	Seattle	WA	98126	5093	
Westside Import Repair	3606 SW Alaska St	Seattle	WA	98126	7538	7538
Westwood Travel Agency	8991 Westwood Village Mall SW	Seattle	WA	98126	4724	
Westwood Village Barber Shop	9008 Westwood Village Mall SW	Seattle	WA	98126	7241	
Westwood Village Cleaning Ctr	9058 Westwood Village Mall SW	Seattle	WA	98126	7215	
Winchell's Donut House	9048 Westwood Village Mall SW	Seattle	WA	98126	5461	
Yasuko's Teriyaki	4402 35th Ave SW	Seattle	WA	98126	5812	

APPENDIX C

WATER QUALITY SAMPLING METHODS AND WASTEWATER DATA

Stormwater Sampling
Aurora area subbasin
North 91st St. & Stone Ave. N.

Introduction

A commercial subbasin was selected in the Bitter Lake/Haller Lake watershed to establish a baseline for the pollutant load carried by storm runoff draining from commercial land uses. The smaller commercial subbasin was chosen to reduce dilution problems inherent in a system with permanent baseflow. The subbasin selected is bounded by N. 100th St. on the North, N. 92nd St. on the south, Fremont Ave. N. on the west, and Stone Ave. N. on the east (Figure 3-1).

Methods

Storm events were sampled by taking flow-weighted composit samples representing the entire storm event. Aliquots were taken at 20 minute intervals throughout the storm, along with flow recordings. ISCO flow meters and samplers were used. Aliquots were manually composited in the laboratory after the storm event by combining appropriate volumes from each aliquot proportional to the flow as recorded by the flow meter.

Storm samples were collected for the following days:

5/14/90
5/29/90
5/31/90
6/07/90
6/10/90.

The May 31 and June 10 storms were 8 hour events. Other storms were smaller 2 hour events.

Samples were analyzed for metals, total suspended solids, organic base/acid/neutrals and presence of oil sheen.

Results & Discussion

Results are discussed in the text in Section 3. Data are given in Table 3-2.

Table of Daily and Monthly Rainfall
Station No. 01 - Haller Lake Shops
Units in 0.01 Inches

1990

Day	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	17	4	-	-	-	-	-	-	-	-	-	-
2	1	18	-	-	18	18	-	-	-	-	-	-
3	5	57	2	-	-	72	-	-	-	-	-	-
4	1	12	-	-	-	9	-	-	-	-	-	-
5	34	39	-	-	-	-	-	-	-	-	-	-
6	110	6	21	-	6	47	-	-	-	-	-	-
7	45	14	83	-	1	-	-	-	-	-	-	-
8	33	15	17	-	-	7	-	-	-	-	-	-
9	141	2	63	-	-	43	-	-	-	-	-	-
10	1	2	1	-	-	17	-	-	-	-	-	-
11	-	40	-	7	2	-	-	-	-	-	-	-
12	1	1	-	-	3	16	-	-	-	-	-	-
13	7	-	28	42	15	-	-	-	-	-	-	-
14	3	-	4	2	7	-	-	-	-	-	-	-
15	13	5	-	-	-	-	-	-	-	-	-	-
16	-	9	-	-	-	-	-	-	-	-	-	-
17	-	17	13	33	1	-	-	-	-	-	-	-
18	1	20	1	-	5	-	-	-	-	-	-	-
19	-	8	1	9	4	-	-	-	-	-	-	-
20	-	40	1	12	7	-	-	-	-	-	-	-
21	4	-	-	-	21	-	-	-	-	-	-	-
22	10	-	15	25	5	-	-	-	-	-	-	-
23	-	5	-	37	-	-	-	-	-	-	-	-
24	-	2	-	4	-	-	-	-	-	-	-	-
25	20	-	-	28	-	-	-	-	-	-	-	-
26	-	-	-	-	-	-	-	-	-	-	-	-
27	31	-	-	28	9	-	-	-	-	-	-	-
28	37	-	-	3	28	-	-	-	-	-	-	-
29	35	-	-	-	-	-	-	-	-	-	-	-
30	26	-	-	-	54	-	-	-	-	-	-	-
31	70	-	-	-	6	-	-	-	-	-	-	-
Total	646	316	250	230	192	229	0	0	0	0	0	0
										Annual Total		1863
Rain Hours	158	112	94	86	55	49	0	0	0	0	0	0
									Annual Total Raining Hours			554

Report Range: 1/ 1/1990 to 6/21/1990

Commercial Wastewater Sampling
Aurora area subbasin
North 91st St. & Stone Ave. N.

Introduction

A commercial subbasin was selected within the Bitter Lake /Haller Lake Drainage Basin to establish a baseline representative of the range and concentrations of pollutants typical of commercial wastewater. The area selected is bounded by N. 97th St. on the North, N. 92nd St. on the south, Aurora Ave. N. on the west, and Stone Ave. N. on the east (Figure 3-2). It is approximately 12 square blocks. The subbasin is similar but not identical to the drainage subbasin due to plumbing configuration differences.

Methods

Samples were 24 hour composites taken by ISCO automatic samplers set to draw 40 ml aliquots at half hourly intervals. Flows were also monitored and recorded in Table 3-1. Diurnal variation was not considered significant enough to switch to flow-proportioned samples. Composite sampling began at 8:00 a.m. and ended the following morning at 7:30 a.m. Sampling was done Monday morning through Saturday mornings for the following days:

May 8-12
May 15-19
May 22-26
May 29-June 2
June 5-9
June 12-16

Upon completion of sampling, partial blockage of tubing by a glue-like substance was found. It was not known when the blockage occurred. The blockage could have been in the line for an extended period of time, and could have caused solids to be under-represented. Therefore an additional week of sampling was conducted after the tubing was replaced, from August 8 to 14, 1990, to determine total solids levels. A manually composited sample consisting of 5 aliquots was also drawn on August 22 as an additional check to determine if the equipment was adequqtely representing solids. The additional week's sampling as well as the manually composited sample were well within the range of total solids collected previously. Thus the samples collected in the weeks given above were considered representative.

Composite samples were analyzed for pH, total suspended solids, oil & grease, petroleum hydrocarbons, volatile organic priority pollutants, and the following metals: Ag, Cd, Cr, Cu, Pb, Ni, Zn. For the first week only, the Base/Acid/Neutral fraction of priority pollutants was also analyzed.

Rainfall data as recorded at the Haller Lake Shops is included following the data tables.

Results & Discussion

Total suspended solids levels were substantially higher during the first week of sampling then in the subsequent five weeks. Oil and grease (O/G) was usually above the detection level of 2 mg/l, the average being 10 mg/l. Most of the O/G was polar in nature, or derived from animal fat rather than petroleum substances. The highest value was 291, the only value over the local sewer discharge limit of 100 mg/l, also polar in nature. It is likely the source of O/G was domestic. Several apartment buildings were in the drainage area, but no restaurants were in business during the sampling time period. The next highest oil and grease value was 54 mg/l.

The only metals that were regularly detected were copper and zinc. Cadmium was detected once during the six week sampling period. All concentrations were low compared to the local limits for discharge to the sewer.

Organics. Only three volatile organics were detected with regularity during the study period: chloroform, a common break down product of chlorinated drinking water, acetone, a common solvent, and toluene, a common constituent of lacquer thinner and other petro-chemicals. Small amounts of other volatiles were infrequently detected, including ethyl benzene, xylene, ethanol acetaldehyde and carbon disulfide.

During the first weel of sampling, semivolatiles were also identified. Very few compounds were detected, and those were at low concentrations. Several PAHs (diethyl phthalate, benzylbutylphthalate, and bis(2-ethylhexyl)phthalate) were detected at low levels. Benzoic acid, phenol benzyl alchohol, 4-methylphenol, and 1,4 dichlorobenzene were also detected. On 5/9/90, 0.024 ppm of cocaine was detected. No other samples showed evidence of drugs.

Except for the one high oil and grease value, these 30 samples are typical of relatively clean wastewater, although the total suspended solids were lower than average values seen at the wastewater treatment plants (personal communication, Dick Finger, August, 1990). One plausable explanation is that these samples were taken "high" in the collection system--that is, close to the point of origin. As such, they are not subject to as much agitation and turbulence which breaks up solids and makes them more likely to be sampled as wastewater collected in larger lines or at the treatment plants.

Appendix C

WASTEWATER DATA: CONVENTIONALS

N. 92nd St. and Stone Ave. N

OLDSTA	DATE	SAMPLE-NUM	TOTAL-SS (MG/L)	OIL-GREASE (MG/L)		NON-POLAR-OIL (MG/L)
S232325	5/ 8/90	9000422	192.0	42.4		3.9
	5/ 9/90	9000423	272.0	23.2		1.2
	5/10/90	9000424	412.0	36.1		1.3
	5/11/90	9000425	315.0	26.0	<	2.0
	5/12/90	9000426	1,130.0	53.7	<	2.0
	5/15/90	9000458	75.0	17.2	<	2.0
	5/16/90	9000459	79.0	22.1	<	2.0
	5/18/90	9000461	100.0	13.1	<	2.0
	5/19/90	9000462	124.0	3.7	<	2.0
	5/22/90	9000477	178.0	25.1		4.0
	5/23/90	9000478	102.0	6.9		3.7
	5/24/90	9000479	122.0	18.4	<	2.0
	5/25/90	9000480	100.0	8.6	<	2.0
	5/26/90	9000481	118.0	7.3		10.5
	5/29/90	9006735	135.0	11.6	<	2.0
	5/30/90	9006736	74.0	9.1	<	2.0
	5/31/90	9006737	93.0	2.0	<	2.0
	6/ 1/90	9006738	80.0	2.5		2.1
	6/ 2/90	9006739	120.0	2.7		2.9
	6/ 5/90	9006784	79.0	5.0		3.0
	6/ 6/90	9006785	92.0	4.4		2.4
	6/ 7/90	9006786	62.0	2.6	<	2.0
	6/ 8/90	9006787	36.0	2.0		11.6
	6/ 9/90	9006789	38.0	5.1		2.1
	6/12/90	9006790	140.0	8.1	<	2.0
	6/13/90	9006791	94.0	4.6	<	2.0
	6/14/90	9006793	33.0	6.8	<	2.0
	6/15/90	9006795	77.0	5.9		2.4
	6/16/90	9006796	44.0	291.0	<	2.0
	8/ 9/90	9008574	100.0			
	8/10/90	9008575	32.6			
	8/11/90	9008576	42.1			
	8/14/90	9008577	54.5			
		MEAN WASTEWATER	143.8	23.0		3.9
		• FREQUENCY	33/33	29/29		13/29

• frequency indicates the total number of detected samples/total number of samples

WASTEWATER DATA: METALS

N. 92nd and Stone Ave. N.

SAMPLE NUMBER	STA	DATE	PH	CTSP	AG MG/L	AS MG/L	CD MG/L	CR MG/L	CU MG/L	HG MG/L	NI MG/L	PB MG/L	ZN MG/L	FLOW MGD	PROJ
9000422	232325	5/ 8/90	6.9	CH24	< .003	< .05	< .002	< .005	.041	< .0002	< .01	< .03	.093		A11235
9000423	232325	5/ 9/90	6.1	CH24	< .004	< .05	< .002	< .005	.031	< .0002	< .01	< .03	.074		A11235
9000424	232325	5/10/90	6.7	CH24	< .003	< .05	< .002	< .005	.028	.0002	< .01	< .03	.075		A11235
9000425	232325	5/11/90	5.9	CH24	< .003	< .05	< .002	< .005	.048	.0003	< .02	< .03	.16		A11235
9000426	232325	5/12/90	5.6	CH24	< .004	< .05	< .002	< .005	.08	.0005	.01	< .03	.52		A11235
9000458	232325	5/15/90	7.5	CH24	< .003	< .05	< .002	< .005	.032	<	.01	< .03	.042		A11235
9000459	232325	5/17/90	7	CH24	< .003	< .05	< .002	< .005	.027	<	.01	< .03	.04		A11235
9000461	232325	5/18/90	6.4	CH24	< .003	< .05	< .002	< .005	.031	<	.01	< .03	.046		A11235
9000462	232325	5/19/90	7.6	CH24	< .003	< .05	< .002	< .008	.028	<	.01	< .03	.04		A11235
9000477	232325	5/22/90	6.1	CH24	< .003	< .05	< .002	.01	.032	< .0002	< .01	< .03	.071		A11235
9000478	232325	5/23/90	6.7	CH24	< .003	< .05	< .002	< .005	.026	< .0002	< .01	< .04	.04	.039	A11235
9000479	232325	5/24/90	6.3	CH24	< .003	< .05	< .002	< .005	.029	< .0002	< .01	< .03	.042	.044	A11235
9000480	232325	5/25/90	6.3	CH24	< .003	< .05	< .002	< .005	.026	< .0002	< .01	< .03	.03		A11235
9000481	232325	5/26/90	7.3	CH24	< .003	< .05	< .002	< .005	.04	<	.01	< .03	.052	.028	A11235
9006735	232325	5/29/90	6.9	CH24	< .004	< .05	< .002	< .005	.04	<	.01	< .03	.04	.029	A11235
9006736	232325	5/30/90	6.5	CH24	< .003	< .05	< .002	< .005	.044	<	.01	< .03	.05	.037	A11235
9006737	232325	5/31/90	6.2	CH24	< .003	< .05	< .004	< .005	.042	<	.01	< .03	.051	.044	A11235
9006738	232325	6/ 1/90	6.6	CH24	< .003	< .05	< .002	< .005	.039	<	.01	< .03	.04	.046	A11235
9006739	232325	6/ 2/90	6.6	CH24	< .003	< .05	< .002	< .005	.042	<	.01	< .03	.042	.041	A11235
9006784	232325	6/ 5/90	6.7	CH24	< .003	< .05	< .002	< .005	.032	<	.01	< .03	.046	.042	A11235
9006785	232325	6/ 6/90	6.6	CH24	< .004	< .05	< .002	< .005	.024	<	.01	< .03	.03	.034	A11235
9006786	232325	6/ 7/90	7.2	CH24	< .003	< .05	< .002	< .005	.026	<	.01	< .03	.04	.042	A11235
9006787	232325	6/ 8/90	7.2	CH24	< .003	< .05	< .002	< .005	.033	<	.01	< .03	.066	.037	A11235
9006789	232325	6/ 9/90	7.2	CH24	< .003	< .05	< .002	< .005	.027	<	.01	< .03	.03	.046	A11235
9006790	232325	6/12/90	7.1	CH24	< .003	< .05	< .003	< .005	.025	<	.01	< .03	.03	.14	A11235
9006791	232325	6/13/90	7.2	CH24	< .003	< .05	< .002	< .005	.024	<	.01	< .03	.04	.037	A11235
9006793	232325	6/14/90	7.3	CH24	< .003	< .05	< .002	< .005	.029	<	.01	< .03	.03	.036	A11235
9006795	232325	6/15/90	7.4	CH24	< .003	< .05	< .002	.009	.02	<	.01	< .03	.03	.033	A11235
9006796	232325	6/16/90	7.2	CH24	< .003	< .05	< .002	< .005	.026	<	.01	< .03	.043	.033	A11235
MEAN								.026	.0335	.0003	.01		.0667		
* FREQUENCY					0/29	0/29	0/29	2/29	29/29	3/9	1/29	0/29	19/29		

* frequency indicates the total number of detected samples/total number of samples

Appendix C

WASTEWATER DATA: Organics (N. 92nd and Stone Ave. N.) **Sheet -- 1**

COMPOUND NAME	DATE	DETECTION	PPB-WET WEIGHT	SAMPLE#	STATION #
SAMPLE NUMBER: 9000422					
ACETONE	900508	10.0	24.0	9000422	232325
BENZOIC ACID	900508	6.0	640.0	9000422	232325
BENZYL ALCOHOL	900508	2.0	8.8	9000422	232325
BENZYL BUTYL PHTHALATE	900508	1.0	2.5	9000422	232325
BIS(2-ETHYLHEXYL)PHTHALATE	900508	1.0	11.0	9000422	232325
CARBON DISULFIDE	900508	2.0	2.7	9000422	232325
CHLOROFORM	900508	2.0	2.9	9000422	232325
DIETHYL PHTHALATE	900508	2.0	8.5	9000422	232325
PHENOL	900508	6.0	14.0	9000422	232325
4-METHYLPHENOL (P-CRESOL)	900508	2.0	95.0	9000422	232325
TTO (ppb)			809.4		
SAMPLE NUMBER: 9000423					
BENZOIC ACID	900509	6.0	500.0	9000423	232325
BENZYL ALCOHOL	900509	2.0	4.6	9000423	232325
BIS(2-ETHYLHEXYL)PHTHALATE	900509	1.0	11.0	9000423	232325
CHLOROFORM	900509	2.0	4.1	9000423	232325
DIETHYL PHTHALATE	900509	2.0	6.4	9000423	232325
PHENOL	900509	6.0	11.0	9000423	232325
TOLUENE	900509	2.0	1.9	9000423	232325
4-METHYLPHENOL (P-CRESOL)	900509	2.0	56.0	9000423	232325
TTO (ppb)			595		
SAMPLE NUMBER: 9000424					
BENZOIC ACID	900510	6.0	330.0	9000424	232325
BENZYL ALCOHOL	900510	2.0	4.6	9000424	232325
BENZYL BUTYL PHTHALATE	900510	1.0	1.7	9000424	232325
CHLOROFORM	900510	2.0	2.7	9000424	232325
DIETHYL PHTHALATE	900510	2.0	5.0	9000424	232325
PHENOL	900510	6.0	44.0	9000424	232325
TOLUENE	900510	2.0	1.1	9000424	232325
1,4-DICHLOROBENZENE	900510	1.0	12.0	9000424	232325
4-METHYLPHENOL (P-CRESOL)	900510	2.0	25.0	9000424	232325
TTO (ppb)			426.1		

WASTEWATER DATA: Organics (N. 92nd and Stone Ave. N.) Sheet -- 2

COMPOUND NAME	DATE	DETECTION	PPB-WET WEIGHT	SAMPLE#	STATION #
SAMPLE NUMBER: 9000425					
BENZOIC ACID	900511	6.0	1,900.0	9000425	232325
BENZYL ALCOHOL	900511	2.0	13.0	9000425	232325
BENZYL BUTYL PHTHALATE	900511	1.0	.9	9000425	232325
CHLOROFORM	900511	2.0	2.4	9000425	232325
DIETHYL PHTHALATE	900511	2.0	10.0	9000425	232325
PHENOL	900511	6.0	24.0	9000425	232325
TOLUENE	900511	2.0	1.7	9000425	232325
4-METHYLPHENOL (P-CRESOL)	900511	2.0	140.0	9000425	232325
TTO (ppb)			2092		
SAMPLE NUMBER: 9000426					
BENZOIC ACID	900512	6.0	870.0	9000426	232325
BENZYL ALCOHOL	900512	2.0	14.0	9000426	232325
BENZYL BUTYL PHTHALATE	900512	1.0	2.0	9000426	232325
CHLOROFORM	900512	2.0	3.2	9000426	232325
DIETHYL PHTHALATE	900512	2.0	6.8	9000426	232325
PHENOL	900512	6.0	120.0	9000426	232325
TOLUENE	900512	2.0	2.0	9000426	232325
4-METHYLPHENOL (P-CRESOL)	900512	2.0	470.0	9000426	232325
TTO (ppb)			1488		
SAMPLE NUMBER: 9000458					
CHLOROFORM	900515	2.0	2.0	9000458	232325
TOLUENE	900515	2.0	1.4	9000458	232325
TTO (ppb)			3.4		
SAMPLE NUMBER: 9000459					
ACETONE	900517	10.0	46.0	9000459	232325
CHLOROFORM	900517	2.0	3.5	9000459	232325
TOLUENE	900517	2.0	2.0	9000459	232325
TTO (ppb)			51.5		
SAMPLE NUMBER: 9000461					
CHLOROFORM	900518	2.0	3.7	9000461	232325
TTO (ppb)			3.7		

Appendix C

WASTEWATER DATA: Organics (N. 92nd and Stone Ave. N.) Sheet -- 3

COMPOUND NAME	DATE	DETECTION	PPB-WET WEIGHT	SAMPLE#	STATION #
SAMPLE NUMBER: 9000462					
ACETONE	900519	10.0	77.0	9000462	232325
CHLOROFORM	900519	2.0	3.1	9000462	232325
TTO (ppb)			80.1		
SAMPLE NUMBER: 9006735					
ACETONE	900529	10.0	56.0	9006735	232325
CHLOROFORM	900529	2.0	4.0	9006735	232325
TTO (ppb)			60		
SAMPLE NUMBER: 9006736					
ACETONE	900530	10.0	36.0	9006736	232325
CHLOROFORM	900530	2.0	2.1	9006736	232325
TTO (ppb)			38.1		
SAMPLE NUMBER: 9006737					
ACETONE	900531	10.0	42.0	9006737	232325
CHLOROFORM	900531	2.0	1.7	9006737	232325
TTO (ppb)			43.7		
SAMPLE NUMBER: 9006738					
CHLOROFORM	900601	2.0	2.1	9006738	232325
TTO (ppb)			2.1		
SAMPLE NUMBER: 9006739					
ACETONE	900602	10.0	54.0	9006739	232325
CHLOROFORM	900602	2.0	2.8	9006739	232325
TTO (ppb)			56.8		
SAMPLE NUMBER: 9006785					
ACETONE	900606	10.0	43.0	9006785	232325
CHLOROFORM	900606	2.0	1.5	9006785	232325
TTO (ppb)			44.5		

WASTEWATER DATA: Organics (N. 92nd and Stone Ave. N.) Sheet -- 4

COMPOUND NAME	DATE	DETECTION	PPB-WET WEIGHT	SAMPLE#	STATION #
SAMPLE NUMBER: 9006786					
ACETONE	900607	10.0	100.0	9006786	232325
CHLOROFORM	900607	2.0	2.1	9006786	232325
ETHYLBENZENE	900607	2.0	1.3	9006786	232325
TOTAL XYLENES	900607	2.0	5.0	9006786	232325
TTO (ppb)			108.4		
SAMPLE NUMBER: 9006787					
ACETONE	900608	10.0	38.0	9006787	232325
CHLOROFORM	900608	2.0	3.8	9006787	232325
TTO (ppb)			41.8		
SAMPLE NUMBER: 9006789					
ACETONE	900609	10.0	49.0	9006789	232325
CHLOROFORM	900609	2.0	4.4	9006789	232325
TTO (ppb)			53.4		
SAMPLE NUMBER: 9006791					
CHLOROFORM	900613	2.0	5.5	9006791	232325
TTO (ppb)			5.5		
SAMPLE NUMBER: 9006793					
CHLOROFORM	900614	2.0	5.0	9006793	232325
TTO (ppb)			5		
SAMPLE NUMBER: 9006795					
CHLOROFORM	900615	2.0	3.5	9006795	232325
TTO (ppb)			3.5		
SAMPLE NUMBER: 9006796					
CHLOROFORM	900616	2.0	2.6	9006796	232325
1,1,2,2-TETRACHLOROETHANE	900616	2.0	33.0	9006796	232325
TTO (ppb)			35.6		

APPENDIX D

SURVEY INFORMATION AND ANALYSIS

METRO

Seattle Engineering Department

Small Business Waste Management Questionnaire

Please complete the following questions and return before April 27. Postage will be paid by Metro. All responses will be kept confidential. Thank you for participating.

Firm name _____

Owner/Manager _____

Address _____

City _____ State____ Zip_____

Phone _____

What service/product does your company provide? ____

_____

Number of employees _____

Please check the answer that corresponds to your understanding of the following: Agree (Y), Disagree (N) or Don't Know (?).

☐Y ☐N ☐? 1. Small businesses are exempt from most regulations about the kinds of wastes that can be discarded into the sewers and garbage.

☐Y ☐N ☐? 2. In the Seattle area, sewage treatment plants are able to give adequate treatment to all the various wastes produced by business and industry.

☐Y ☐N ☐? 3. Harmful or hazardous chemicals are only used by relatively large industries.

☐Y ☐N ☐? 4. Small businesses as a group contribute much less than large businesses and industry to the overall waste loads handled by sewage treatment plants.

☐Y ☐N ☐? 5. It is sometimes hard to tell if a waste or product contains hazardous chemicals.

☐Y ☐N ☐? 6. It is against the law to allow oil to enter street drains in areas that have separate drains or sewers for rain water and for sewage.

☐Y ☐N ☐? 7. Used oil, paint thinner and antifreeze should not be poured onto the ground because they could pollute the ground water.

☐Y ☐N ☐? 8. My business recycles some of the wastes it produces or handles (either those that would go down the drain or into the garbage).

9. If the above answer is no, check the reasons which apply.
   ____ no need
   ____ too expensive
   ____ no recycler available
   ____ takes too much time, not convenient
   ____ don't know how
   ____ haven't thought about it
   ____ other (what?) _____

Please answer the following questions based on a scale of 1-5, with 1 being agree strongly and 5 being disagree strongly.

10. Pollution control is good business – customers use "environmentally friendly" establishments even if their prices are slightly higher.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

11. I pay attention to waste disposal, but only when required to by regulations.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

12. It's a common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down street or outside drains.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

13. Never ask for information about waste disposal from a government staff person – you'll just get into trouble.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

14. I know the current recommended method of disposal for all the wastes my company handles or produces, not just harmful or hazardous ones.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

Please provide the following information about your business.

15. Does your company:
   a. use water for anything other than restrooms?
      ☐no ☐yes
      If yes, check uses that may apply.
      ____ in product or service
      ____ cooling water
      ____ Steam cleaning
      ____ washing (specify) _____
         ____ vehicles
         ____ dishes
         ____ metal parts
         ____ floors
         ____ laundry
         ____ other (specify) _____
         _____
      ____ rinse water
      ____ other (specify) _____
      _____
   b. have an oil/water separator?
      ☐no ☐yes ☐don't know
   c. have a grease trap? ☐no ☐yes ☐don't know
   d. use a rendering barrel? ☐no ☐yes
      (Who picks up?) _____
   e. have a storm drain on the property?
      ☐no ☐yes ☐don't know
   f. belong to a trade or business association?
      ☐no ☐yes (which) _____

16. What kinds of chemical products does your business use or recycle (put an R for recycle). Check all that apply.
   ____ detergents, soaps
   ____ paint
   ____ paint thinner, stripper
   ____ oil and transmission fluid
   ____ antifreeze
   ____ brake fluid
   ____ solvents and degreasers
      (kinds) _____
      _____
   ____ flammable materials
   ____ acids
   ____ bases or caustics (ammonia, sodium hydroxide, etc.)
   ____ bleaches, peroxides or oxidizers
   ____ photographic fixer
   ____ inks or dyes (solvent or water based?)
   ____ pesticides
      (kinds) _____
      _____
   ____ herbicides, weed killer
      (kinds) _____
      _____
   ____ fertilizers
   ____ other (specify) _____

Appendix D

17. What is the best way for you to learn about waste management regulations and practices which affect your business? Rate the following on a scale from 1-5 with 1 being the best.
    ____ printed information (brochures, pamphlets)
    ____ information in trade/business newsletter
    ____ articles in newspaper
    ____ from business associates
    ____ attend meeting (☐ day ☐ evening ☐ weekend)
    ____ on-site consultation with agency staff
    ____ on-site consultation with private specialist
    ____ from product suppliers or waste haulers
    ____ calling an information hot-line
    ____ other (what?) _____

18. In the past year, has your business made any changes in the way it disposes of wastes? ☐ no ☐ yes
    If yes, did you
    ____ change disposal method? (how) _____
    ____ recycle some or all of your waste?
    ____ change to less toxic products?
    ____ use a hazardous waste disposal service?
    ____ change practices? (how) _____
    ____ other (what?) _____

19. Why might you make one of the changes mentioned in question 18. (Check all that apply).
    ____ high disposal costs
    ____ new technology available
    ____ economically advantageous
    ____ concern about government enforcement
    ____ concern about liability
    ____ concern for the environment
    ____ concern about public image

20. Under what conditions would you like information or assistance in dealing with waste disposal problems (check all that apply):
    ____ would like assistance now
    ____ if I thought it would save me money
    ____ if given without mandatory or regulatory requirements
    ____ if there were changes in regulations that affected my current practices
    ____ if disposal rates (garbage and sewer) increased substantially
    ____ if under an enforcement or compliance order
    ____ other (specify) _____

Thank you for your responses.
Please fold, staple and return. Postage is pre-paid.

If you have questions or comments, please contact Louise Kulzer, Metro Industrial Waste Section, 684-2373.

METRO

Seattle Engineering Department
Drainage and Wastewater Utility
680 Dexter Horton Building
710 Second Avenue

Small Business Waste Management Questionnaire II

Your opinion counts. Please help us by completing the following questions. Return before Nov. 21. All responses will be kept confidential. Do it today! Thank you.

Firm name _____

Owner/Manager _____

Address _____

City _____ State____ Zip_____

Phone _____

What service/product does your company provide? ____

_____

Number of employees _____

Please check the answer that corresponds to your understanding of the following: Agree (Y), Disagree (N) or Don't Know (?).

☐Y ☐N ☐? 1. Small businesses are exempt from most regulations about the kinds of wastes that can be discarded into the sewers and garbage.

☐Y ☐N ☐? 2. In the Seattle area, sewage treatment plants are able to give adequate treatment to all the various wastes produced by business and industry.

☐Y ☐N ☐? 3. Harmful or hazardous chemicals are only used by relatively large industries.

☐Y ☐N ☐? 4. Small businesses as a group contribute much less than large businesses and industry to the overall waste loads handled by sewage treatment plants.

☐Y ☐N ☐? 5. It is against the law to allow oil to enter street drains in areas that have separate drains or sewers for rain water and for sewage.

☐Y ☐N ☐? 6. Used oil, paint thinner and antifreeze should not be poured onto the ground because they could pollute the ground water.

☐Y ☐N ☐? 7. My business recycles some of the wastes it produces or handles (either those that would go down the drain or into the garbage).

8. If the above answer is no, check the reasons which apply.
   ____ no need
   ____ too expensive
   ____ no recycler available
   ____ takes too much time, not convenient
   ____ don't know how
   ____ haven't thought about it
   ____ other (what?) _____

Please answer the following questions based on a scale of 1-5, with 1 being agree strongly and 5 being disagree strongly.

9. Pollution control is good business – customers use "environmentally friendly" establishments even if their prices are slightly higher.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

10. I pay attention to waste disposal, but only when required to by regulations.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

11. It's a common practice in my area to clean sidewalks and parking lots by washing the accumulated litter down street or outside drains.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

12. Never ask for information about waste disposal from a government staff person – you'll just get into trouble.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

13. I know the current recommended method of disposal for all the wastes by company handles or produces, not just harmful or hazardous ones.

Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
1	2	3	4	5

14. Please rank the following practices based on your opinion of their potential **liability to businesses**. Use a scale of 1-5 with 1 being the most risky and 5 the least risky.

Major risk	Definite risk	May be risky	Not much risk	Not risky
1	2	3	4	5

a. oil or solvent leaking into the ground.
   1 2 3 4 5
b. dispensing solvent or fueling vehicles in an area that drains directly into storm drains.
   1 2 3 4 5
c. storing liquid wastes in an unpaved area without a roof.
   1 2 3 4 5
d. washing detergents or soapy water into street or storm drains.
   1 2 3 4 5
e. letting antifreeze drain into street or storm drains.
   1 2 3 4 5

Appendix D

15. Please rate the same practices based on the risk they pose to **polluting the environment.**

Major risk	Definite risk	May be risky	Not much risk	Not risky
1	2	3	4	5

a. oil or solvent leaking into the ground
1 2 3 4 5

b. dispensing solvent or fueling vehicles in an area that drains directly into storm drains.
1 2 3 4 5

c. storing liquid wastes in an unpaved area without a roof.
1 2 3 4 5

d. washing detergents or soapy water into street or storm drains.
1 2 3 4 5

e. letting antifreeze drain into street or storm drains.
1 2 3 4 5

16. What is the best way for you to learn about waste management regulations and practices which affect your business? Rate the following on a scale from 1-5 with 1 being the best.
____ printed information (brochures, pamphlets)
____ information in trade/business newsletter
____ articles in newspaper
____ from business associates
____ attend meeting (☐ day ☐ evening ☐ weekend)
____ on-site consultation with agency staff
____ on-site consultation with private specialist
____ from product suppliers or waste haulers
____ calling an information hot-line
____ other (what?) _____

17. In the past year, has your business made any changes in the way it disposes of wastes? ☐ no ☐ yes
If yes, did you
____ change disposal method? (how) _____
____ recycle some or all of your waste?
____ change to less toxic products?
____ change waste storage practices?
____ use a hazardous waste disposal service?
____ change practices? (how) _____
____ other (what?) _____

18. Why might you make one of the changes mentioned in question 18. (Check all that apply).
____ high disposal costs
____ new technology available
____ economically advantageous
____ concern about government enforcement
____ concern about liability
____ concern for the environment
____ concern about public image

Thank you for your responses.
Please fold, staple and return. Postage is pre-paid.

If you have questions or comments, please contact Louise Kulzer, Metro Industrial Waste Section, 684-2373.

WORKSHEET: Calculation of 95% Confidence Interval (CI)

Baseline Survey, n = 93
(p = proportion of correct responses)

Question	p	$(1-p)$	$S=\sqrt{\frac{p(1-p)}{n}}$	$1.96(S)$	95% C. I. $\pm 1.96(S)$
1	.81	.19	.0407	.08	.73 – .89
2	.60	.40	.0508	.10	.50 – .70
3	.87	.13	.0349	.07	.80 – .94
4	.42	.58	.0512	.10	.32 – .52
5	.68	.32	.0483	.09	.59 – .77
6	.85	.15	.0370	.07	.78 – .92
7	.92	.08	.0281	.06	.86 – .98
8	.76	.24	.0443	.09	.67 – .85

Appendix D

WORKSHEET: Calculation of 95% Confidence Interval (CI)

Random Sample, Baseline Survey
n = 24

	p	$(1-p)$	$S = \sqrt{\frac{p(1-p)}{n}}$	2.07 (S) ($t_{.025}$, d.f = 23)	95% C.I.
1	.71	.29	.0926	.19	52% - 90%
2	.63	.37	.0986	.20	43% - 83%
3	.92	.08	.0554	.11	81% - 100%
4	.50	.50	.1021	.21	29% - 71%
5	.79	.21	.0831	.17	62% - 96%
6	.71	.29	.0926	.19	52% - 90%
7	.96	.04	.04	.08	88% - 100%
8	.46	.54	.1017	.21	25% - 67%
18	.67	.33	.096	.20	47% - 87%

WORKSHEET: Calculation of 95% Confidence Interval (CI)

Postsurvey, n = 81

Question #	# Correct responses	proportion correct ($\bar{p}$)	$\sigma = \sqrt{\frac{p(1-p)}{n}}$	95% conf. interv. $\pm 1.96(\sigma)$
1	61	.75	.048	± .094
2	57	.70	.051	± .099
3	66	.88	.036	± .071
4	31	.38	.054	± .105
5	70	.86	.039	± .076
6	78	.96	.0218	± .043
7	58	.72	.050	± .098

APPENDIX E

OUTREACH MATERIALS USED

Are you pouring water quality down the drain?

Metro is preparing to build a new storm drain to divert stormwater runoff from north Seattle to a new discharge outfall in Lake Union. And Metro needs your help to make sure this project succeeds in protecting the environment. Metro doesn't want the stormwater to contain unnecessary pollutants that could reduce the quality of water and sediment in Lake Union. Your personal actions can help.

At work:

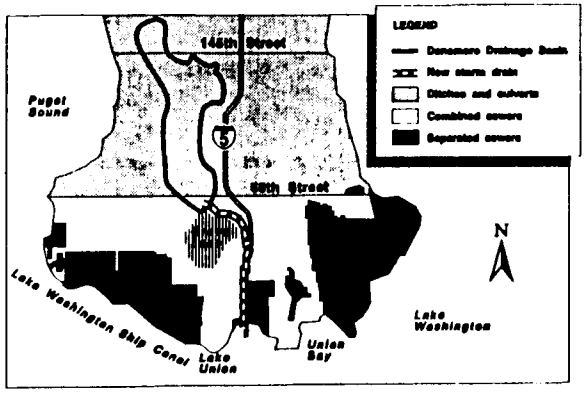
Source reduction. When buying chemicals or petroleum-based products, get only what you need. Without excess materials, you won't have as big a disposal problem. Use only what the job requires – twice as much does not mean twice the results. Also, consider using a nontoxic or less-hazardous product for your job.

Housekeeping measures. Regular yard sweeping can prevent dirt and debris from being washed into storm drains. Methods to control dust in parking lots and on roadways include paving, using road fabrics and applying chemical mixtures of calcium chloride (don't use waste oil to control dust).

Oil storage areas. Concrete or asphalt berms and curbs around drums or oil storage areas can catch leaks and spills before pollutants run into storm drains. Also, roofing the drain or oil storage areas can prevent contamination of runoff.

Employee education. Informing co-workers about the dangers of careless or excessive use of potentially harmful products can help protect the environment. Dumping toxic products down storm drains into area waters is illegal. It can result in jail terms or large fines.

Sewage treatment. Some materials should never go down a sink or toilet because they can damage sewers, affect the treatment process and hurt treatment plant workers. These materials include flammable or explosive substances, material that can clog the sewer, substances that cause toxic vapors, corrosive materials that can cause structural damage, foul-smelling materials that can create a public nuisance and substances with a temperature of 150 degrees Fahrenheit or more.



Pretreatment. You can dispose of certain types of waste, properly pretreated by your firm, through the sewer lines. You may dispose of the following common wastes only in restricted quantities: acids; grease and fat; metals such as copper, lead and zinc; oils; organic chemicals; and solvents such as acetone and degreasers. The amount and type of waste you produce determines what pretreatment methods you should use. For more waste-reduction ideas, call the state's 24-hour Recycle Hotline, 1-800-RECYCLE.

Chemical products. Never put chemical products of any kind down a storm drain. These materials include waste oil and hydraulic fluids, floor cleaners, cleanup water, detergents, degreasers, antifreeze, wastewater from steam cleaning and high-pressure wash water. Recycle them or discharge them into the sanitary sewer provided they meet pretreatment standards.

Metro can give your company more information about proper disposal procedures, discharge limits and permits, pretreatment techniques and oil/water separators.

For more information, call Metro's industrial waste program at 684-2300.

Keep everything out of storm drains except the rainwater they are designed to collect. Don't put anything down a storm drain that you wouldn't want to swim in.

Clean water doesn't just happen. It's your investment ... a Sound investment.

METRO

Produced by Metro's communications division for the University regulator project.

F0562A
5/90

University Regulator/CSO Control Project

Public information document

October 1990

PUBLIC MEETINGS
Monday, Oct. 15, 7 p.m.
Green Lake Community Center, Room 1
7201 E. Green Lake Drive N.

Thursday, Oct. 18, 7 p.m.
Wallingford Senior Center
Good Shepherd Center
4649 Sunnyside Ave. N.
Wheelchair accessible

New pipeline, pump station to reduce overflows in Portage Bay

The aim of Metro's University regulator/CSO control project is to separate stormwater flows – street and roof runoff – from the existing combined sewer system in the Green Lake and Ravenna areas.

During periods of high rainfall, the University regulator – located near the University of Washington Hospital – receives more flow than the collection system can handle hydraulically. At these times, it discharges combined stormwater and raw sewage into Portage Bay. The overflow of stormwater and raw sewage is called a combined sewer overflow.

The new storm drain would greatly reduce these overflows. The University regulator now discharges the largest annual volume of combined sewage to fresh water in the Seattle area – 211 million gallons annually, or about 40 percent of total overflows to the Ship Canal-Lake Union system.

CSOs today continue to have a negative impact on the water quality of Lake Washington, Lake Union, the Lake Washington Ship Canal and Elliott Bay. Besides causing water quality problems like disease-causing bacteria and viruses from CSOs, increased stormwater and other non-contaminated waters entering the combined sewers place an added demand on sewage treatment plants.

Metro would collect stormwater runoff from the Densmore drain, Green Lake overflow and I-5 drainage area and convey it in a new gravity pipeline to a pump station. That flow would then go by force main and gravity pipeline to an outfall into Lake Union.

Background for the project

Metro began its study of the University regulator project in 1986. A 22-member citizens'advisory committee and Metro studied many alignments to carry the stormwater to Lake Union. Metro also held public meetings during this planning process to discuss the alignments and pump station options. In February 1989, the committee supported the Ravenna/I-5 alignment described in this report.

The Ravenna/I-5 alignment had the least impacts on the environment and community. In March 1989, the Metro Council's Water Quality Committee passed a motion supporting the Ravenna/I-5 alignment.

During final design work, the consultants are looking at the best location for the pump station, conveyance alignment and discharge point at Lake Union. The options are described here.

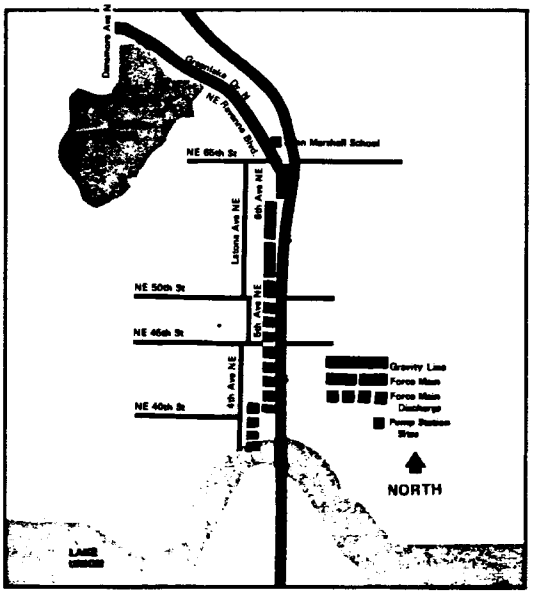
Pipeline alignment options

The first section of the project is a 42-inch **gravity pipeline** from Densmore Avenue North around the east edge of Green Lake to the pump station site. The recommended alternative of those studied thus far is the shallow street option, which crosses over a 54-inch sewer at Northeast Ravenna Boulevard and Woodlawn Avenue Northeast. The shallow street alignment would require less time to build and less restoration. It would also allow the pump station to be shallower, which would reduce construction time and operation costs.

The second section is the 42-inch **force main** that will carry the flow from the pump station to the high point near Northeast 50th Street. The recommended alignment runs directly across Northeast Ravenna Boulevard to S[illegible] Avenue Northeast. It then proceeds south along Sixth Avenue Northeast and west along Northeast 60th Street to the intersection with Fifth Avenue Northeast. This alignment would have the least impact on local residential and business access.

South of Northeast 60th Street, the recommended alignment is underneath the westerly parking lane of Fifth Avenue Northeast.

The third section of the project is a **gravity pipeline** from the force main to the discharge at the Ship Canal. The recommended alignment continues along Fifth Avenue Northeast to Northeast 40th Street. It then goes west along the south planting strip of Northeast 40th Street to Fourth Avenue Northeast and south along Fourth Avenue Northeast to the Ship Canal.



METRO
Clean Water . A Sound Investment

Map showing gravity pipeline, force main and pump station sites for the University Regulator/CSO Control Project.

Pump station site alternatives

The proposed new pump station, would be completely underground, and contain three submersible pumps. The pump station would be 40 feet deep and 50 feet in diameter. An underground electrical substation would be next to the pump station.

Metro has identified three proposed sites for the pump station, which will convey stormwater to Lake Union for discharge. All three are southeast of Green Lake Way near the intersection of Northeast Ravenna Boulevard and I-5 freeway. Each site is described below.

During construction of the pump station, Metro anticipates some noise and traffic impacts. The pump station construction will take about one to two years to complete. Most of the noise impacts will occur during the initial four-month period required to excavate the site and build the underground pump station structure.

Metro will control noise from operation and maintenance of the pump station to meet City of Seattle ordinances. Noise control measures are part of the station's design.

Parking restrictions during construction will be required to avoid interruption of traffic and recreational use during the nine-month construction period.

Ravenna median. This site, in the Northeast Ravenna Boulevard median strip between I-5 and Northeast 65th Street, is in the public right-of-way but out of the travel area. The site would have a low impact on the public because construction would be confined to the median strip. At times construction would affect bikers, recreational users and traffic.

John Marshall School play area. This site is on school property and will require coordination with the school district's staff. The noise and disruption would affect the students and an on-site day-care center. The Marshall School site would have less impact on the public, except for students, and the least traffic impact of all the alternatives.

Triangle Area. The triangle area is bordered by Northeast 65th Street, Northeast Ravenna Boulevard at I-5 freeway and the park-and-ride lot under the freeway. The site access is constrained by the I-5 bridge structures and the entrance to the park-and-ride lot under the freeway. Metro considers the site to have a high impact on public facilities, especially traffic.

Both the John Marshall School and triangle sites would require the gravity pipe to cross over a 60-year-old, 90-inch brick sewer 25 feet deep in the middle of Ravenna Boulevard. This work would result in extensive traffic disruption.

What is the project schedule?

Predesign	complete
Final design	April 1990 - November 1991
Construction	November 1991- December 1992
System operational	December 1992
Final restoration	by April 1993

What are your thoughts?

Metro wants to know your thoughts on the pump station site and conveyance lines. Two public information meetings are scheduled (see front). Your comments will be shared with the Metro Council's Secondary Treatment/Combined Sewer Overflow Control Program Oversight Committee.

If you have questions about the University Regulator/CSO Control Project or want to schedule a speaker for your community or business group, call Mary Lundt, Metro community relations planner, at 684-1145 (684-1682 for hearing-impaired persons using TTY equipment), or write her at Metro Community Relations, 821 Second Ave., M.S. 95, Seattle, WA 98104-1598.

Produced by Metro's communications division

METRO
Municipality of Metropolitan Seattle

Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

July 6, 1990

Greetings:

Your business is getting a new storm drain outfall. "A what?" you say? Yes, it's true. Rainwater from the north Aurora area will soon flow to Lake Union rather than into the combined sewer, as it does now. This change is necessary because during large rainstorms, the capacity of the sewers to handle both sewage and rainwater is exceeded--and overflows of untreated sewage (mixed with the rainwater) occur at overflow points along the Ship Canal.

Metro and the City of Seattle need your involvement to make sure your runoff water stays clean on it's way to Lake Union. Field staff may be contacting you this summer to check storm drain connections at your business site. And how you use and store petroleum products and chemicals is also important to prevent spillage into the storm drains.

Please take a minute to read the enclosed flyer. You can get additional information on reducing potential waste disposal problems at your business if you wish. Metro will provide on-site no-fault consultations, or supply information that applies to your business activity. Specific information is available free of charge on the following business operations:

Analytical labs
Auto repair and body shops
Boat yards and repair shops
Dry cleaners
Machine shops
Print shops, photo labs & graphics firms

In addition to good management of chemicals and petroleum products, it is important to keep excess debris and soap out of the storm drains. We are asking all business owners to be careful about two things:

1) Sweep sidewalks and parking areas rather than hose debris into outside drains (especially important around garbage dumpsters).

2) Soapy water from washing cars or trucks shouldn't go down street grates or storm drains. The same soap that kills germs is also very harmful to aquatic life. And oils and metals washed from vehicles is also harmful to fish. If possible, wash vehicles where the water can drain or be pumped to the sanitary sewer, use a commercial car wash, or reduce the number of vehicles washed to just a few a week.

To request information, call Metro's Industrial Waste Section at 684-2325. If you have questions specifically about your site, or to request a no-fault consultation, call Louise Kulzer, 684-2373.

The care you take to keep stormwater from your site clean will mean better water quality for all users of Lake Union, and a healthier environment too. Thanks for your cooperation.

Sincerely yours,

Leon Maday
Metro Project Manager
University Regulator

Louise Kulzer
Metro Industrial Waste Section

Cindy Thrush
Seattle Drainage & Wastewater Utility

LRKA\lgenureg

METRO
Municipality of Metropolitan Seattle
Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

October 1, 1990

Dear Shop Owner:

Subject: Cleaning Shop Floors

As I may have told you when I visited your shop, wash water from cleaning shop floors should not be rinsed into the street or storm drains. Floor wash water contains oil, trace metals and detergents, all of which are toxic to fish and other aquatic life. And don't be fooled by "biodegradable" detergents. They still are toxic, they just break down over time (actually, all detergents are biodegradable, sooner or later).

Storm drains in the North Aurora drainage area currently overflow into Green Lake when it rains hard, and in the future will drain, untreated, directly into Lake Union.

Keeping floor wash water out of the storm drains not only protects Green Lake and Lake Union, it protects you too. If Department of Ecology regulatory personnel observe the discharge of wash water to the street or storm drains, fines of up to $10,000 per day may result.

A number of shop owners in the Aurora area are already using environmentally acceptable practices to keep floors clean. You can deal with cleaning shop floors legally by using one of the four methods below. Which method you choose depends on the size of the shop, the amount of spilled oil you typically have, and to some extent, personal preference.

1. DRY

Use Floor-dri or Grease-sweep to pick up spills. Sweep up & save for re-use until it's absorbing power is gone. Bag the used Floor-dri and dispose of it in the trash.

2. DRY & SPOTLESS

Put down a little parts cleaning solvent on the spilled oil before applying Floor-dri. Caution: You & your workers will be exposed to more solvent fumes since the solvent will evaporate in the shop. And depending on the solvent used, it could make the Floor-dri a hazardous waste which could no longer be put in the trash.

3. WET & PRETTY GOOD
If general cleaning with water is desired, lightly wet down floor. Sprinkle with detergent of choice, working in with a broom to remove soil build up. Use mop & bucket or a wet vacuum to pick up dirty detergent/water residue. Dump dirty water into the toilet or sanitary sewer.

4. WET & SAFE
For large shops or if lots of spills are common, the wet & pretty good method won't meet the limits for discharge of oils to the sanitary sewer (100 mg/l). Install a floor drain and an oil/water separator connected to the sanitary sewer. It's a good idea to provide a drain downstream of the separator for antifreeze (if you don't recycle it) or for oil-free soapy water. Anti-freeze and soap shouldn't go through your separator since they break the oil/water emulsion. This allows accumulated oil to escape from the separator into the sewer, possibly exceeding discharge limits. Regular maintenance is important, too. Remove accumulated oil and dispose of sludge at least yearly.

If you are not already using one of these alternatives, please chose one and change your practices accordingly. This change should take place by October 15. If you have questions or think other methods will work, please give me a call and we can talk about it. My phone number is 684-2373. Just leave a message if I'm out. After mid October, I will be collecting samples in the storm drains to check if further pollution control work is needed in the area.

I'd also like to let you know the Northwest Waste Information Trade Fair will be held November 7 and 8 at the Seattle Trade Center. There will sessions specifically on auto shop waste problems. It's a good chance for you to gather information and practical ideas from leaders in your industry.

It was a pleasure meeting you this summer. Thanks for your cooperation to make our Lakes healthy places for people and good habitats for wildlife.

Very truly yours,

Louise Kulzer

Louise Kulzer
Metro Industrial Waste Section

METRO
Municipality of Metropolitan Seattle
Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

Nov. 2, 1990

Businesses with fuel pumps:

You may have recently worked through the underground tank regulations. If you've replaced or modified tanks, you've helped protect groundwater from fuel contamination. In most cases, however, rain runoff from fueling areas still drains into the natural storm drainage system, unprotected.

No, we're not going to ask you to dig up your station again. There are some simple actions you can take however, to reduce the amount of fuel-contaminated rain water that leaves your site.

Why? All fuels are toxic to aquatic life. Gasoline is especially toxic and is suspected to cause cancer in humans. Storm drains in the North Aurora drainage area currently overflow into Green Lake when it rains hard. In the future the water will drain, untreated, directly into Lake Union. Keeping gasoline wash-off out of Green Lake and Lake Union keeps both people and wildlife safer.

To reduce the likelihood that small, chronic fuel spills will be washed into the natural drainage system, we recommend that you take the following steps.

1. Post signs at your pumps. The City plans to have signs available with the message: "Fuel is toxic to aquatic life. Please dispense fuel carefully, and wipe up any spills with material provided. Thank you." People, including employees, often are unaware that the mess they make ends up in our area waterways.

2. Provide simple clean up materials. You can use paper towels, kitty litter or Floor-dri compound, or oil sorbent pads to absorb spills. You should also provide a place for soiled materials.

3. Make sure all employees know where the emergency shut off valve is. If pumps deliver 6 gallons a minute, there isn't much time to react if something goes wrong.

4. Stencil the catch basins on your site with the message "Dump no waste, drains to Lake." Be sure catch basins are cleaned out at least once a year. You can borrow stencils and traffic paint free of charge from the City Drainage Wastewater and Utility, 684-7597.

traffic paint free of charge from the City Drainage Wastewater and Utility, 684-7597.

5. If your catch basin doesn't have a turned-down elbow, install one. Gasoline doesn't mix well with water and it's also lighter than water. This means that any spill that makes it to your catch basin can be detained there and cleaned up before it enters the drainage system. Remove the top layer of contaminated water with absorbent pads. If the spill is large, have a hazardous waste hauler pump out the catch basin. See the enclosed sheet for suppliers of spill control materials.

6. For mobile fueling operations, consider if there might be a way to seal the storm drain inlet or catch basin temporarily during fueling operations. A piece of rubberized strip magnet cut to fit would provide a good seal. Many safety supply houses also stock a thick, oil absorbent blanket that could be cut to cover storm drain inlets while fueling.

You should be aware that the City of Seattle is considering additional requirements for new construction of facilities with fueling islands. These requirements include having the island covered, paving with concrete rather than asphalt, providing a perimeter drain on the downstream edge of the island connected to the sanitary sewer, and installing a shut-off valve and an oil-water separator in the line. These requirements may also extend to remodeling activities.

Taking action now reduces the likelihood that toxic fuels will be carried into Green Lake and Lake Union. Providing the measures recommended not only protects the environment-- it also protects you from the liability of dealing with spills later on.

The City and Metro can assist you by providing signs, storm drain stencils and technical advice about waste disposal. Please call Louise Kulzer at Metro (684-2373) or Jennie Goldberg at the City (684-7597) for assistance.

Thanks for your help in making Seattle a good place to live.

Very Truly yours,

Louise Kulzer

Louise Kulzer
Metro Industrial Waste

Jennie Goldberg
Seattle Drainage and Wastewater Utility

Appendix E

SUPPLIERS OF SPILL CONTROL MATERIALS
11/1/90

Burlington Environmental
2203 Airport Way South
Seattle
243-6776

Envirosorb Corporation
8128 187th S. W.
Edmonds
778-7485

Rice Safety Equipment Co
4930 3rd Avenue South
Seattle
821-2229

Safety & Supply
5510 East Marginal Way
Seattle
762-8500

Sahlberg Safety & Supply
5950 4th Avenue
Seattle
762-8080

Sanderson Safety Supply Co
401 South Brandon
Seattle
767-9888

Seattle Marine & Fishing Supply Co.
2121 West Commodore Way
Seattle
285-5010 (Have 6" rope and diapers)

Sound Safety Products
3602 Broadway
Everett
259-0026
Seattle phone no: 467-8580

METRO
Municipality of Metropolitan Seattle
Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

RECOMMENDED WASTE DISPOSAL OPTIONS FOR AUTO SHOPS

USED OIL.	Recycle. Oil must be free of gasoline, antifreeze, water, chlorinated solvents and degreasers. Store in area out of rain.

Note: GEAR LUBE OIL, DIFFERENTIAL FLUID, TRANSMISSION FLUID, and HYDRAULIC FLUID can be recycled with CRANKCASE OIL.

BRAKE FLUID	Can sometimes be recycled. Check with specific recycler. Otherwise hazardous waste hauler.
ANTIFREEZE.	Recycle. Two companies, Clean Care Corp (627-3925) and Antifreeze Environmental Service (483-9197) have recently begun recycling operations. Small amounts can be disposed of in the sanitary sewer. Antifreeze should not go through oil/water separators since it breaks the emulsion.
SOLVENTS & DEGREASERS.	Recycle or distill on-site. Safety Kleen Corp. and Recycling Technologies Inc. provde various recycling arrangements. Citri-solve, a biodegradable solvent, is toxic to fish and should not enter storm drains. If discharged to the sanitary sewer, must still meet the limits for oils (100 ppm), pH (above 5.5) & metals. Other solvents, including carberator cleaner, Hazardous waste hauler.
FLOOR WASH-UP WATER	Pre-treat through Oil/Water separator connected to sanitary sewer. No floor wash water should ever be drained into storm or street drains. Use dry sorbants rather than water for clean-up.
WASTE TIRES	Retreaders or tire chippers. Shreds may have high zinc and cadmium levels. Prevent contact with rainwater.
LEAD-ACID BATTERIES	Trade-in or recycler(1-800-RECYCLE). Store in covered area out of rain.
HOT DIP TANKS	Hazardous waste hauler.
LACQUER THINNER	Re-use or hazardous waste hauler.
OIL BASED PAINTS	Use up completely (empty cans OK in solid waste), or Hazardous Waste Hauler.

Metro Industrial Waste Section, 684-2325 July 1990

OIL RECYCLERS, North Seattle Area 4-25-90
Source: Recycling Info Service, 1-800, 732-9253

Name	Address	phone	cost	Quant (gal.)
60 Minute Tune	16622 Aurora Ave. N.	546-1188	NC	NL
Bob's Aurora Unical	16510 Aurora Ave. N	542-8300	.25	12
Gateway ARCO	1130 N 185th	542-9947	.25	10
Lucky's Automen Auto Repair	325 NW 85th	783-1014	NC	5
Murphy's Exxon	7301 5th Ave. NE	522-0507	.25	5
R & H Garage Ltd.	7223 Aurora Ave. N.	782-7809	.25	5
S & S Foreign Auto	14315 Lake City Way NE	363-4225	.25	5
Schuck's Auto Works	20319 Ballinger Wy NE	361-1025	NC	10
Seattle North Transfer Station (City residents only)	1350 N. 34th	684-7600	NC	5
Wallingford Chevron	1420 N 45th	545-7262	.25	5
also take antifreeze for recycling			.50	2
Wedgewood Chevron	7300 35th NE	523-9470	.25	10

NC = No Charge NL = No Limit

Chemical Processors 5501 Airport Way So. 767--0351 NC 25
Oil & small quantities hazardous waste taken Thursdays, 8 - 12.
Hazardous Waste from Small Businesses taken last Tues. of month. Fee $15/gal 1st gallon, $8/gal for additional gallons.

Seattle Barrel, 4716 Airport Way So. 622-7218 NC
Takes clean, empty 55 gallon drums(metal) for reconditioning.

Oil Pick up Services

NW Enviro Service 622-1090
FEE: Vehicle fee $68.50/hr plus .15/gallon

Chemical Processors 223-0500
FEE: $100 < 250 gallons
$.08/gallon if 250--499 gallons
Free if > 500 gallons

Marine Vacuum Service 762-0241 Fee varies

Important: To be recycleable, oil must be free of substances such as gasoline, solvents, anti-freeze, etc. Also, Service stations do not dispose of containers used to transport oil. Plan to take your container home with you.

METRO
Municipality of Metropolitan Seattle
Exchange Building • 821 Second Ave. • Seattle, WA 98104-1598

INFORMATION FACT SHEET: STORM DRAINS & SANITARY SEWERS
UNIVERSITY REGULATOR SEWER SEPARATION PROJECT

STORM DRAINS

o In the Aurora Ave. area of North Seattle, the Densmore storm drain currently enters the sanitary sewer line just north of Green Lake.

o The University Regulator project will remove the storm drain and extend it so that it discharges in Lake Union.

o What should be disposed of in a storm drain?

ONLY CLEAN WATER. It is against the law to put oil, dirty water from washing floors, or other waste water in storm drains. Drains from mop sinks and floor drains should be connected to the sanitary sewer.

SANITARY SEWERS

o In the Aurora Ave. area of North Seattle, sanitary sewers take sewage to the West Point Treatment Plant.

o Currently sewage is given primary treatment before being discharged to Puget Sound. Soon, however, construction will be underway to upgrade the Plant to secondary treatment.

o Not everything can be disposed of in sanitary sewers.

Metro limits the use of sewers for non-sanitary wastes. Both the type and concentration of some substances are restricted. This is done for two reasons. Some chemicals are not removed by treatment plants and can enter Puget Sound untreated. This is not good for the environment, and may cause Metro to violate it's waste discharge permit and incur fines. Secondly, limiting the discharge of some types of chemicals is necessary to protect the safety of treatment plant workers.

<u>Prohibited Substances</u>

Flammable or Explosive Materials (such as fuels)
Substances which can clog the sewer
Odorous or foul-smelling substances
Substances that produce toxic vapors
Acid with pH lower than 5.5
High temperature wastes (over 150 F)

Concentration Restrictions: usually pre-treatment required before discharge is permitted.

Oil (petroleum based)
Grease and fats
Metals arsenic
cadmium
chromium
copper
lead
mercury
nickel
silver
zinc
Cyanide
Hydrogen sulfide
Settleable solids
Toxic organics (such as paint stripper, degreaser, lacquer thinner, chlorinated solvents, benzene, toluene, phenol, pentachlorophenol, pesticides, PCB's, etc.)

Typical approved discharges to the sanitary sewer

Sewage
pet waste
most wash waters
boiler blow down
non-contact cooling water with algicide

High Strength Waste

Waste containing more than the typical household waste load is "taxed" by Metro. An extra surcharge is added to the customer's regular sewer bill. Industries such as large bakeries, food processors and laundries often are charged these fees.

If a business or industry produces restricted or high strength wastes, Metro requires that the industry apply for an Industrial Waste Discharge Permit. The Permit defines numerical limits and usually requires monitoring to ensure the limits are met. There is a fee for this permit.

Dischargers of small quantities of wastes may be issued a Discharge Authorization rather than a full Permit. A Discharge authorizations is usually issued if the discharge is intermittent, is a small quantity, or poses little risk to the treatment process or workers, or the environment. There is currently no charge for a Discharge Authorization.

For more information, contact Metro's Industrial Waste Section at 684-2373 or 684-2325.

Clean Shop and Clean Water - You Can Have Them Both

by Louis Kulzer, Industrial Waste Investigator METRO, Municipality of Metropolitan Seattle (Special to The MANIFOLD)

Do you wash your shop floors with detergent and hose the oily mess down the drain or out your shop door? Well, if that drain is a storm drain, then it is time to reassess.

Washing detergents and oil laden water into the storm drains means that pollutants end up on the creeks, lakes and Puget Sound with no treatment whatsoever. Except in a few cases in the City of Seattle which still has areas of combined sewers, storm drains or street drains are simply an engineer's version of the natural drainage system that was present before development. Storm drains were meant to carry clean rain water via ditch or pipe to the nearest water body.

Detergents, oils and other pollutants need to be kept out of storm drains. In addition to protecting the environment, you're also protecting yourself. If viewed by regulatory staff from the Department of Ecology, washing detergents or oil into storm drains could result in fines of up to $10,000.

But what if your shop doesn't have floor drains connected to the sanitary sewer? Many older shops don't, says Metro, who is working on a sewer separation project in the North Seattle area along Aurora Avenue North. Metro has found that many businesses in that area have adapted to the situation in an environmentally friendly way.

The following methods for cleaning shop floors are all preferable to washing wastes into street or storm drains:

1) **Dry & Easy** — Rather than water, use a floor-dri compound to soak up spills as they occur. Many shop owners don't like to wet floors at all saying it is messy. After the spill is absorbed the compound can be stored and used over until the absorbing properties are finally lost. When used up, floor-dri should be bagged and disposed of in the dumpster with other solid wastes.

2) **Dry & Spotless** — Some shop keepers prefer putting a little solvent over the spill before they apply floor-dri. They say it prevents stains and gets better, faster oil removal. One caution however, since whatever solvent you apply will evaporate, using solvent this way increases the exposure to you and your workers. The Fire Department doesn't really care for this practice either.

3) **Wet & Pretty Good** — While some shop keepers think water is messy, others swear it's the only way to go. You can still use water and detergent on floors if you prefer without risking fines or polluting the environment. Wet the floor and sprinkle with detergent as usual. Rub it down with a broom to loosen soiled areas. Instead of hosing, get a mop and bucket and pick up the soiled water with the mop. When through, the dirty water should be dumped down the toilet or in a shop sink (if connected to the sanitary sewer).

This method is pretty good, especially for smaller shops with fairly low accumulations of oil. There are, however, limits to the amount of oil that can be disposed of in the sanitary sewer too. For large shops or in shops with lots of oil spills, the Wet & Safe method below is preferred.

4) **Wet & Safe** — Connect floor drains to the sanitary sewer and install an oil/water separator in the line (minimum size is usually 500-600 gallons). While spendy, this method should keep you in compliance with current regulations if regular cleaning of the separator is done.

Accumulated oil should be removed once a year at a minimum. Some shops, Metro's buss bases for instance, find that separators need to be cleaned every two weeks. Oily floor wash water should be discharged through the oil/water separator. However, antifreeze should never pass through an oil/separator since in breaks the oil/water emulsion and allows for much oil to be discharged.

Although an oil/water separator should get oil concentrations down low enough to discharge to sanitary sewers (below 100 parts per million), there are no guarantees. Theoretically, soapy water could emulsify enough oil so that it won't separate in the short time it is in the separator chamber.

Sampling the wastewater at the outlet 'T' and having it analyzed for oil and grease is the only sure way of knowing if things are working as planned.

Adopting one of these four floor cleaning methods will keep pollutants (both detergents & oils) out of natural waters. Which method you choose depends a bit on preference and on the volume of oil or other spilled fluids you accumulate.

If you would like more information on oil/water separators, or have questions about wastes from your shop, call Metro at 684-2300 or 684-2373.

The MANIFOLD Oct 1990

The North Seattle Press, October 3 - 16, 1990 - Page 13

Metro Regulator Project: more than just a pipeline

By JAMES BUSH

Metro's University Regulator project will separate storm water and sanitary sewer lines in the Haller Lake/Bitter Lake drainage basin, putting an end to combined sewer overflows (CSOs) to Lake Union and Portage Bay.

CSOs release untreated sewage into local waters when the lines are overloaded during heavy rains.

Next summer's construction project will provide a new pipeline from an area just north of Green Lake to Portage Bay — a comparatively simple achievement for the entire project.

The difficult part will be getting people to change their habits regarding dumping in storm sewers, said Louise Kulzer of the Metro Industrial Waste Section. Kulzer is working on ways to educate the owners and employees of businesses in the drainage basin on how to properly dispose of wastes.

"We want to make sure people know their drainage system is connected to a natural waterway," she said. "After we build this line, all of this water will drain to Lake Union, all of the time."

The water coming through the Densmore storm drain line currently enters the sanitary sewer line just north of Green Lake. By rerouting the storm water, Metro will be able to reduce the flow to the West Point Sewage Treatment Plant, while also tackling the thorny CSO problem.

But since the project is largely one of water quality improvement, it is up to residents and business people to make sure dumping in storm sewers doesn't make it a liability, she said.

Used motor oil is the largest single source of oil pollution in water bodies nationally, accounting for more than 40 percent of the problem, according to a Metro pamphlet. Other major polluters are antifreeze, paints, solvents and cleaners dumped down drains.

Kulzer said low-phosphate soaps should be used when washing cars and trucks and the amount of soapy water used should be minimized. She recommended that businesses sweep — not hose down — parking lots and sidewalks, especially around garbage dumpsters.

Because the North Aurora corridor includes many auto dealers and repair shops and acres of asphalt parking lots, Kulzer's job of educating seems like a tough one. However, auto-related businesses are often careful and conscientious in disposing of oil and other fluids, she noted.

"Each shop's individual contribution to the pollution problem isn't major, but there are so many of them it does add up."

> 'After we build this line, all of this (storm) water will drain to Lake Union, all of the time.'

KULZER'S SUMMER JOB this year was to contact many of the businesses in the Haller Lake/Bitter Lake Drainage area and distribute information about controlling non-point source pollution. Metro's literature suggests people buy only as much chemical or petroleum-based products as they will likely use, add concrete or asphalt berms around stored oil drums, educate employees on clean water issues and determine what types of substances might be released into sewer lines and in what quantities.

Materials such as fuels, foul-smelling substances, products which produce toxic vapors, acids and high-temperature wastes are prohibited from being dumped even into sanitary sewers.

Included in the educational project is the stencilling of storm drains around the area with the message "Drains to Lake, Dump No Waste."

Also on the agenda are visits to area schools, to explain to children how dumping in storm drains can damage water quality.

Kulzer is also surveying businesses on waste management, and will repeat the process after the campaign to see how much information has been retained.

The University Regulator project is one of several sewer separation efforts in the planning stages as Metro continues to address the problem of CSOs.

Residents who are seeking to dispose of used motor oil can take it to several North End locations. There is usually a limit of 5 gallons (although this varies, depending on the location) and a nominal charge for disposal (up to 25 cents per gallon).

North End oil recyclers are:

- Seattle North Transfer Station (Seattle residents only), 1350 N 34th St.
- R&H Garage Ltd., 7223 Aurora Ave. N.
- Murphy's Exxon, 7301 5th Ave. NE.
- Lucky's Automen Auto Repair, 325 NW 85th St.
- S&S Foreign Auto, 14315 Lake City Way NE.
- Wallingford Chevron, 1420 N 45th St. (also accepts up to two gallons of antifreeze for recylcing).
- Wedgwood Chevron, 7300 35th Ave. NE.
- Bob's Aurora Unocal, 16510 Aurora Ave. N.
- 60 Minute Tune, 16622 Aurora Ave. N.

APPENDIX F

SOAP USE AND TOXICITY INFORMATION

DETERGENT AND SOAP TOXICITY ASSESSMENT

SAMPLES

Detergent and soap samples were delivered to the Metro Environmental Laboratory (MEL) on 11-23-90 and 11-26-90 by Louise Kulzer.

Brand Names

HI SUDS 206, Westmar
Dr. Bronner's Pure-Castile Soap
Simple Green, Sunshine Makers Inc.
Armor All Car Wash, Armor All Products Corp.
Joy, Procter & Gamble
Ecover, Ecover Belgium
ESP, Zep Mfg. Co.
Crystal White Octagon, Colgate-Palmolive Co.

CONTROL AND DILUTION WATER

The control and dilution water for tests with rainbow trout was freshwater obtained from a 55 ft. deep well located at MEL. Trout are routinely cultured in a continuous flow of this water.

Physical-chemical characteristics of the well water:

Temperature	13.9 C chilled to 12 C	
Conductivity	305	umhos/cm
pH	7.134	
Hardness	109	mg/L as CaCo3
Alkalinity	100	" " "
Cd	<0.002	"
Cr	<0.005	"
Cu	<0.002	"
Ni	<0.01	"
Pb	<0.03	"
Zn	0.02	"

Pesticides and PCBs	25	cpds. not detectable
Volatile Organics	35	" " "
Organic Analysis	63	" " "

TESTING

The rainbow trout (Oncorhynchus mykiss) survival test was modified from that outlined in Peltier and Weber (1985). Briefly, 16 L of dilution water was placed in glass containers, aerated to > 8 mg/L dissolved oxygen (DO) and cooled to 12 C in a temperature-controlled water bath. Temperature and DO measurements were recorded. Watchglasses holding a weighed amount of sample were rinsed clean in the dilution water. The solutions were mixed and pH measurements were made. Five trout (avg. wt.=1.4 g, s=0.56) were placed into each container from a

stock acclimated to 12 C well (dilution) water for 83 days. All detergents were tested together at a concentration selected from a geometric series. The concentrations eliciting 0 % and 100 % mortality were replicated as well as an intermediate concentration, also in geometric series. The tests were 96 hours in duration.

QUALITY CONTROL

A Cd Quality Control Sample obtained from the U.S. Environmental Protection Agency was used as a reference toxicant. The control chart for trout located at the end of this report is constructed to monitor their sensitivity to the reference toxicant and thereby provide an indication of their over-all sensitivity (to other compounds).

TEST RESULTS

Table 1 shows the percentage mortality in the concentrations indicated in the column to the left. The detergents/soap are arranged from least toxic (survival in the highest concentration) on the left to most toxic (survival in the lowest concentration) on the right.

Table 1. The percentage mortality of rainbow trout after exposure for 96 hours to the indicated concentrations of detergent or soap (n=10).

CONCEN-TRATION	DETERGENT/SOAP							
mg/L	Simple Green	ESP	Dr. Bronner Pure-Castile Soap	Armor All	HI SUDS 206	Crystal White Octagon	Joy	Ecover
250	100							
176.8	0	100						
125		0	100					
88.4			30					
62.5			10	100	100			
44.2				10	60	100		
31.25			0	0	0	0	100	
22.1							30	100
15.63							0	20
7.81								0

Table 2 shows the concentration of detergent or soap which was lethal to 50 % of the trout and the associated 95 % confidence limits. The smaller the value, the more toxic the sample. As shown in Table 2, the detergents/soap are listed from least toxic on the left to most toxic on the right.

Table 2. The Lethal Concentration to 50 % (LC50) and associated 95 % Confidence Limits (95 % C.L.) for rainbow trout exposed for 96 hours to various detergents and a soap.

MEASUREMENT	DETERGENT/SOAP							
mg/L	Simple Green	ESP	Dr. Bronner Pure-Castile Soap	Armor All	HI SUDS 206	Crystal White Octagon	Joy	Ecover
LC50	210	149	90	51	43	37	24	17
Lower 95 % C.L.	*	*	78	48	38	*	21	15
Upper 95 % C.L.	*	*	105	54	48	*	26	19

* Data not amenable to this measurement

The response of the trout exposed to non-lethal concentrations of Simple Green (176.8 and 125 mg/L) and ESP (125 mg/L) exhibited an apparent narcosis that was characterized by over-turn and slowed respiratory movements. Near the end of the 96-hour test these fish showed recovery through increasingly active movements and periodic uprighting.

REFERENCE

Peltier H. and C.I. Weber. 1985. Methods for measuring the acute toxicity of effluents to freshwater and marine organisms. Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati OH. EPA 600/4-85-013.

TESTED BY

Metro Environmental Laboratory
322 West Ewing Street
Seattle WA 98119
(206) 684 2314
Jim Buckley and Jim Laughlin
19 Dec 1990

Appendix F

APPENDIX

The following detergents were tested by MEL in August and September of 1989. The test species, dilution water source and test system was the same as used in the present testing.

SAMPLES

Brand Names

J-Wax Believe, Johnson & Son, Inc.
All-Soil, Pacific Chemical Co.
Xotox, Ecology Recovery Co.

TEST RESULTS

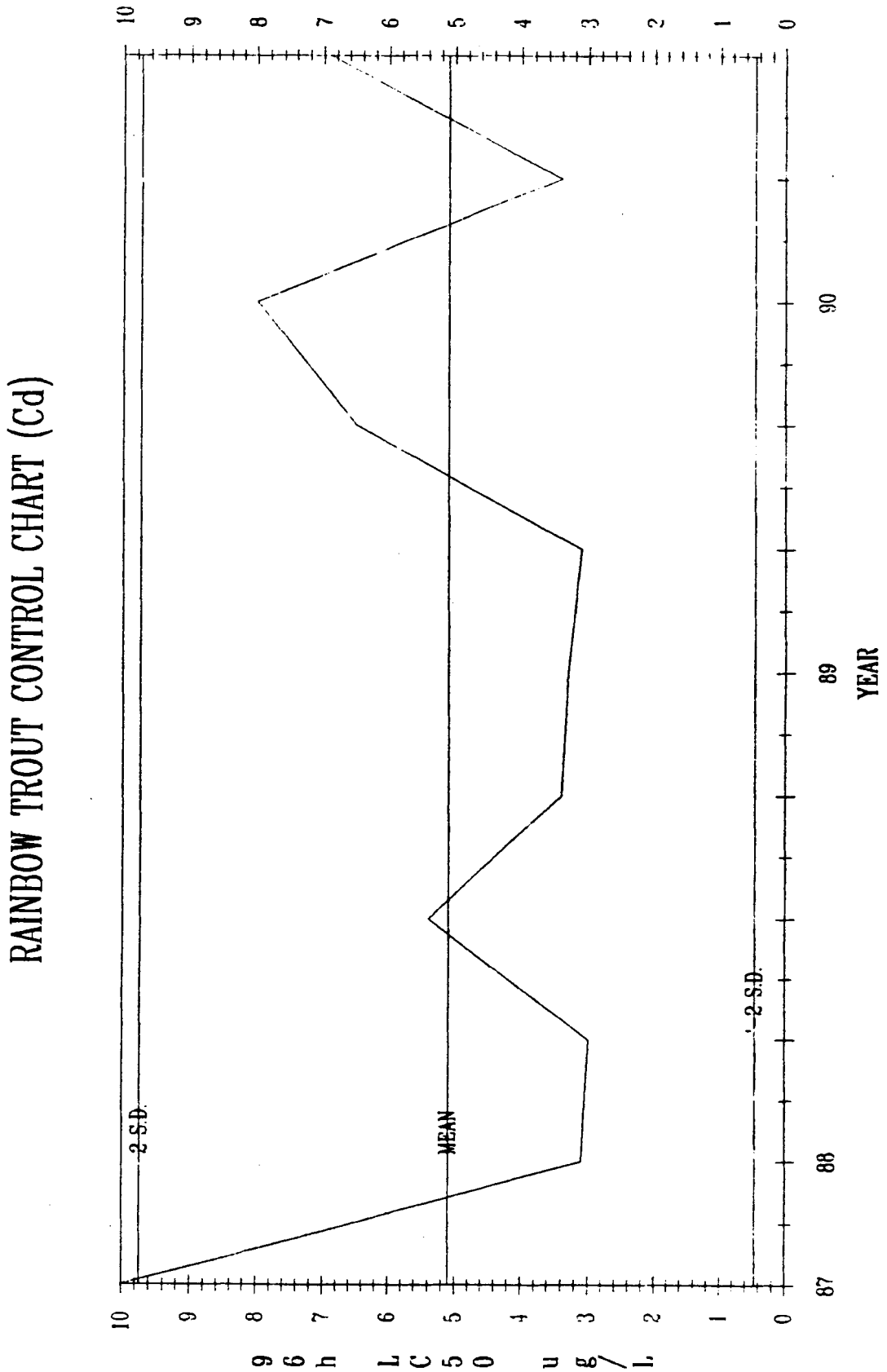
Table 1. The percentage mortality of rainbow trout after exposure for 96 hours to the indicated concentrations of detergent.

CONCENTRATION	DETERGENT	CONCENTRATION	DETERGENT	
mg/L	Wax Believe	mg/L	Xotox	All Soil
360	100	250	100	100
288	75	125	0	8
216	0	63		8
		31		0

Table 2. The Lethal Concentration to 50 % (LC50) and associated 95 % Confidence Limits (95 % C.L.) for rainbow trout exposed to detergents.

MEASUREMENT	DETERGENT		
mg/L	J-Wax Believe	Xotox	All Soil
LC50	266	177	157
Lower 95 % C.L.	249	*	135
Upper 95 % C.L.	283	*	184

* Data not amenable to this measurement


RAINBOW TROUT CONTROL CHART (Cd)
96h LC50 ug/L
10
9
8
7
6
5
4
3
2
1
0
2 S.D.
MEAN
-2 S.D.
87
88
89
90
YEAR

Appendix F

MICROTOX ASSESSMENT OF DETERGENT AND SOAP TOXICITY

SAMPLES

HI SUDS 206 , Westmar
Dr. Bronner's Pure-Castile Soap
Simple Green, Sunshine Makers Inc.
Armor All Car Wash, Armor All Products Corp.
Joy, Proctor and Gamble
Ecover, Ecover Belgium
ESP, Zep Mfg. Co.
Crystal White Octogon, Colgate-Palmolive Co.

CONTROL AND DILUTION WATER

The dilution water for the initial dilutions of the soaps was deionized through reverse osmosis, charcoal filtration and then purified with a 0.22 micron pore size Barnstad filter. Dry NaCl was added to the solutions to make a working concentration of 2%. The solutions were then further diluted with an aqueous solution of 2% NaCl where neccesary. Final dilutions were performed with Microtox diluent as per Microtox procedure.

TESTING

The solutions were made by adding 0.5 grams of the detergent to a tared, sterilized, screw top, 1000 ml. pyrex bottle. The dry NaCl was added and the solution was diluted with 500 mls of deionized water and mixed. The standardized Microtox procedure was used to perform the assays.

QUALITY CONTROL

A control of 20% ethanol was performed daily. The standard EC50 range for this toxicant is 30,000 to 40,000 ppm.

TEST RESULTS

The test results, presented in the table, show the EC50 for the Microtox organisms in mg/l with the upper and lower 95% confidence levels. The EC50 is conceptually the same as an LD50 value. The second portion of the table gives a comparison of the percent concentration of sample, toxic to 50 percent of the respective Microtox and trout populations.

		95% LIMIT		PERECNT CONCENTRATION	
	EC50	LOWER	UPPER	MICROTOX	TROUT
		mg/L			
Joy	2	2	3	0.0002	0.0024
Ecover	12	10	15	0.0012	0.0017
Crystal White	19	16	22	0.0019	0.0037
ESP	24	19	28	0.0028	0.0149
HI SUDS	43	40	47	0.0043	0.0043
Armor All	43	40	46	0.0043	0.0051
Dr. Bronner's	58	53	63	0.0058	0.0090
Simple Green	579	482	695	0.0579	0.0210

The pH of all the samples ranged between 6.41 and 6.88.

Mark Wallin Microbiologist
12/31/90

Memo

August 31, 1990

TO: File

FROM: Louise Kulzer

SUBJ: Car wash soap uses by businesses,
Haller Lake/Bitter Lake Watershed

The following information was obtained from field surveys and interviews with local business operators during the last week of August, 1990.

Business name	Soap used	No. of vehicles on site
101 Auto Body	Lemon joy	
AAA Recreation	ZEP Formula 50	20
Aurora Collision	Wesmar High Suds 206 Bus & Kar	
Aurora Motors		40
Bill's Wheel House	Wesmar Hi Suds 206	40
Cars to Go		30 - 40
E-Z Auto Buy	Armor All Car Wash	30
Emerald City Sales	Crystal White Octagon (Colgate)	20
Fraser's Auto Sales	Wash & Shine Car Shampoo Verax Co., Maltby	100
J & C Used Cars	Blue Korral	24
Moore's Body Shop	SHUR Wonder Wash	
North Seattle Chrysler/Plymoth •	Wesmar High Suds	
Oaklake Auto Body Collision	Shur Wonder L.E. Carter, distributor	
Parade Motors	Fiesta (dish wash soap)	80 (40 washed)

METRO

Premium Auto Sales	Car Groom	30
R-K Motors		30
Rainier North End	Hotsy concentrate	5
The Car Store	Water only	100
Olympic Lincoln Mercury *	PLC Blue Magic	

---

* Discharge to Sanitary Sewer

APPENDIX G

BUSINESS SITES VISITED DURING THE SOURCE CONTROL PROJECT

APPENDIX G
BUSINESS SITES VISITED DURING THE SOURCE CONTROL PROJECT

AAA Automotive
AAA Spraying
AM PM Mini Mart (N. 105th & Aurora)
AM PM Mini Mart (N. 85th & Aurora)
Andy's Collision Autobody
ARCO AM PM Mini Mart (N. 144th & Greenwood)
Aurora Auto Service
Aurora Collision
Bekin's Moving & Storage
Biddle & Crowther Company
Botting Mechanical Contractors
British Car Shoppe
Brown Bear Car Wash
Bug-Aid
Buggy Washers at Larry's Market
Burgess Industries
Buser Ornamental Iron Works
CARS, Inc.
Circle K
City Light North Service Center
Clary's Transmission
Cochran Electrical Construction
Colbeck & Company
Crow Roofing
Dizzard Masonry Inc.
Econolube
Edward's Auto Service
Emerald City Electric & Lighting
Evergreen Washalli
Exxon
F & F Auto Repair
Fleet Repair Service
Grund & Company
Handy Andy Rent a Tool
Hansen Brothers
Highland Unocal 76
Honda Masters
Japan Auto Service
Jim's Body Works
K-Mart Auto
Kemi-K Products, Inc.
Lang Towing
Laurelhurst Fuel Company
Lee's Auto Enterprises
Lincoln Auto Wrecking
McCall Heating Company
Medalia Auction
Meridian Excavation & Wrecking
Moores's Body Shop
Mundy Company
My Mechanic Automotive
Nordic Services, Inc.
North Seattle Chrysler & Plymouth
Northwest Brake Shop
Northwest Metal Salvage
Oaklake Autobody Collision
Olympic Lincoln–Mercury, Inc.
Pacific Consolidated Services Corporation
Pacific Northwest Engine Works
Pacific Rainier Roofing
Paradise Moters
Peigot, Etc.
Phelps Tire Company
Pioneer Builders Supply
Puget Sound Masonry Restoration
Rainier North End Distributing
Ratelco (North 100th Street)
Ratelco (Stone Avenue North)
S & S Signs
Schwaben Motors
Seattle Engineering Department, Haller Lake Shops
Seattle Golg Club
Seattle Parks & Recreation (Ashworth Avenue)
Sound Truck Equipment, Inc.
Superior Tire Service
Terries Auto Service
Transmission Factory
United Transmission, North
University Mechanical Contractors
University Moving & Storage
Unlimited Tile Company
Unocal 76 (Stone Avenue North & North 130th Street)
Walt's Radiator & Muffler
Washington Limousine
Washington Natural Gas, North Base
Westlund Buick GMC
Wright Marine

REFERENCES

Barrett, S. 1990. Personal communication. Department of Ecology Technical Assistance Program.

Brown & Caldwell. 1989. "Analysis of Stormwater Monitoring Data for Time Trends and Land Use Differences." Letter to Claudia Corson, City of Seattle Drainage and Wastewater Utility. Seattle, WA.

Chempro. February 1991. Personal communication.

Conlin, R. December 1990. Personal communication, MetroCenter YMCA.

Cox, C. February 1991. Personal communication. City of Seattle, Drainage and Wastewater Utility, Haller Lake Shops.

Department of the Environment, Health and Natural Resources. 1990. Raleigh, North Carolina.

Dorfman, R., and N. Dorfman. 1977. *Economics of the Environment: Selected Readings*. W. W. Norton & Co., Inc. New York.

Fisher, A., and F. Peterson. 1976. "The Environment in Economics: A Survey." *Journal of Economic Literature*. 14(1):1-33.

Galvin, D., and R. Moore. 1982. "Toxicants in Urban Runoff." *Metro Toxicant Program Report #2.*

Goldberg, J. December 1990. Personal communication. Seattle Drainage and Wastewater Utility.

Grigalunas, T., and J. Opaluch. 1988. "Assessing Liability for Damages Under CERCLA: A New Approach for Providing Incentives for Pollution Avoidance," *Natural Resources Journal*. 28:509-533.

Hahn, R. W. 1989. "A Primer on Environmental Policy Design." Harwood.

Hanson, N. November 1990. Personal communication. City of Bellevue Drainage and Wastewater Utility.

Higgins, T. March 1991. Personal communication. U.S. Geological Survey. Tacoma, WA.

Hubbard, T., and T. Sample. 1988. "Source Tracing of Toxicants in Storm Drains." In: *Proceedings of the Engineering Foundation Conference, Current Practices and Design Criteria for Runoff Water Quality Control.* American Society of Civil Engineers.

Kramer, Chin & Mayo, Inc. 1990. "Comprehensive Drainage Plan, Bitter Lake-Haller Lake Drainage Basin for Seattle Drainage and Wastewater Utility." Seattle, WA.

Mishan, E. J. 1971. "The Postwar Literature on Externalities: An Interpret Essay." *Journal of Economic Literature.* 9(1):1-28.

Montgomery, James M. and Entranco Engineers. 1987. "University Regulator Combined Sewer Overflow Control Predesign Project." Prepared for the Municipality of Metropolitan Seattle.

Mundt, D. December 1990 and March 1991. Personal communications. Washington State Department of Ecology, Urban Bays Program.

Myers-Browne, D. February 1991. Personal communication, Metro, Supervising Resident Engineer.

Patmont, C. 1990. "Final Report on the Proposed Evaluation Design for the Local Hazardous Waste Management Plan." Hart Crowser and Statistics & Epidemiology Research Corp. Seattle, WA.

Paulson, A. J., et al. July 11-14, 1989. "Decreased Fluxes of Pb, Cu, and Zn from Elliott Bay." Proceedings of the Sixth Symposium on Coastal and Ocean Management. Charleston, South Carolina.

Piccolo, V. January 1991. Personal communication. Puget Sound Water Quality Authority.

Pitt, R., and P. Bissonnette. 1984. "Bellevue Urban Runoff Program Summary Report." Bellevue, WA.

Portney, P. 1990. "Public Policies for Environmental Protection." John Hopkins.

Puget Sound Air Pollution Control Authority. 1989. "1989 Air Quality Data Summary for the Counties of King, Kitsap, Pierce, and Snohomish." Seattle, WA.

Puget Sound Water Quality Authority. 1991. "Puget Sound Water Quality Management Plan." Seattle, WA.

Renstrom, D. December 1990. Personal communication, Bellevue Storm and Surface Water Utility.

Rogers, P. and A. Rosenthal. 1988. "The Imperatives of Nonpoint Source Pollution Policies." *JWPCF.* 60(11):1912-1921.

Rosen, H. S. 1988. "Public Finance."

Russell, C. S. 1988. "Economic Incentives in the Management of Hazardous Waste." *Columbia Journal of Environmental Law.* 13(2):257-274.

Ryan, C. 1989. "Effective Nonpoint Source Public Education and Outreach: A Review of Selected Programs in Region 10." U.S. Environmental Protection Agency. EPA 910/9-89-023. Seattle, WA.

Shapiro & Associates, Woodward-Clyde and Linn & Associates. 1989. "Pipers Creek Watershed Action Plan." Seattle Drainage and Wastewater Utility. Seattle, WA.

Thomas, L. M. 1987. "Management of Nonpoint Source Pollution: What Priority?" *Journal of Soil and Water Conservation.* 40(1):1.

Thrush, C. December 1990. Personal communication, Seattle Drainage and Wastewater Utility.

Tomlinson, R., et al. 1978. "Fate and Effects of Sediments From Combined Sewer and Storm Drain Overflows in Seattle Nearshore Waters." Fourth Quarter Report: August 1979 to October 1978. Municipality of Metropolitan Seattle.

True, C. J. 1989. "Lander Separation Project: Industrial Inventory and Source Control." Municipality of Metropolitan Seattle.

Uniform Fire Code. 1988 Edition, Article 80. "Hazardous Materials." International Conference of Building Officials and Western Fire Chiefs Association.

U.S. Environmental Protection Agency. 1986. "Quality Criteria for Water."

U.S. Environmental Protection Agency. 1983. "Results of the Nationwide Urban Runoff Program." Vol. III Data Appendix. NTIS PB84-185578.

U.S. Environmental Protection Agency. 1987. "Unfinished Business: A Comparative Assessment of Environmental Problems." Office of Policy Analysis. Washington, D.C.

Waddell, D. December 1990. Personal communication, Metro, Transit Environmental Compliance Officer.

Winters, Suzanne. March 1991. Personal communication. Department of Ecology, Northwest Regional Office, Spill Coordinator.

Wonnacott, T., and R. Wonnacott. 1984. "Introductory Statistics for Business and Economics." 3rd Edition. John Wiley & Sons.