THE CARE AND CLEANING OF CAMBRIDGE:

ANALYSIS AND RECOMMENDATIONS

by

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Submitted in Partial Fulfillment

of the Requirements for the

Degree of Bachelor of Science

at the

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ABSTRACT

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The care and cleaning of the urban environment is one of the major activities of city government today. In the City of Cambridge, the care and cleaning of the city is the responsibility of the Department of Public Works. The Sewer, Street Cleaning, Rubbish Collection, and Snow Removal Divisions within the Public Works Department are the primary actors in this cleaning process. The condition of Cambridge suggests that these four individual divisions are inefficient and uneffective, and this is true. There are political, economic, social, physical, and labor-related constraints which act to reduce the effective provision of sewer cleaning, street cleaning, rubbish collection, and snow removal services.

Recommendations have been made to the Cambridge City Council for improved equipment and management techniques in the Public Works Department to improve the performance of these four divisions. However, implementation of these recommendations has been slow due to limitations imposed by the constraints on the system. It appears that recommendations to correct the deficiencies of the system must fall within a very narrow area specified by the limitations, thus, making an improvemnet to the physical environment of Cambridge very difficult.

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METHODOLOGY

The report which forms the core of this thesis was produced for the Cambridge City Council Committee on the Environment during the summer of 1973. The collection of data for this report was accomplished through observations, personal interviews, records reserach, and a state of the art review of the municipal services discussed here. Access to the city departments and their files and personnel was acheived through introduction to the City Manager by the Chairman of the Committee on the Environment. The City Manager subsequently explained the nature of the study to the Commissioner of Public Works who made available all personnel and records associated with the four divisions studied.

The same procedure was used for data collection in each division. An introduction was secured with the head of the division from the Commissioner of Public Works, and a brief description of the study was given. Three to four weeks of actual interview, observation, and file research were spent on each division. A week was spent on a personal interview with the division head while accompanying him about his daily routine and observing the division's operation. Interviews were also held with other people who had knowledge of the division's operation. Public Works records for the division were examined, and past studies of the Cambridge Public Works Department were reviewed.

The report for each division was written to first describe the present situation and the problems that exist, then possible resolutions to these problems were discussed in the recommendations section of the report.

The data for the systems constraints portion of this thesis was obtained through discussions with personnel in various city departments, and people who have been closely associated with Cambridge city government at some time or another. Some data used in this section is from personal observation conducted while working as a staffer to the Cambridge City Council Committee on the Environment.

The material for the discussion of the implementation to date on this report has been obtained through observation and discussion with supervisory personnel in the Department of Public Works.

INTRODUCTION: Past Research and The State of the Art

Over the years, urban residents have come to rely on a series of municipal services which protect the quality of their urban environment. Few citizens probably know or care how the city government goes about seeing that the streets are clean, that their rubbish is collected, that their street is plowed in the winter, or that their sewers continue to function. The citizen only wants to be sure that they are done, and done as economically as possible to prevent any increase in his tax rate. In the last few years, the rapidly rising urban tax rates have caused city governments to look more closely at the services they provide, and the cost and efficiency of these services.

As city governments turn their attention to the municipal environmental services, they have found this area to be one based on folklore, myths, and practices produced through years of experience. The analytic rigor associated with the planning practices of most large organizations is missing in many of the organizations responsible for municipal environmemtal services. Any attempt to establish a program of analysis and planning for these municipal activities is difficult because of the lack of concrete data and rigorous evaluations of past performance.

An attempt to analyze the state of the art of providing municipal environmental services is a complex process since the state of the art is not based solely on a technological level or a

management level, but rather on both of these and the social, political, and economic factors that influence the provision of these services. However, for the purposes of the discussion here, one can look at the highest levels of the available technology and management skills involved in the provision of environmental services as a point of reference for the current practices in many urban areas. The state of the art technology for urban environmental services is based largely on the kinds of equipment used for catch basin cleaning, street cleaning, rubbish collection, and snow removal.

Catch basin cleaning has progressed from a long handled shovel to a high-powered vacuum machine equipped with a hydraulic jet to aid in drawing the muck out of the catch basin. This machine can clean a catch basin in ten to fifteen minutes. There are several different machines available for street cleaning including the common double broom (horizontal curb broom and vertical main broom) machine, a machine using high pressure water jets capable of flushing dirt from the street to catch basins, and a vacuum machine similar to the catch basin cleaning machine. A standard fire hose with a tapered nozzle can also be used for flushing a street. The primary piece of equipment used in the rubbish collection process is the packer truck which compresses the collected rubbish into a smaller volum then it is at when set out at the curb. These trucks come in a variety of

sizes, are quite powerful (the newer trucks can handle a refrigerator), and can be built to make little noise. They can also be equipped to empty the large metal rubbish containers used by many of the larger buildings today for rubbish disposal. Plastic bags, although not a piece of equipment, have been a substantial advance in the technological state of the art for rubbish collection.[A] There are two principal ways for dealing with snow removal; one is to physically move the snow off the streets, and the other is to melt it. Snow plows, snow blowers, snow lifters (snow is picked up off the street by a revolving set of blades; these put it onto a conveyor belt which lifts it into a waiting dump truck), front-end loaders, snow shovels, and small caterpillar tread tractors are all pieces of equipment used to physically move snow. The equipment used in the melting process makes use of gas flame jets, electricity, infrared beams, and other heat sources to melt the snow. Another way to melt the snow is to apply a mixture of sand and salt and let the heat of street traffic melt the snow. (There have also been some attempts to incorporate heating grids into roadways to melt the snow as it hits the road. These heating grids have not proven very successful.) Technological advancement in the quality of equipment for these four municipal environmental services comes slowly since little municipal reserach effort is put into the design of effective equipment to combat the

problems at hand.

The state of the art management skills for urban environmental services are based largely on personnel deployment, scheduling, routing, record keeping, and level of service determinations. The very nature of these management skills lend themselves to more analytic techniques, and consequently many people have seen this area as a good one to conduct academic research in. This research has taken the form of mathematical models to find the shortest path for rubbish collection abd street cleaning vehicels, improved traffic flow and parking analysis techniques, data collected dealing with maximum rates of service versus population density, and computer simulations of the entire service provision process.[B]

Some of these analytic techniques and different management skilss have been used in the provision of catch basin cleaning, street cleaning, rubbish collection, and snow removal services.

The major management skilss involved in catch basin cleaning consist largely of determining when a catch basin needs cleaning, and then taking the appropriate steps to see that it is cleaned. Analytic techniques have determined that the major efficiencies available in catch basin cleaning are those ontainable through better scheduling and a up-to-date record system.[C] Personnel deployment problems are limited since the Vactor needs x men to work, and if each knows his

job, the machine can only clean the basins so fast. Routing is relatively unimportant since the number of street-miles covered should not be too great. A full day's work usually can be found within an average three square block area.

Management of a street cleaning operation necessitates skills which allow one to make a level of service determination for the streets of the city, and then seeing that the work is done in the most efficient way possible. Analysis has shown that greater efficiencies can be obtained through the proper deployment of men and equipment, and by following minimum path routes.[D] Records should be unnecessary when street cleaning is done on a regular and frequent schedule. Scheduling of streets to be cleaned would be worked through once, and implemented into a regular schedule.

Rubbish collection management has as given the location and amount of rubbish to be collected. The necessary determination which must be made is how to most efficiently collect it. A great deal of work and research has gone into the question of the most efficient method of rubbish collection in such areas as routing decisions, personnel incentives, equipment utilization, and factors influencing the rate of collection.[E]

The snow removal management problems are difficult to analyze since the time and rate of snowfall are highly irregular.

Each situation must be reacted to individually, but there are certain factors which will be present each time the snow falls. Minimum path plowing routes can be established and regular personnel deployment plans can be implemented to acheive some efficiencies. Records are useful to keep for future evaluations of past performance as a way of preparing for the next snow season. Traffic flow criteria and parking restrictions are also important in any discussion of snow removal analysis.

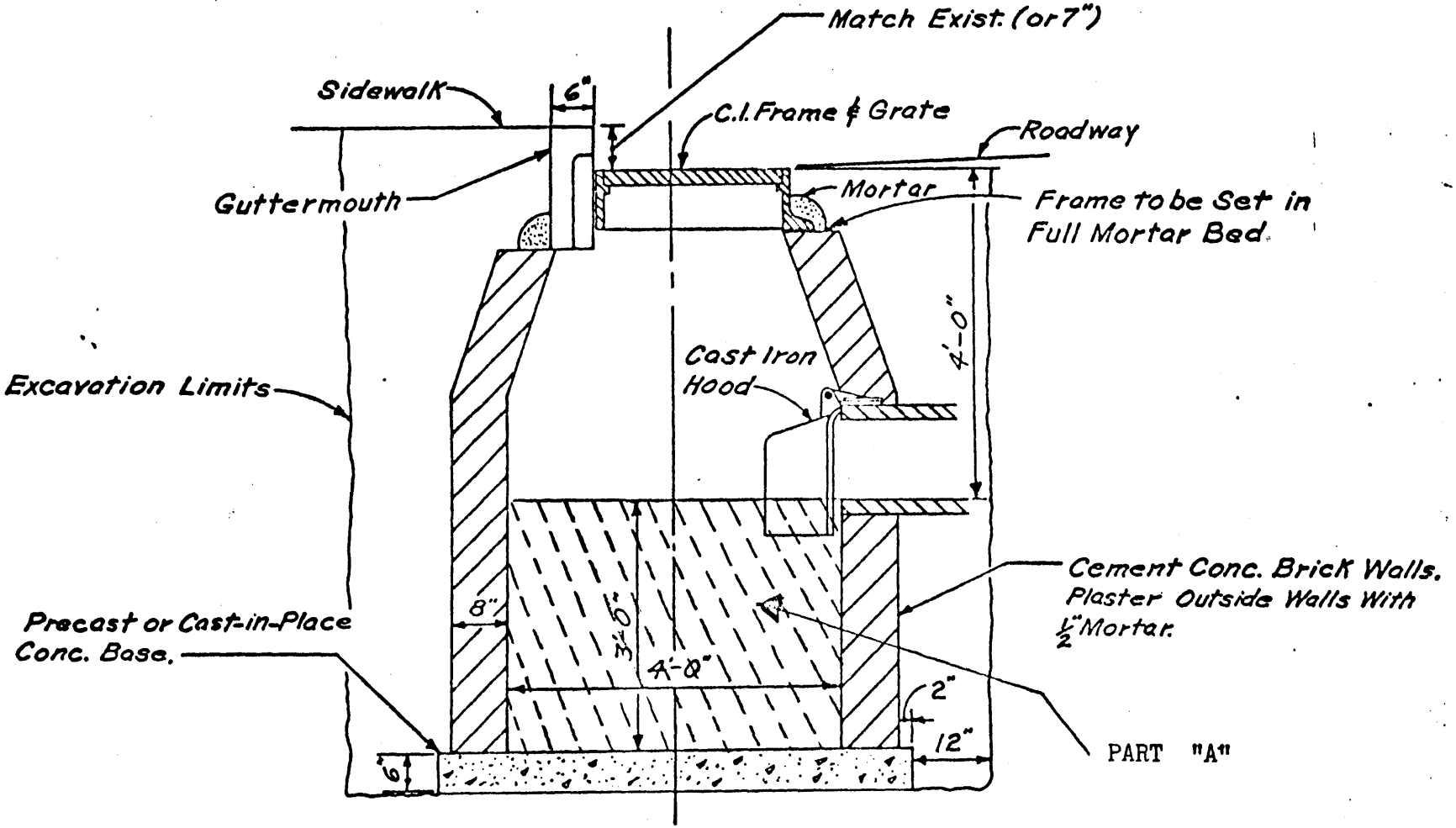
These, then, are some of the state of the art technological solutions and management tools available for finding solutions to the problems encountered in these four municipal environmental services. Unfortunately, although these solutions and tools offer the answer to some problems, the actual resolution of the problems is difficult to acheive since there are social, political, and economic constraints fighting to keep the system as it is. The City of Cambridge is an excellent example of these problems. This paper will look at the four municipal services in the City of Cambridge discussed and analyze their potential for improvement.

STATUS QUO - CATCH BASIN CLEANING [1]

The catch basin and storm drain system provides drainage for the City of Cambridge. All runoff water eventually finds its way into a catch basin and then into the storm drain system. The storm drain and sewer system are tied into lines provided by the Metropolitan District Commission (MDC). The MDC processes the sewage and runoff water, and dumps the then clean water into the ocean. The remaining sludge and debris is taken to a landfill site for proper disposal.

As the runoff water makes its way to the catch basins, it picks up leaves, bits of paper, dirt, and other debris. (For details of catch basin design, see Figure 1) The catch basins collect this debris, and consequently need periodic cleaning. People also see the catch basins as a convenient place to deposit all kinds of things, including sticks, stones, clothes, shoes, paper cups, magazines, newspapers, and anything else they can fit through the grillwork.

The present cleaning system is based on observation and complaints. There are several symptoms that may be present if a catch basin needs cleaning: the failure of water to drain from a street after a heavy rain, the grillwork on the catch basin being covered with debris, visible dirt is near the top of the catch basin mouth (seen by looking through the grillwork) or an unpleasant odor.



SECTION F-F

FIGURE 1

CATCH BASIN DETAILS [2]

NOT TO SCALE

When the Sewer Division supervisor observes any of these symptoms and deduces that a catch basin needs cleaning, he assigns one of the available cleaning trucks to the basin in question. Usually other basins in the same area not obstructed by cars are cleaned also. The supervisor also receives citizen complaints about clogged or smelly catch basins. After investigation, he will assign a cleaning truck to the area if that is what is called for in that case. In both cases, the supervisor may choose to have the public works night crew block the area with benches and barrels to prevent parking that would hinder the cleaning trucks. This is presently done on a 24 hour notice basis.

The present system has adequate provisions for a systematic record keeping process, but these provisions are not presently in use. The result is that adequate records are not available as to which catch basins have been and have not been cleaned. The last date of cleaning is also not immediately available.

There are approximately 3,000 catch basins in the City of Cambridge. In a working year of 180 days, (this takes into account weekends, holidays, and inclement weather) seventeen catch basins would have to be cleaned a day to clean them all in one year. Only about ten catch basins are now cleaned a day, so it would take nearly two years to clean all the catch basins in the city. The catch basin

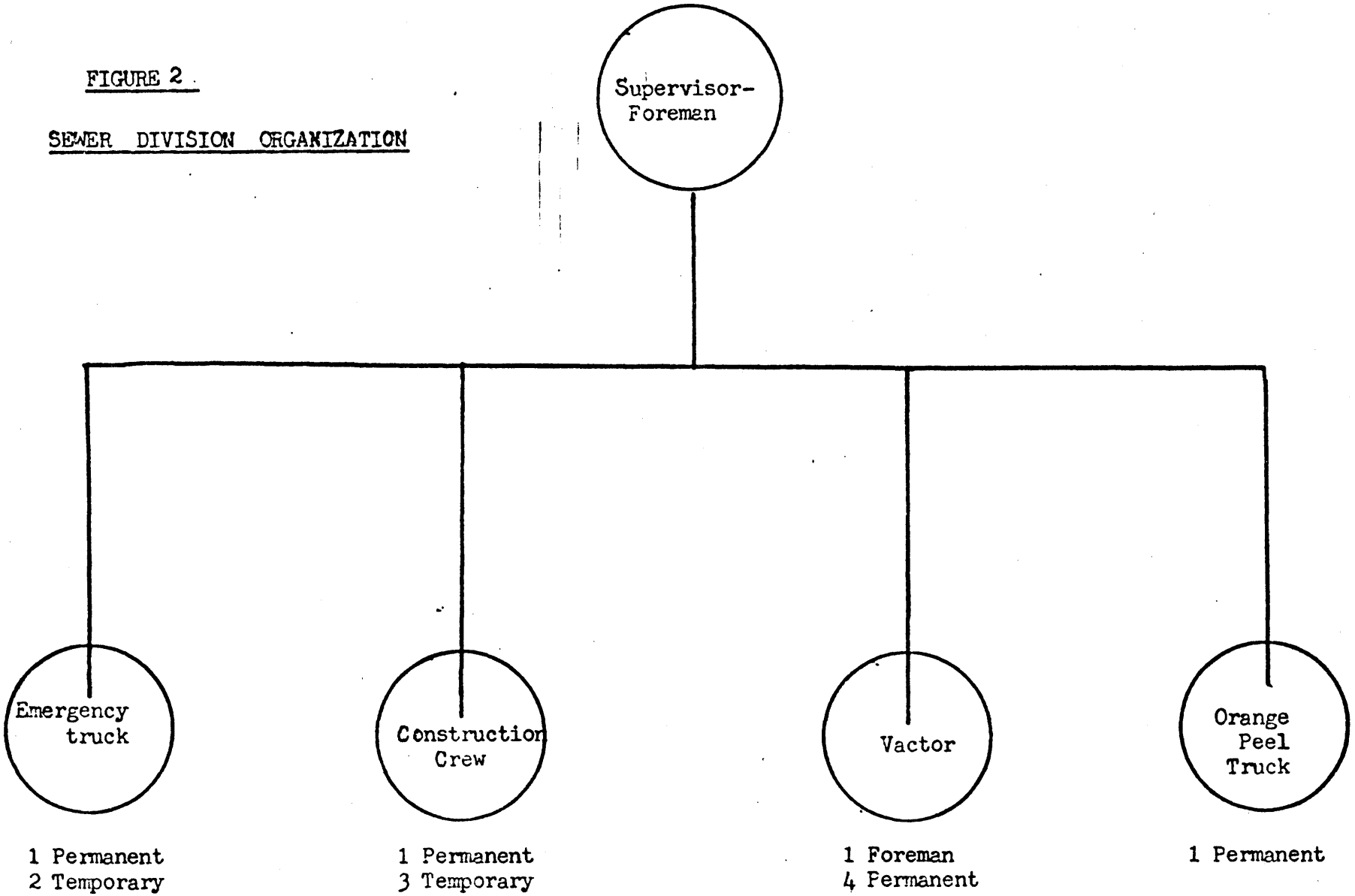
breakdown by ward is as follows in Table 1.

TABLE 1	CATCH BASINS BY WARD [3]
Ward 1	406
Ward 2	355
Ward 3	133
Ward 4	162
Ward 5	206
Ward 6	247
Ward 7	187
Ward 8	245
Ward 9	161
Ward 10	197
Ward 11	227

The Sewer Division, which is responsible for the catch basin, storm drain, and sewer systems, is presently composed of fourteen men. Five are designated as temporary employees, while the other men are all permanent employees. The division is broken down into four subgroups with one overall supervisor-foreman.(Figure 2) One such unit is the emergency truck with one permanent and two temporary men. Under the present system, the emergency truck does not enter into the preventive maintenance program, although, the emergency truck crew aids the supervisor in spotting catch basins that need to be cleaned.

FIGURE 2

SEWER DIVISION ORGANIZATION



Another unit of the Sewer Division is the construction crew. The construction crew does not enter into the preventive maintenance program unless as a basin is cleaned, repair work appears that was not visible prior to cleaning. Then, the construction crew would be called in to do the work.

A vactor unit of the Sewer Division works under the preventive maintenace program part time. The vactor is a truck-mounted suction device emptying into a large compartment. The vactor is also equipped with a hydraulic water jet that is used in the cleaning process. The vactor crew is composed of one permanent and three temporary men. To clean a basin, the cover is removed, the vactor is psoitioned over the basin, the extension tubes are connected to the suction device, one man operating the control box moves the suction arm into the catch basin, one man operates the hydraulic water jet, one man uses a long pair of tongs to remove objects that the suction device can not handle, one man cleans the area and the curbs near the catch basin, the extension units are disconnected, the catch basin cover is put back in place, and the cleaning job is completed. The average time for this entire operation is on the order of twenty to thirty minutes, and the catch basin is left nearly spotless.

If no new funds are forthcoming, the workhorse of the preventive maintenance program will remain the machine known as the orange peel. The orange peel is basically a dump truck with a

hydraulic claw on an extension arm with cables to lower and raise the claw. The roange peel is presently operated by one man, but two men are necessary to conduct the operation in a efficient and effective manner. The catch basin cover is removed, the claw is swung from the truck and positioned over the catch basin, and while one man operating the controls lowers the claw into the catch basin, the other man guides its position by hand. The claw is removed from the basin and swung into the truck, the claw is opened and emptied, the area and the curb near the catch basin are cleaned, the claw is swung back and lowered into the catch basin, and after going through the same process ten to twenty times, the catch basin cover is replaced, and the operation is complete. The average time involved in the operation is forty minutes, and the basin is nearly empty, but not clean.

The result is that during a normal working day, with time for trips to the dump (about forty minutes) taken out, the orange peel can clean about six catch basins a day on the average. The vactor can clean eight catch basins a day if it is working full time on cleaning. The number ten used earlier as total basins cleaned a day under the present system is obtained by adding the average orange peel production to half that of the vactor; the vactor is also used to do work other than catch basin cleaning.

Associated with the problem of unclean catch basins are certain costs which the citizens of Cambridge must bear. These costs are as follows: the smell produced by an unclean basin, the flooding and related water damage to property that can occur when a catch basin backs up (flooding during winter leads to increased ice on the roads and potholes, flooding during spring and summer leads to small pools that may act as a breeding place for insects, and poor drainage does not allow debris from the streets to collect in or near the catch basins).

When a heavy rain occurs, catch basins that are already full are not able to retain all the debris a heavy runoff entails. This unretained debris is swept into the sewer - storm drain system, and eventually finds its way into the Charles River. This pollution of the river is a cost that must be borne by the entire metropolitan Boston region and its population.

Under the present cleaning program, these costs are all too prevalent. This is due to poor workmanship when the basins are cleaned, a hit-or-miss decision process for choosing which basins are to be cleaned, and insufficient men and equipment to clean the catch basins throughout the city on a sufficiently frequent and regular basis to insure the proper functioning of them all.

RECOMMENDATIONS - CATCH BASIN CLEANING

The following section contains the recommendations for the catch basin preventive maintenance program. The recommendations are in the form of three plans. The difference between the plans is the level of initial expenditure and the quality of service that will be possible as a result. The three plans have one set of ideas in common, and those shall be covered first.

The plans are based on the idea that the city will be divided into twenty-seven sectors that include 90-100 catch basins each. (See Table 2 and Figures 3A and 3B) The number of catch basins that would comprise a sector was arrived at by the fact that this is the number of basins that can be cleaned in two weeks by the orange peel and the vactor combined. The orange peel and the vactor would be assigned to one sector and would remain there until all the the basins in the sector had been cleaned. In case of emergency in other areas and for other cleaning, the vactor would respond, while the orange peel remained in the preventive maintenance sector. Upon completion of the other work, the vactor should return to the active sector and begin cleaning catch basins where it left off. Only when a sector is completely finished should the supervisor assign a new sector.

The supervisor should maintain an adequate record system,

TABLE 2 CATCH BASIN BREAKDOWN BY SECTOR

Sector 1	91
Sector 2	93
Sector 3	95
Sector 4	87
Sector 5	103
Sector 6	90
Sector 7	93
Sector 8	95
Sector 9	107
Sector 10	92
Sector 11	98
Sector 12	88
Sector 13	99
Sector 14	85
Sector 15	97
Sector 16	92
Sector 17	97
Sector 18	95
Sector 19	94
Sector 20	98
Sector 21	98
Sector 22	101
Sector 23	81
Sector 24	92
Sector 25	97
Sector 26	86
Sector 27	54

FIGURE 3A

Map of Catch Basins in Cambridge by Sectors

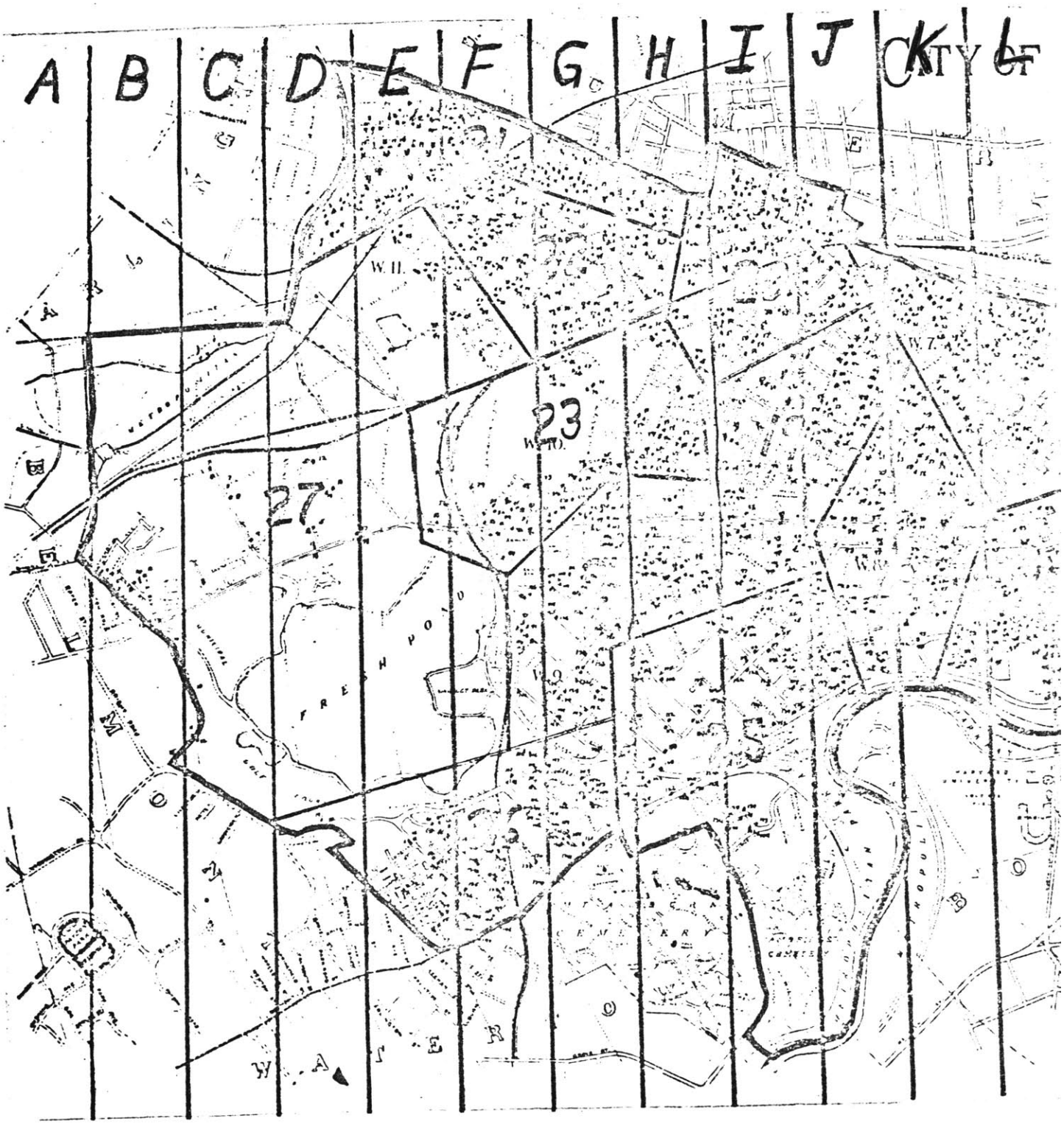


FIGURE 3B

Map of Catch Basins in Cambridge by Sectors

and should insist that both orange peel and vactor crews keep thorough daily records of work completed. The daily crew records should then be entered on a catch basin map covered with acetate that can be marked with a grease pencil. It would also include a card file that would contain one card for every catch basin. When the basin is cleaned, a mark (color-coded by month, 12 colors in all) would be put next to the catch basin on the acetate-covered map. The date of cleaning would be entered on the card for that basin, and any other pertinent comments could also be entered. A new acetate would be put up when all basins were cleaned under the preventive maintenance program.

Once this program is initiated, the sector due for cleaning should be announced on the radio and in the newspapers one week in advance of scheduled cleaning. This is to inform people that they will be expected to move their cars away from the vicinity of any catch basin in their neighborhood when the catch basins are scheduled to be cleaned. The clearing process might be made easier if the curbs at the basin were painted for visibility to facilitate residents in identifying where their cars should not be on cleaning day. Areas to be cleaned should be blocked 48 hours in advance of the actual cleaning. The blocking work should be done by the night crew as it is presently done. Cars that violate "no parking" provisions of this program should be fined and towed.

Plan #1 is based on the use of presently available equipment. The only costs involved would be the hiring of one more laborer to work on the orange peel truck, and regular maintenance costs for the vactor and orange peel. (The orange peel is 17 years old, and needs constant maintenance. In fact, one out of every five working days is spent in the repair shop.)

Plan #2 is based on the purchase of a new orange peel machine (initial purchase price of $12,000), and the use of the old vactor. The costs involved would be a new truck, the salary of one laborer, and the maintenance costs of the old orange peel, the new orange peel, and the vactor. The old orange peel should be kept in reserve for use when the new orange peel breaks down. This would eliminate dead time due to the present frequent unavailability of equipment.

Plan #3 is based on the purchase of a new vactor (initial purchase price of $56,000), and the use of the old vactor. The costs involved would be that of the new vactor, the salaries of three laborers, and the maintenance costs of the old orange peel, the new vactor, and the old vactor. The orange peel should be kept for emergencies. The present driver of the orange peel (truck #308) would be transfered to the new vactor.

Table 3

CATCH BASIN PREVENTIVE MAINTENANCE PROGRAM EXPENSES

INITIAL EXPENDITURE BY PLAN

Plan # 1	$ 0	- No new equipment
Plan # 2	$12,000	- One orange peel machine
Plan # 3	$56,000	- One vactor

(Prices quoted are based on latest estimates available June, 1973)

YEARLY EXPENDITURES BY PLAN OVER PRESENT LEVEL

Status Quo			3-5 year lapse between cleanings
Plan # 1	$ 8,573	- Wages (1 laborer)	3-4 year lapse between cleanings
	$ 1,972	- Fringe and Benefits	
	0	- Additional Maintenance and Overhead	
	0	- Equipment Depreciation	
	$10,545	- Total	
Plan # 2	$ 8573	- Wages (1 laborer)	2 year lapse between cleanings
	$ 1972	- Fringe and Benefits	
	$ 1000	- Additional Maintenance and Overhead @ 8%	
	$ 1800	- Equipment Depreciation @ 15%	
	$13,345	- Total	
Plan # 3	$25,719	- Wages (3 laborers)	1 year lapse between cleanings
	$ 5,916	- Fringe and Benefits	
	$ 4,500	- Additional Maintenance and Overhead @ 8%	
	$ 8,400	- Equipment Depreciation @ 15%	
	$44,535	- Total	

This completes the basic recommendations for the catch basin preventive maintenance program. However, there are several related issues that are brought up by this program. There is presently no general set of specifications available for all sewer and drain work done in the City of Cambridge. This is a deplorable situation, because without specifications the taxpayer is not assured of good value for the money spent. Manholes and catch basins should be equipped with hoods and traps (See Figure 1), but they are not. Properly installed and functioning hoods help stop back flows and excessive smell from coming out of the sewers and storm drains. The mulch taken from the catch basins during the cleaning operation reportedly makes an excellent fertilizer, and the city may be able to sell it. In the area of personnel, the Sewer Division is presently forced to rely on temporary help. This is grossly inefficient, since every so often new people must be trained all over, and the work of the Division is disrupted. If the temporary help were forced to leave, the Sewer Division would be critically understaffed.

There is another alternative to the problem of catch basin preventive maintenance which would eliminate the necessity for the regular cleaning of the catch basins in Cambridge. The alternative would be a massive renovation to the entire catch basin-storm drain system. This renovation would consist of rebuilding every catch basin

in the city so that they would not collect any debris at all. This could be accomplished by filling in the catch basin (part "A" of Figure 1) to the proper point. (A side view of a modified catch basin would appear to be an L-shaped pipe.) The grill-work presently covering the mouth of the typical catch basin would be replaced with a grill of smaller openings. A modified catch basin of the type described here would mean that water and only small bits of debris would enter the storm drain system, and be sent to the treatment plant. The debris screened out by the smaller grill-work and left in the gutter would be swept up by the street cleaners on a regular basis.

There are some basic problems inherent in a catch basin-storm drain system of this type. Unless the streets are swept quite frequently, the grillwork will become clogged with leaves and papers. People will still force things through the grill-work into the catch basins. The catch basins may still need to be cleaned when they become clogged, or filled up with dirt or debris. The cost for converting the present catch basins would be quite high due to their age and design. However, maintenance costs should be low for a working drainage system of this type. A preliminary analysis indicates that it would be more expensive over time to renovate the system as it presently exists then to continue with the costs of the most expensive plan suggested here

over time.

These, then, are the recommendations for a preventive maintenance program for the catch basin-storm drain system of Cambridge.

SEQUENTIAL WORK PROGRAM FOR PREVENTIVE MAINTENANCE OF CATCH BASINS

For implementation of the catch basin preventive maintenance program, it is recommended that the following sequential procedure be used.

1. Sector to be cleaned is publicized two weeks in advance per determination of supervisor
2. Supervisor chooses sector to be cleaned
3. Area is blocked 48 hours in advance of expected cleaning
4. Supervisor assigns orange peel (and vactor, if available) to blocked area
5. Orange peel (and vactor) clean blocked off areas
6. Lead man in orange peel (and lead man in vactor) fill out sewer division report forms with location and number of basin cleaned
7. Report forms given to supervisor everyday
8. Supervisor updates catch basin map and file daily, put Sewer Division report forms in file by date
9. Update map by marking each basin cleaned with grease pencil (per color code of month) and card file with date of cleaning and remarks
10. Supervisor notifies night crew for sector area to be blocked
11. When necessary notifies media of next sector's basins to be cleaned
12. Repeat procedure every day as necessary

Sample of Sewer Division Catch Basin Cleaning

Report Form

(to be used by vactor and orange peel crews)

Note: Depth of mud notation on the form can be used to determine time necessary to clean the basin, and it can determine whether abnormal erosion is taking place in that area.

City of Cambridge
Public Works Dept. — Sewer Div.
Catch Basin Cleaning Report

.....19

C. B. No.	Depth of Mud	Remarks

Dump_____

Men_____

_____in charge

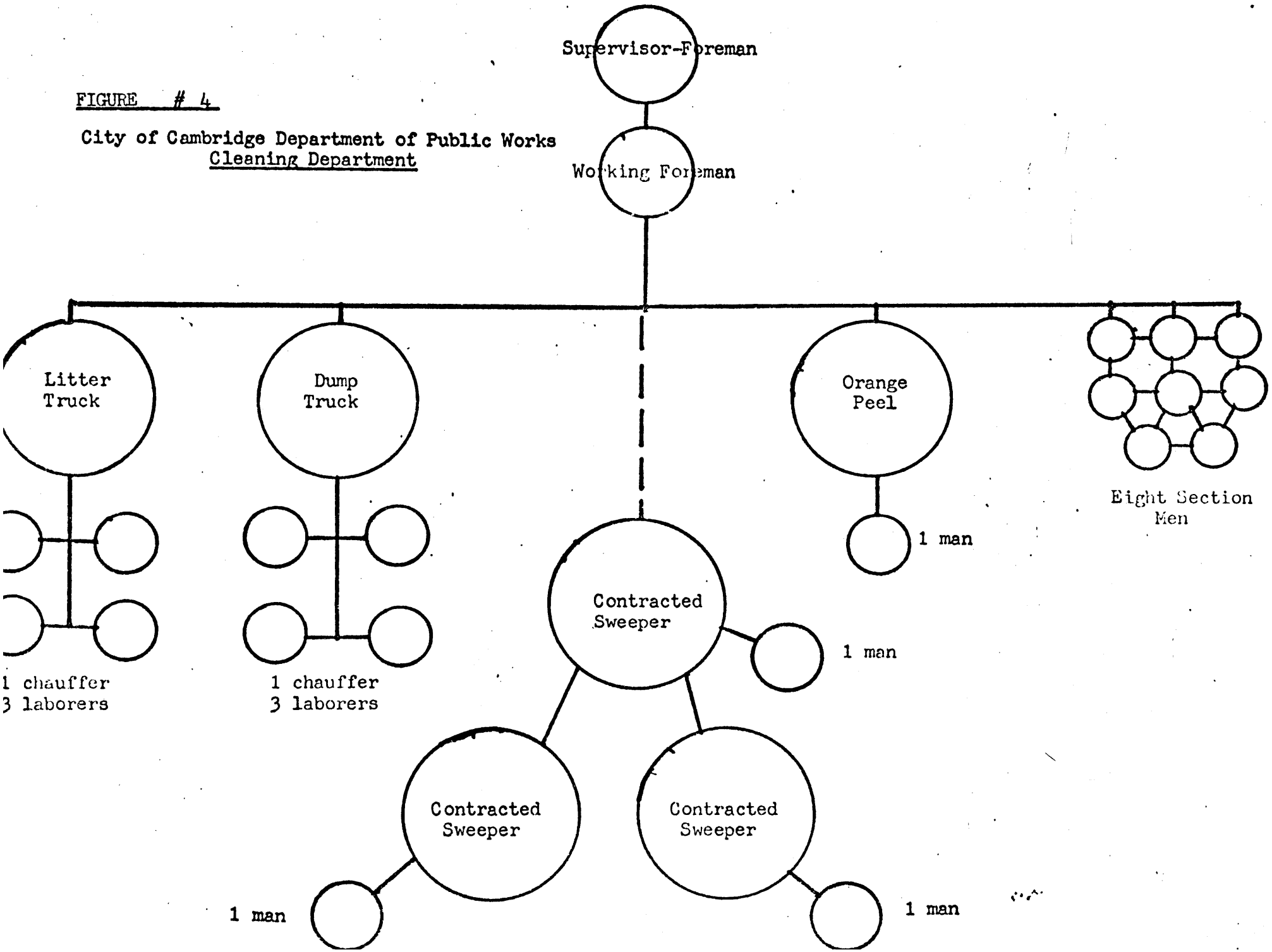
STATUS QUO - STREET CLEANING [4]

The City of Cambridge has approximately 125 miles of streets or 250 miles of curbs and sidewalks, all of which get dirty. The problem of getting them clean would seem to be simple, but is in reality quite complex. It is not the actual act of cleaning the streets that is difficult; to see that the sidewalks are cleaned, and cars are moved out of the way, cooperation is necessary between several governmental groups and the private sector. The governmental groups involved are the Department of Public Works and its Cleaning Department, the Traffic and Parking Department, and the Police Department. The private sector includes the contractor who provides machines and operators to the city for street cleaning, businessmen, and the residents of Cambridge. The relationships or non-relationships of these various groups cause the problem of street cleaning to be a complex matter.

The job actually of cleaning the streets of Cambridge is presently the responsibility of the Cleaning Department of the City of Cambridge Public Works Department. To accomplish this task, the Cleaning Department has seventeen men of its own, and three who work for the sweeping contractor, but fall under the jurisdiction of the Cleaning Department by contract. (Figure 4) One foreman-supervisor and one working foreman oversee the operation of the Cleaning Department. The equipment available to the department includes: a litter

FIGURE # 4

City of Cambridge Department of Public Works
Cleaning Department



truck, a dump truck, a catch basin cleaning machine (orange peel), the equipment used by the eight section men, a payloader and crew, and the sweepers that are used under the sweeping contract. The city owns two sweepers of its own, but they are not presently used since they are old and in poor working order.

The supervisors have two options available when they want the sweepers to clean a street. They can just send the cleaners onto a given street and not worry about cars being in their way, or they can have the cars removed before the cleaners go onto the street. The first option is viable in areas where there are very few cars parked along the curb, such as is the case in the Brattle Street area, or in the squares and industrial areas at night. The second option is necessary in the high density residential areas of the city. When the second option is chosen, the procedure used is as follows: the dump truck crew erects no parking tow signs (See Figure 5) along the curbs of the streets to be cleaned twenty-four hours in advance of the expected cleaning (the signs must be posted twenty-four hours in advance if they are to be legally binding), at eight a.m.,on the morning of the sweeping, the working foreman drives along the posted streets and announces over a public a address system that the streets are going to be cleaned and any cars that are remaining when the sweepers arrive will be tagged and towed at the owner's expence,

FIGURE 5 - Street Cleaning Parking Sign

and finally any cars remaining when the sweepers arrive are tagged by the Police (a special Police detail is assigned to work with the street cleaning operation) and towed by a private outfit. If the area to be cleaned is very heavy with debris, a payloader crew is sent ahead of the sweeper to scrape the street. In an area that has not been cleaned in a long time, the sweeper will make several passes over the same street to make sure that it is really clean. When the sweeper is through, the no parking signs will be taken down by the dump truck crew.

During the sweeping process, a great deal of dirt and debris is picked up by the sweepers, and it must be periodically dumped. At the beginning of the working day, a decision is made to dump at some centrally located point by the foremen or the sweeper operators. The dumping points are communicated to the payloader crew which will pick up the piles in the late afternoon. The dirt and debris is taken to the dump and used as cover soil.

The street cleaner operators begin their day at five a.m. From this time until seven or eight a.m., they usually sweep the squares, the main streets,and the industrial areas. This early in the morning in these areas, there is very little traffic and very few cars are parked along the streets. Even with no parking restrictions, the sweepers are able to do a very effective job during this time period. From eight a.m. on, the sweepers do the blocked streets,

and areas where they will only make one pass as part of a larger route. The city presently rents three machines from the contractor, who also supplies the operators for the machines.

It is well within the capabilities of the three street cleaners to sweep all the streets of the city in a week. On an average day, assuming the street cleaners travel at 5 miles per hour and work for 6 hours with the brooms down, each street cleaner can sweep 30 curb-miles. There are 250 curb-miles in the city, and 90 curb-miles could be cleaned a day with the three street cleaners. Thus, theorically all the streets in the city could be cleaned in less than 3 days. Under the present circumstances, however, the street cleaners are lucky if they can do a thorough job on a residential street once a year. Squares and main streets are swept at least once a week, and some areas of the city are done every day. The section men working with shovel, broom, and push-cart concentrate on congested and high-use areas along the main streets during regular working hours.

The law at present deals with both cleaning and parking: property owners must clean and maintain the sidewalk that borders on their property and failure to comply will result in a fine not to exceed fifty dollars. Nor may a car be left on a public way for a period in excess of twenty-four hours.[5] Both laws, if enforced, would help the cleaning department do a more effective job.

The determination for which streets are to be cleaned is

made by the supervisors in a 24 hour basis. The supervisor determines an area is in need of cleaning and prepares to spend a few days in that area doing a very thorough job. In other words, an area like East Cambridge is chosen to cleaned and different streets will be blocked several days in a row until the whole area has been thoroughly cleaned. Records are kept of when a street was last cleaned, but it would be difficult for an outsider to find out this information without assistance from one of the cleaning department foreman. This record system seems to help the cleaning department make sure that all the streets in the city are cleaned at least once a year. The working year for the cleaning department is the non-winter months of the year. The street cleanirgmachines can not work effectively on very cold days, because the dust spray will freeze. The current practice of clean-in residential streets on an infrequent basis means that when the street is finally cleaned, more time will have to be spent on it to do a good job.

RECOMMENDATIONS - STREET CLEANING

The following section contains recommendations for an effective street cleaning program in Cambridge. The goals of this program would be to clean all the streets of Cambridge once a day. There is unanimous consent in all the departments which deal with cleaning that the one major obstacle to an effective street cleaning program is the great number of cars in Cambridge, and the consequent problems they create for the street cleaners as they go about their work. It is obvious that if an effective street cleaning program is to be obtained, it must be coordinated closely with a city-wide parking program tailored to street cleaning requirements.

Therefore, it is recommended that a city-wide parking program be established for the purpose of street cleaning. There are many valid arguments for different types of parking programs, but one fact stands out over all: the fact that the size of Cambridge and the resources presently available for cleaning the streets are such that a very effective job can be done on all the streets once a week. The parking program best suited to these circumstances is one of the two day-alternate side variety. In other words, alternate sides of the streets would be cleaned on Monday and Thursday, Tuesday and Friday, and Wednesday and Saturday in different parts of the city. Each street involved in this parking program would have permanent signs posted that would describe day and times the street cleaner would be by on

that street. A program of this naturewould minimize inconvenience to residents since they would not be allowed to park in front of their home for only a short period of time each week. Streets in their immediate vicinity would not be posted for no parking on the same day, or at worst, at the same times. Additionally, a program of this nature would allow for a very thorough job of cleaning the streets. Most of the other possible programs do not allow for cleaning both sides of the street during the same week. Day-to-day experience shows that a street cleaned one day is dirty one week later. To clean only one side of a street a week is to not really clean the street at all. When both sides are cleaned at relatively close intervals, the street tends to stay cleaner for a longer period of time.

The streets of the city run through basically three types of areas: 1) Industrial, 2) Retail and Office, 3) Residential . The character of each area and its parking requirements are not the same. Enough cars to obstruct sweeping remain in the industrial areas from 7 A.M. to 7 P.M. in most cases. The retail and office areas can have cars in them from 7 A.M. to 2 A.M. The residential areas have cars in them 24 hours a day. It is clear that not all areas would have to be posted with parking restrictions. It is suggested that all residential areas be posted with the appropriate parking signs. These signs are not necessary in retail and industrial areas, rather it is

recommended that a special schedule be established for the cleaning of industrial and retail areas. Special cleaning shifts should be established that will allow for cleaning these areas at night and on weekends. The present resources of the city would indicate the ability to clean the industrial and retail areas (all main streets in the city) once a night and once on the weekends. This night and weekend cleaning would need no special restrictions since these are times in these areas when the presence of cars is at its lowest point for the day. The practice of people working at night and on the weekends is not new, and adequate compensations have already been developed that would not create financial difficulty for the city.

When discussing a parking program, one must also discuss enforcement techniques. Parking enforcement is carried out now by the Police Department both for street cleaning and other purposes that require restricted parking. The Traffic and Parking Department is charged with following through after the citation is issued. At present, there is nearly a two year backlog of issued citations from Cambridge that have not been brought to conclusion. (This situation should change shortly due to modern computer methods of processing that are being implemented.) After living under the lax enforcement procedures of the present system, the public has come to disregard any parking regulations. If any kind of parking program for the purposes of street cleaning is to be implemented, this attitude on the part of the public

must be changed, or the program will fail.

Therefore, to correct these attitudes and create a more efficient parking enforcement system, it is recommended that all responsibilities for all parking enforcement be shifted to the Department of Traffic and Parking, and the Department be authorized to hire sufficient personnel to carry out these new responsibilities. This shift of responsibilities has a special benefit to the street cleaning program since it would now require communication between only two departments, Public Works, and Traffic and Parking, where additional departments were included before with some difficulty. It is also recommended that the fine for parking violations be increased by some substantial amount to help make drivers more aware of parking laws, and also to help defray the cost of any new sign posting program.

There is a contention among many people in and out of Cambridge government that there are more miles of cars owned in Cambridge than there are legal curb miles of parking space. This claim appears to be true, but its relevance to the problem of street cleaning is questionable. There are several factors which reduce the severity of this problem. The number of off-street parking spaces, though insufficient to handle all the cars in Cambridge, is still substantial enough to aid in a program related to street cleaning. This number has been estimated at 10,000 spaces by the Traffic and Parking Department.

Additionally, many of the cars in the city's residential areas leave during the day and return after the working day is over. The few hours necessary for cars to be moved while street cleaning takes place could be used as a time to shop or run errands by residents so affected. There are many short-term solutions available, but only a long term solution (e.g., residential off-street parking) can solve the parking problems of Cambridge as they relate to street cleaning permanently.

An integral part of any effort to keep the streets clean is, and must be, a simultaneous effort to clean the sidewalks. Under the present system, the streets of the squares may be cleaned beautifully early in the morning, but by 10 A.M. the dirt from the sidewalks has been blown into the streets by wind and pedestrian traffic. It is recommended that the city pursue the notion of purchasing equipment that can effectively clean the sidewalks and other small areas. There are presently cleaning machines on the market that can be driven, and yet are small enough to fit on the sidewalks. These would be most effective on main streets and in the squares.

At the present, a catch basin cleaner works with the Cleaning Department. The logic behind this is the fact that when the Cleaning Department blocks a street for street cleaning, the catch basins are exposed, and consequently, easily accessible to the catch basin cleaner. The catch basin cleaner does take advantage of this absence of cars

and cleans many basins a day that would otherwise be inaccessible. However, the only person who knows what basins were cleaned in the operator of the cleaner. It is suggested that the catch basin cleaner, now with the Cleaning Department, be reassigned to the Sewer Division. This will promote better supervision and a more adequate record keeping system for catch basin cleaning. It is suggested that the catch basin cleaning of the Sewer Division be closely coordinated with the street cleaning and parking programs recommended in this report. This coordination would allow the Sewer Division to take advantage of the parking restrictions of the street cleaning program, and it would allow the streets to be cleaned following the cleaning of the catch basins. This system would work as follows: If a street were to be cleaned Monday between 8 A.M. and 11 A.M., the catch basin cleaners would move in and clean during this time. At the end of the street cleaning day, one street cleaning machine would be assigned to make a pass at the area that the catch basin cleaners had just cleaned. When cleaning in industrial and retail raeas during the day, a regular blocking method will have to be used by the Sewer Division. These streets will be swept the night of the day the catch basin cleaning was done as part of the regular routes through these areas. The sectors previously established for catch basin cleaning will still be operative since each sector will have

streets that are cleaned on different days of the week, and after a period of two weeks of working on streets that are scheduled for cleaning, ample time will have been available on each street and throughout the sector for adequate cleaning of all catch basins in that sector. Under the proposed catch basin cleaning preventive maintenance schedule, a catch basin would only be cleaned once a year. As a result, inconvenience to residents will be limited to one day a year of multiple sweeper passes on the same street on the same day.

The street cleaning contractor presently supplies three street cleaning machines. The Public Works Department has two street cleaning machines of its own. These machines owned by Public Works sit idle because it has been found they are more expensive to run than the contractor's machines. They are in fair condition, but could easily be used as they are. It is possible that an arrangement could be developed with the contractor that would allow him to lease the machines from the city at some nominal fee, and run the machines for the city as part of the overall street cleaning program. The addition of these two machines to the street cleaning program would cover the possibility of a mechanical breakdown disrupting the program by having an extra machine on hand. It is also possible that one of the two machines could be assigned a route that would involve all the no parking

areas of the city and the area in which the catch basin cleaners are active. The result would be all no parking areas claened once a day, and the catch basin cleaning area would be swept with no disruption of the regular schedules for that purpose. There is legal precedent for a leasing arrangement of this sort. The major problem one might expect from a transaction of this type would be the labor questions involved in changing jobs from the public to the private sector.

If the proposed street cleaning and parking programs are implemented, no record system for work done by the sweepers will be necessary. This is due to the fact that at a minimum all streets in the city will be cleaned once a week. The purpose of a record system is to make sure all streets are cleaned regularly, and if the schedule and routes are followed correctly, there will be no problem with the streets being cleaned regularly. A city-wide schedule will be available to answer questions from concerned residents, but the posted signs should answer all questions that could develop. Additionally, this program, if implemented, would surpass any past service previously available, and consequently should not cause many questions or complaints beyond the implementation stage.

The city of Somerville has for some time had a street cleaning program that makes use of a parking restriction algorithm which calls for street sweeping on even sides on even days, and sweeping on odd sides on odd days. This program reportedly works well, but could be

due to a lesser population density, and fewer registered cars then Cambridge.

The routing system for this street cleaning program is designed to minimize inconvenience to all the residents of the city. Adjacent streets are not swept on the same day at the same time. In some case, though, this is unavoidable. As mentioned previously, it is suggested that the routes be arranged such that one side of a street is cleaned on Monday and the other on Thursday; another route such that one side is swept on Tuesday and the other side on Friday; the last route would be such that one side is cleaned Wednesday and the other side of Saturday. Each complete route, both sides of the street included, is approximately 80 curb miles. This is the distance that one sweeper working rather quickly should be able to handle in two days (i.e., Monday and Thursday), or two sweepers working at a more leisurely pace. These routes were designed with the latter in mind. The discussion to this point has been strictly in reference to the two day-alternate side routes, which run largely through the residential areas of the city. There are three two day-alternate side routes, and there are three night routes. The night routes are designed for one machine each. Each of these routes is composed of 30 curb-miles, and should be able to be cleaned in one night with no trouble. The night routes require no parking restrictions since cars are not in these areas

at night. The night routes run through the industrial and retail areas of the city. It is suggested that the night shift begin at 12 midnight and end at 7 A.M. The day time shift working on restricted parking routes should begin at 8 A.M. and end at 4 P.M. These times should not be interpreted to be punch-in times, rather they are the times that the actual sweeping should end and begin. Overtime may be required for the day shift to make this plan feasible. Each route with restricted parking will be divided into two sections: morning and afternoon. Morning signs would read no parking tow away zone 8 A.M. to 11 A.M. or 12 noon, and afternoon signs would read 12 noon or 1 P.M. to 4 P.M. The hour uncertainty at noon is due to the hour for lunch of the operators. This should not be difficult to resolve. The decision of where dump sites will be along the routes should be made by the supervisors before this program begins functioning. The procedure for dumping and pickup will remain relatively unchanged.

This concludes the street cleaning program report and major recommendations. A full set of maps is available with suggested routes for both day and night street cleaning routes. A program for implementation of this report follows. This implementation program contains only major decisions and actions which must be taken to implement this program. Other details are left to the departments involved.

It must be remembered that an integral part of any street cleaning program is how the public responds to it. This will determine its success or failure in the long run. Therefore, at the point of implementation a careful and thorough information publicity program will have to be conducted, such that residents and others are not caught off guard by this new program.

Sequential Implementation Program
For Street Cleaning and Parking Proposal

1. Program is approved by the City Council, and appropriations for necessary expenditures should be made (major expenditures would be for signs and equipment and personnel of Traffic Dept)
2. A meeting with all department heads affected by the program should be held.
3. Traffic Department Preparations
    1. Location of all new signs should be charted
    2. Amount of new signs needed should be calculated and ordered
    3. Advertise for enforcement personnel (meter maids, etc.)
    4. Hire required personnel
    5. Buy required equipment (bicycles for meter maids)
    6. Design and print all necessary paper forms (tickets and towing)
    7. Train personnel in all phases of parking enforcement
    8. Post signs with correct information in predesignated spots
    9. Conclude presently pending parking violation cases
4. Police Department Preparations
    1. Conclude all pending parking violation cases
    2. Reassign personnel previously involved in parking enforcement
5. Public Works Department Preparations
    1. Design new contract for sweeping with double shifts, 7 operators, and provisions for leasing 2 DPW machines to contractor
    2. Submit contract to bid per law
    3. Investigate and encourage demonstration of new more efficient

and effective methods of cleaning sidewalks

4. Purchase sidewalk cleaning machines (section men can run them)
5. Have contractor and his operators learn routes and details of scheduling operation
6. Contact Traffic Dept for coordination of activities prior to implementation of program
7. Have all equipment ready for program activities

Note: Steps 3,4, and 5 (Departmental Activities) occur simultaneously

6. Publicize new Street Cleaning Program
   1. to residents, through mailings
   2. to businessman and industry at suitable meetings
   3. Through rigorous initial and enforcement efforts
   4. Through radio, T.V., and all newspapers
7. Uncover signs, begin implementation.
8. Sweepers assigned to routes according to plan
9. Coordinate in catch basin cleaning procedures with Sewer Division
10. Assign sidewalk cleaning machines to sweeping routes
11. Assign meter maids to ride along with sweepers and conduct enforcement efforts
12. After one month, progress report to public and City Council on success of new cleaning program

Public Works Implementation

1. Day route sweepers assigned to route by supervisor
2. Coordinate sweeper location with meter maids
3. 8 A.M. to 12 noon route assigned and completed
4. 1 P.M. to 4 P.M. route assigned and completed
5. Supervisor assigns payloader crew to dump sites along routes
6. Supervisor does work report for entire department
7. Assign night crew to routes
8. Payloader assigned to pick up night dumpings in the morning
9. Maintenance done between 4 P.M. and 11 P.M. on all sweeping machines
10. Repeat procedure as necessary every day

STATUS QUO - RUBBISH COLLECTION [6]

The citizens of Cambridge generate over 1.6 million pounds of rubbish per week on the average. The collection and disposal of this rubbish is a major activity; the ordinances of Cambridge require the city to "maintain regular schedules of garbage and rubbish collection ... and ... publicize said schedules by all appropriate means". The same chapter defines garbage as "the animal and vegetable waster from the handling, preparing, cooking and consumption of food" and rubbish as "combustible and noncombustible waste materials except garbage, and the term shall include the residue from the burning of wood, coal, coke, and other combustible materials, paper, rags, cartons, boxes, wood, excelsior, rubber, leather, tree branches, yard trimmings, tin cans, metals, mineral matter, glass, crockery, dust and other similar substances". [7]

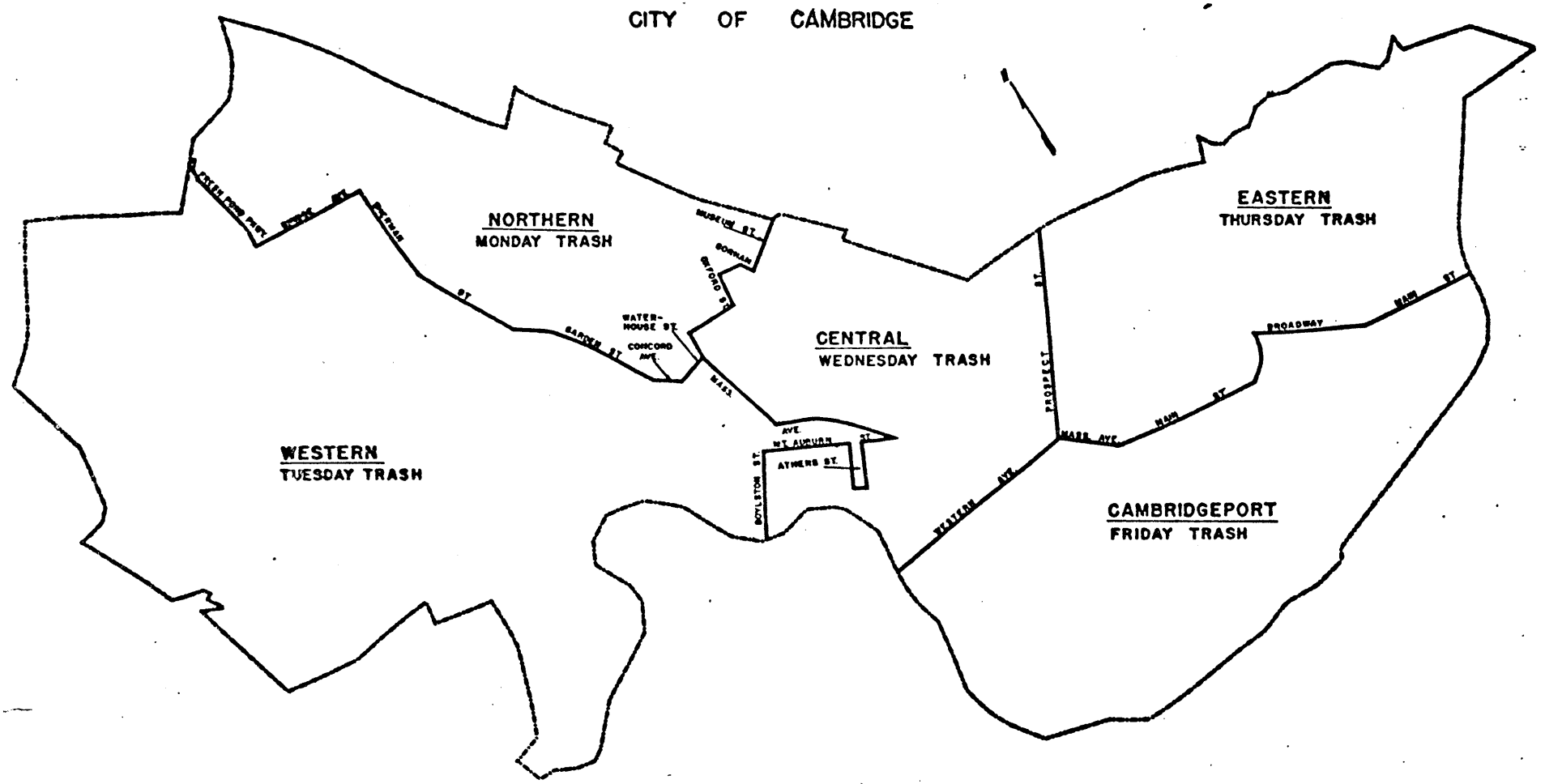
The responsibility for the collection of rubbish as specified by law falls on the Rubbish Division of the Public Works Department of the City. The Rubbish Division has divided the city into five sections, and each section is programmed as one day's work. (Figure 6) Each day's work is divided into fourteen routes, including the business route that goes through the retail areas and the squares every day.

The Rubbish Division has at present sixteen trucks of the "packer" type for the collection of rubbish. The packer is a modern

FIGURE 6

RUBBISH COLLECTION SCHEDULE*

CITY OF CAMBRIDGE



* Source: Cambridge Public Works Department, August 1973

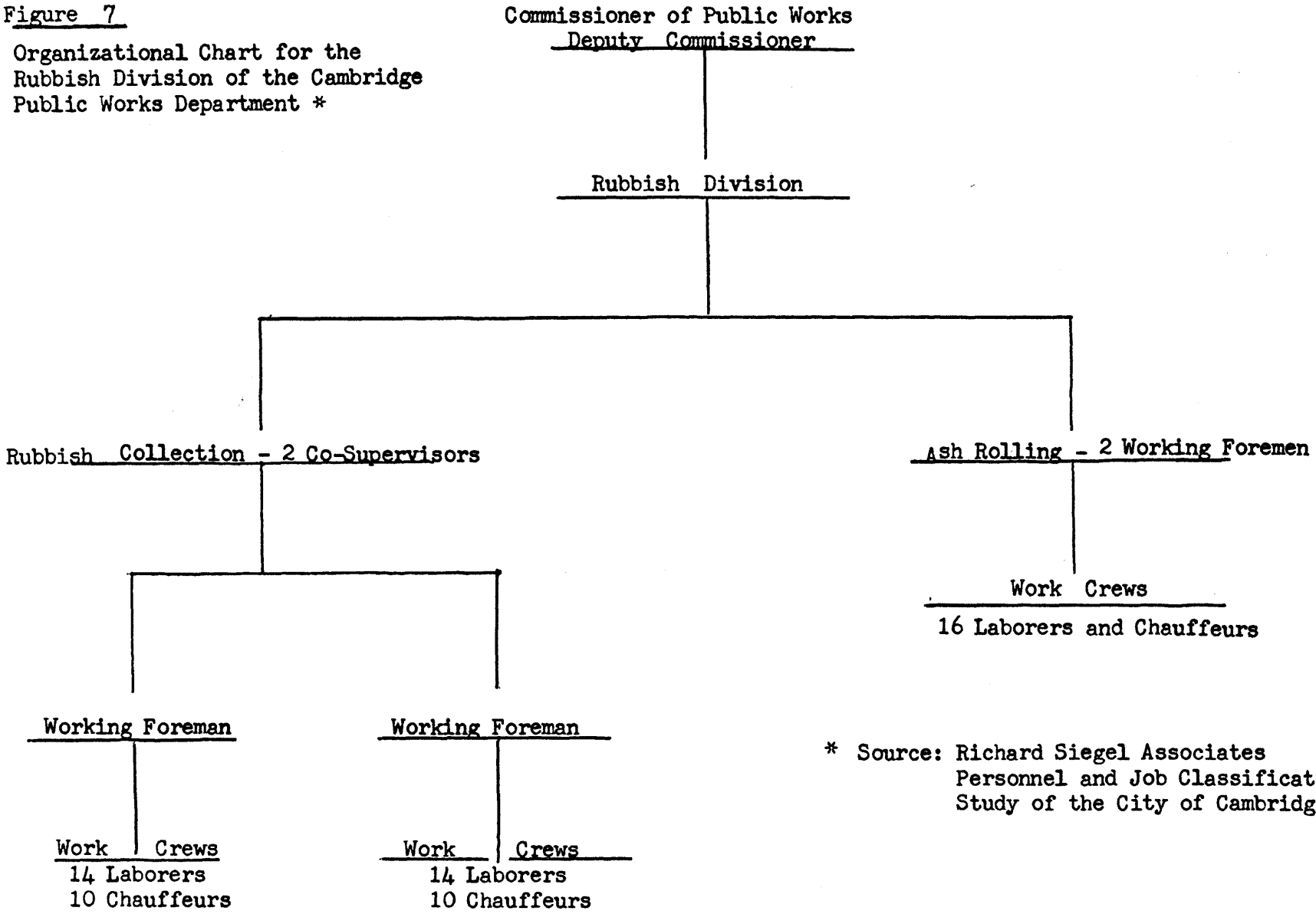
high capacity truck with a hydraulic compressor to reduce the volume of the rubbish. In theory, one truck is assigned to one route for each of the day of the week. Since there are fourteen daily routes, including the business route, and since there are sixteen trucks, there should be an excess of two trucks that are able to help with the heavy areas of each day. It will be shown in this report that this is not always true.

To man the trucks, and to supervise their activities, the Rubbish Division staffs 71 permanent positions.[8] (Figure 7) The Rubbish Division has two co-supervisors and three foremen at present. Each packer truck has one chauffeur and two laborers assigned to it. The Rubbish Division also makes extensive use of so-called temporary help, who cover for permanent employees on vacation and supplement the work force of the Division. The result of this policy is that at times there may be three of four laborers on one truck. At times, there may be only one permanent man on a truck with several temporary men.

The sixteen packer trucks presently owned by the Public Works Department are of varying ages and reliability. The newer diesel-powered trucks, of which there are eight, are able to handle heavier work. They are also less subject to repeated breakdown than are the older trucks. The other eight older trucks are gas-

Figure 7

Organizational Chart for the Rubbish Division of the Cambridge Public Works Department *



* Source: Richard Siegel Associates
Personnel and Job Classification
Study of the City of Cambridge

powered and are liable to develop problems if they attempt any heavy work, and develop radiator and transmission related problems after long periods of use. Both old and new trucks develop problems related to the packing section of the truck. The electric switches and hydraulic parts have a tendency to stick or operate erratically. The result of all of these problems combined is the fact that on a typical day at least one truck is unavailable to the regular collection routes.

Under the present system, at the beginning of each day, the supervisors form their men into crews, each crew is assigned to a truck, and each truck is assigned to a specific route or section composed of a set of streets. Each truck then works in its section for approximately two hours and then drives to the dump for unloading. The dumping site is the lot of Reclamation Systems, INC. in East Cambridge. The trucks return to their section, work for an hour and a half, and make another dump trip. During this morning work, one of the older trucks usually breaks down, and must go into the shop for repairs. Down time may be as little as one hour or as long as three days. If the truck is going to be out for a long period, its crew will be reassigned, and other trucks will have additional streets added to their routes to cover for the truck being serviced. In some cases, a decision is made to take one truck out of its section to complete the section of the absent truck, after which it will return

to its original section. After an hour and a half lunch, the trucks continue to work in their original section, which may have been slightly altered. During the day, the supervisor receives complaints of missed rubbish. These are investigated, and trucks are sent to pick up any rubbish which may have been overlooked. These complaints may arise for several reasons: barrels are rolled late by the rollers or by residents, the truck crew did not see the rubbish, the material to be picked up was outside of the requirements of the law (e.g., a barrel full of cement would not meet the weight requirements), or a truck may have missed a street in its section.

There are several factors, other than the men and equipment of the Rubbish Division, that influence that influence the daily collection of rubbish from the various areas of the city. Among these factors are the weather conditions on the day of collection, holidays that occur on collection days, the regular seasonal variations during the year, and special cleanups that occur during the spring. However, the factors that seem to most heavily influence the daily collection of rubbish are the physical factors associated with the different areas of the city. These physical factors can be divided into three groups: net residential area (in acres), average population density (in people per acre), and dominant dwelling type. Table 4 presents these facts for the five daily rubbish areas of the city.

TABLE 4 - PHYSICAL FACTORS BY DAILY AREAS AFFECTING RUBBISH COLLECTION *

Daily Rubbish Area	Net Residential Area (in acres)	Average Population Density per acre	Dominant Building Type**	Total Units	Ratio	Average Daily Tonnage
Monday's Area	316.9	65.7	Apartment and Triple Decker	19500	1.8	167
Tuesday's Area	442.5	43.1	Single Family House	18900	1.7	151
Wednesday's Area	312.0	103.2	Apartment and Triple Decker	31000	2.9	168
Thursday's Area	170.7	114.4	Triple Decker	19500	1.8	181
Friday's Area	127.1	93.0	Triple Decker	11000	1	136

** Definition of Building Types:
Apartment = 5 or more families in one building
Triple Decker = 3 story building with 1 to 3 families
Single Family House = 1 or 2 story building with 1 family

* Source: Social Characteristics of Cambridge, 1971 Volume 1. Planning & Development Department City of Cambridge Community Development Program

Monday's section is the northern area of Cambridge. (Figure 6) This area has 317 residential acres and an average population density of 66 people per acre with the dominant building type being apartments and triple deckers. (Table 4) The large area of this section combined with a medium population density produces a situation with the following results for the Rubbish Division: 1) a large number of street-miles which must be covered, 2) an above average number of stops per residential block, and 3) an above average number of barrels to be collected at each stop.

Figure 6 shows Tuesday's section as western Cambridge, an area of 442 residential acres and an average population density of 43 people per acre with the dominant building type being single family houses. (Table 4) Tuesday's area, the largest of the five daily areas, and a low population density produce a situation that has the following characteristics: 1) a very large number of street-miles which must be covered, 2) a below average number of stops per residential block, abd 3) only a few barrels to be collected at each stop.

Central Cambridge as shown on Figure 6 is Wednesday's rubbish section. This area has 312 residential and an average population density of 103 people per acre with the dominant building type being apartments and triple deckers. (Table 4) The large area of this section and the high population density produce a situation that has the following

characteristics for the Rubbish Division: 1) a large number of street-miles which must be covered, 2) an above average number of stops per residential block, and 3) a large number of barrels to be collected at each stop.

Thursday's section. the East Cambridge area, has 171 residential acres and an average population density of 114 people per acre with the dominant building type being the triple decker. The small area of this section combined with the highest population density in the city produces a situation with the following characteristics: 1) a small number of street miles to be covered, 2) a very high number of stops per residential block, and 3) a very large number of barrels to be collected at each stop.

The Cambridgeport area of Cambridge is the Friday section for rubbish collection. (Figure 6) Cambridgeport has an area of 127 residential acres with an average population density of 93 people per acre with the dominant building type being the triple decker. (Table 4) With the smallest residential area and an above average population density, the situation for the Rubbish Division in this area is as follows: 1) the smallest number of street-miles which must be covered, 2) an average number of stops per residential block, and 3) an above average number of barrels to be collected at each stop.

The characteristic of the five daily rubbish collection areas as described previously generate the following typical scenario for the weekly collection process: Monday morning the collection process begins in the Monday area, and that night the Monday area is only partially completed. (The full complement of men and equipment available to the Rubbish Division is necessary to complete it in only one day; this full complement is rarely available.) Tuesday's area could be completed in one day if the the full complement of men and equipment were available, but usually it is not since some equipment is still in Monday's area. Wednesday sees work in its area, and the completion of Tuesday's work. The size (i.e., the actual street-miles driven by the packer trucks) of Wednesday's area is sufficiently small to allow a less than full complement of the Rubbish Division to service it in one day. The extra slack truck or two can be used to finish the past days' work. Consequently, there is usually no backlog Thursday morning. If there is still a backlog, Thursday's workload is sufficiently small to provide the slack trucks also. Friday's area, being the smallest, does not need the full complement of trucks, and the slack here is the city's assurance that all rubbish will be picked up once a week.

Each day one truck and a supervisor is assigned to the business route. This is a route that services many of the smaller

retail stores, some larger stores, and some industrial firms. By law, the city does not have to collect the rubbish from these establishments. To have their rubbish picked up by the city, businesses must call up Public Works and have their name added to a special list. If the Rubbish Division does not feel it can handle the amount of rubbish the firm would like to have collected, it can refuse to add their name to the list and will recommend that the firm contact a private disposal outfit. If the firm's name is added to the business route, the special truck and supervisor will come by on mutually agreeable days and collect the firm's rubbish. The city charges the firm a pre-set per-barrel fee of 25¢. A book of 25¢ tickets is sold to the firm, and every time collection is made, the supervisor collects one ticket per barrel. (A prior program used decals in the firm's window which specified by color code the number of barrels of rubbish a firm had paid to have collected per day or week. The firms were billed on a more long term basis, about every three months. But, this decal program was abandoned when the accounts were found impossible to keep current. The ticket system has done away with paper work.)

A statistical analysis of the number of tons [9] of rubbish collected from the beginning of 1973 through the middle of July 1973 shows that the average amount of rubbish collected is 161 tons per

day with a standard deviation (a measure of the variability of the collections) of 34 tons. (Figure 8) The mean for the weeks in which rubbish was collected Monday thru Friday, is 801 tons, and the standard deviation is 116 tons. (Figure 9) The average tonnage collected for the days of the week in the period of observation is shown in Table 5 and Figure 10.

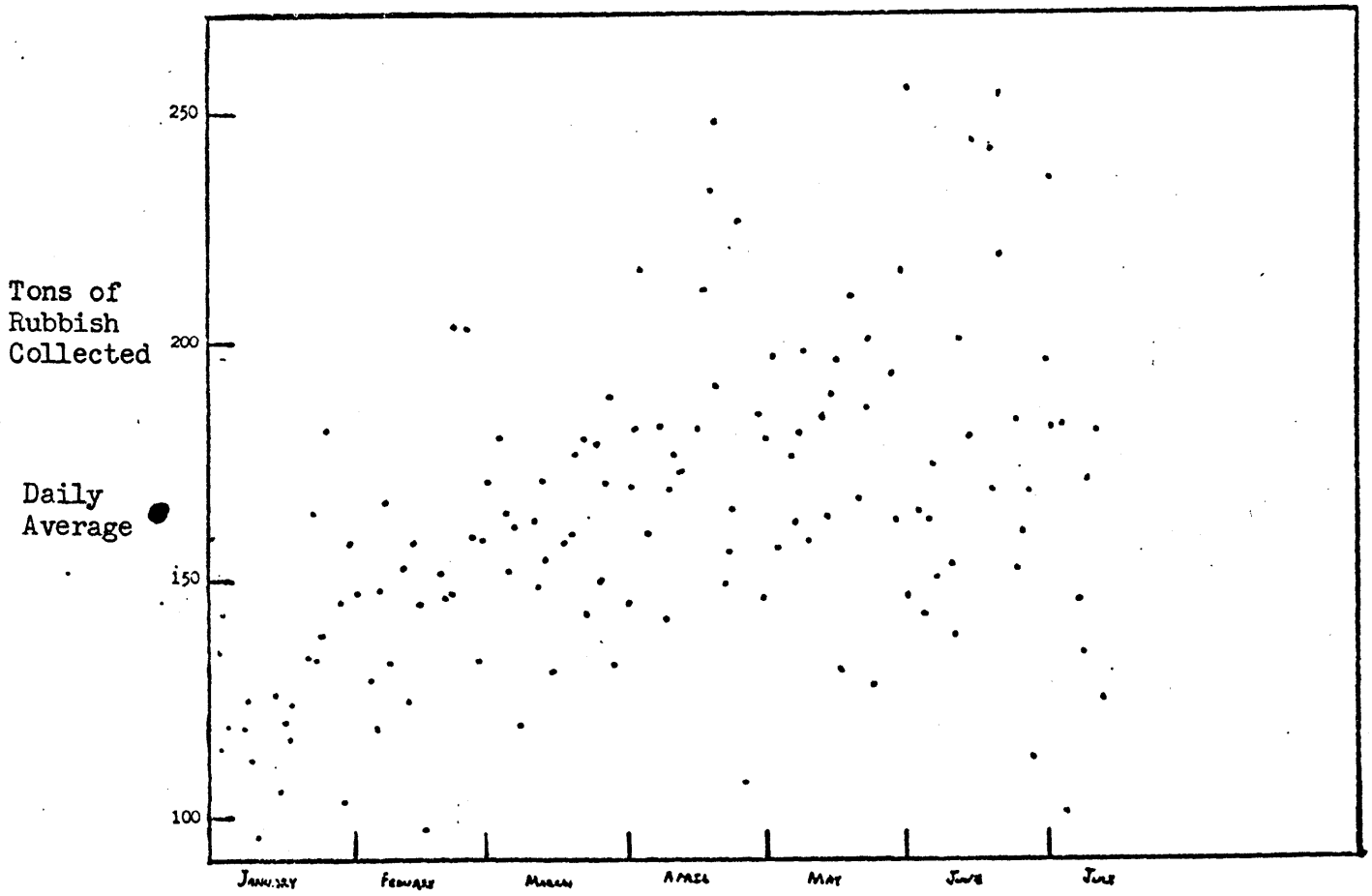
TABLE 5

Average Tonnage for the Days of the Week

Monday	Average	167 tons	Standard Deviation	25 tons
Tuesday	Average	151 tons	Standard Deviation	22 tons
Wednesday	Average	168 tons	Standard Deviation	33 tons
Thursday	Average	181 tons	Standard Deviation	40 tons
Friday	Average	136 tons	Standard Deviation	32 tons

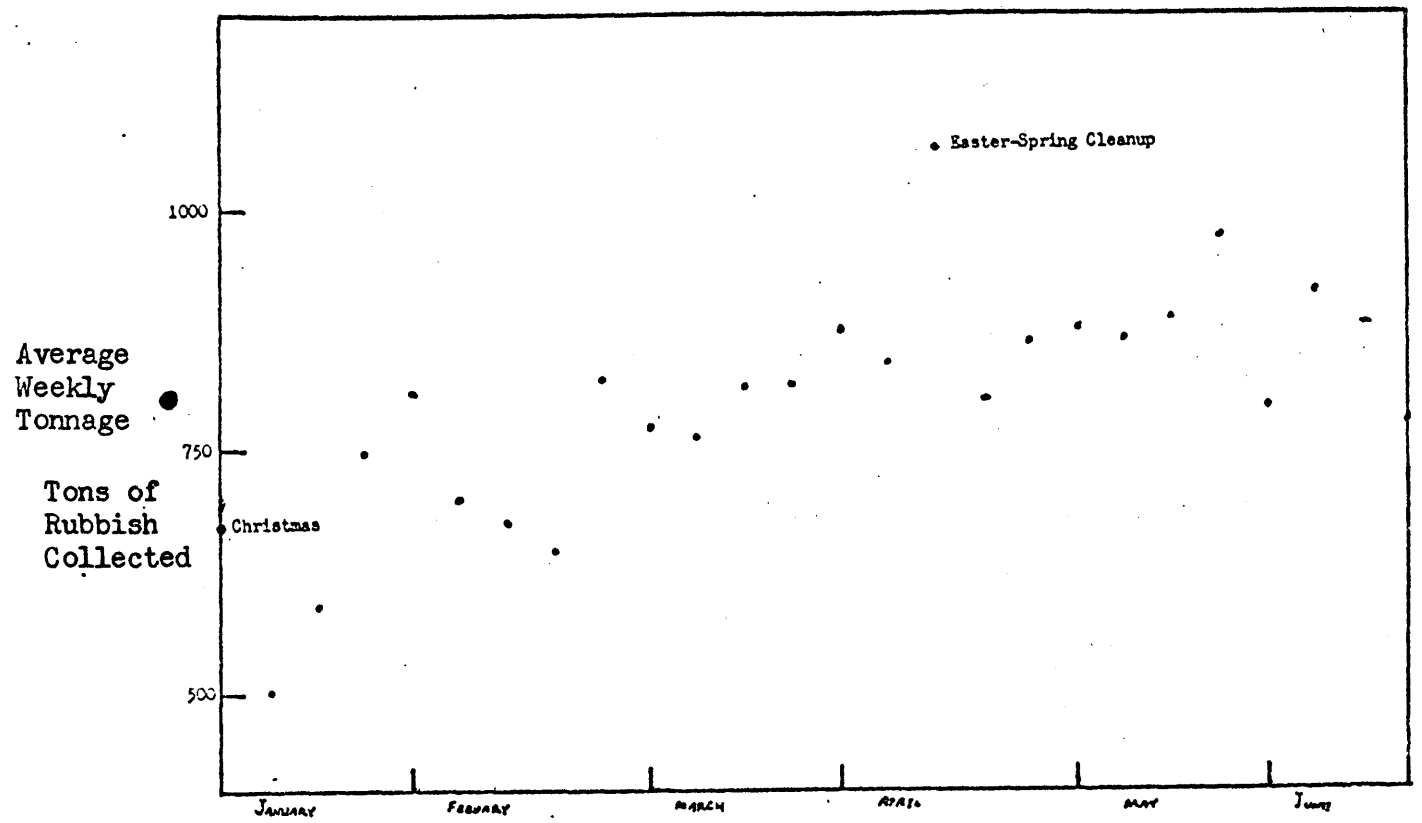
The daily averages and deviations would seem to suggest that tonnage is closely correlated with population density and residential area. (Table 4) Figure 9 demonstrates the nature of part of the annual cyclical variation of rubbish collection in Cambridge. This cyclical variation can be traced to the cycle of the seasons, and the effects it has on the way people throw out rubbish. In winter, people only throw out what they have to from their house, their yards are rather dormant during this time period. In spring and summer, people are throwing away their leaves, grass clippings, and all the things they

Figure 8 - Daily Rubbish Tonnage Collected
For The Period From January 1 - July 17,1973 *



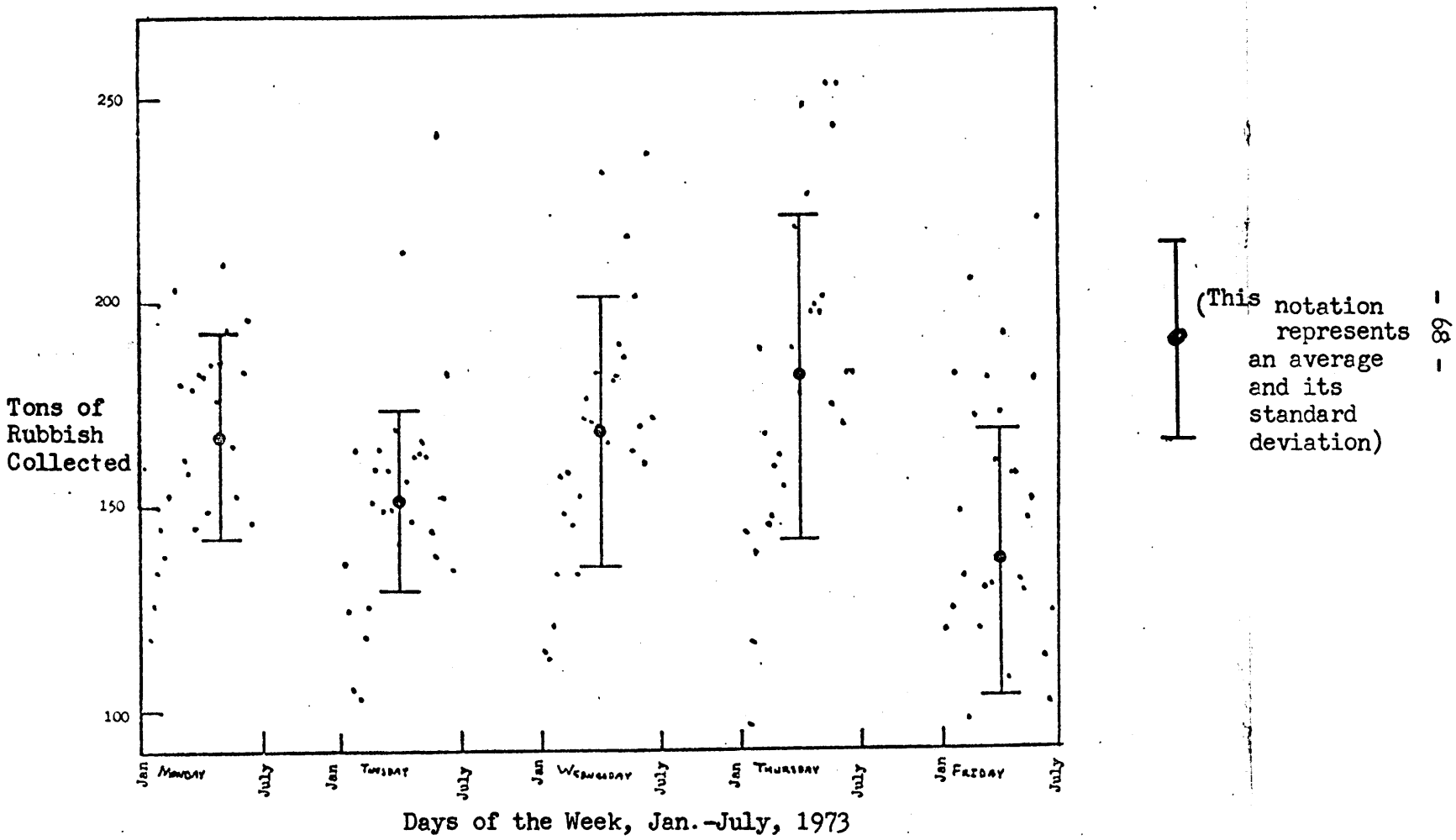
* Source: Cambridge Public Works Department Records

Figure 9 - Weekly Rubbish Tonnage Collected
For The Weeks of January through July, 1973 *



* Source: Cambridge Public Works Department Records

Figure 10 - Daily Average Tonnage with Standard Deviation For The Days During January through July, 1973 *



* Source: Cambridge Public Works Department Records

have been saving in their attics or basements all year. After fall has occured, the amount of rubbish goes down again until the spring. This ctclical and seasonal nature of the rubbish problem is attested to by the men who have been in the Rubbish Division for many years. Holidays are responsible for the major upward deviations from this cycle.

RECOMMENDATIONS - RUBBISH COLLECTION

The following section contains the recommendations for an effective and well-organized rubbish collection system in Cambridge. The goal of this system would be the regular collection of rubbish on a strict basis by schedule with no deviations which would leave full rubbish cans standing at the curb. If this goal is attained, it is conceivable that the number of complaints received at Public Works would diminish, the amount of supervision would decrease, and the workers would be able to work without the pressure of catching up to schedule.

Taking the goal of the city as being provision of rubbish collection on a regular basis hides several implicit decisions already made. The first decision is for the city to provide the service itself rather then contract to a private company. There is some literature on shifting rubbish collection services from the public sector back to the private sector.[10] This literature suggests that the private collection of rubbish is more efficient, and less costly to the taxpayer than a city-run operation. This might be the case in Cambridge as well, but for social and political reasons (e.g., labor problems, patronage opportunities, lack of analytic management techniques, etc.), the decision has been made to have the city provide it. Another implicit decision is to have the city maintain its own fleet of

rubbish packer trucks rather then lease them from a private firm which could also maintain them. The same social and political factors are responsible for this decision also. A third decision based on these same factors is the decision to make use of "temporary" employees throughout Public Works; the Rubbish Division is particularly subject to their use as crews on the packer trucks.

Under the present system, social and political decisions aside, there seem to be two major problems that account for the inability of the Rubbish Division to establish a strict schedule and stick to it. These problems are a lack of motivation for the personnel employed in the Rubbish Division, and repeated equipment malfunction.

The problem of equipment malfunction is the easier of the two problems to handle. We understand that there are presently six new packer trucks on order. This is the first step in bringing the rubbish fleet up to some minimum standard of workable quality. It is recommended that two of the older trucks be kept by Public Works, so as to form a reserve that the Rubbish Division can use in the event of a major mechanical problem on one of the newer trucks. There are certain costs associated with maintaining these trucks as a reserve. These costs are as follows: 1) Storage Space - The trucks could be stored in the Public Works garage or on the land adjacent to it, but the cost involved would be that of less space being available for

other Public Works activities. It is difficult to assign a dollar value to this space cost, but if the trucks were stored in a nearby private facility, the cost would be thirty dollars per month per truck. 2) Maintenance Costs - If a full time mechanic were hired only to look after these trucks, his salary, by the current Public Works scale, would be $9,500 per year. The cost for parts, cleaning and painting the trucks could be estinated at $1000 per year. In sum, the costs are:

Costs for Reserve Packer Truck Pool @ 2 Trucks

Storage Space @ $30/month/truck	=	$ 720
Maintenance Costs	=	$10,500
Mechanic @ $9500/year		
Parts, Cleaning, Painting @ $1000/year		
Total	=	$ 11,220

The total of $11,220 works out to a charge of 12 ¢ per citizen for continuous and smooth operation in the Rubbish Division on a day-to-day basis. Additionally, a preventive maintenance program should be implemented for all rubbish trucks. The costs for a program of this type are already included in the Public Works budget, since there is a night crew of mechanics which would handle this program in addition to their present duties. This program should take the form of a nightly check by a qualified mechanic of the major mechanical systems in each

packer truck. The packer trucks are particularly susceptible to problems in the cooling system (including radiator and all hoses), the transmission, and the packing section of the truck (electric switches and hydraulic units). All rubbish trucks should also be washed at least once a week for health reasons. Records should be kept of the work done on each truck for both major repairs and preventive maintenance. It is suggested that a program should be implemented that would provide for the purchase of one or two trucks every year with a rotation of the fleet downwards. In other words, as new trucks are purchased the older trucks in the reserve fleet should be junked, and the older trucks in the active fleet go into the reserve fleet. This system would impose little financial strain on the city, and would allow the Rubbish Division to keep an up-to-date fleet of packer trucks at its disposal.

The problem of motivating workers is more difficult, because it will require a complex series of negotiations with the Cambridge Public Works Union (AFL-CIO affiliated). The employees of the Rubbish Division should be allowed to work on the so-called "work-through" [11] basis. Under the work-through incentive program, workers are assigned one section of the day's work, and when their section is complete to the satisfaction of their foreman, they are free to leave but they

are paid for a full day. This means that the workers do not stop for lunch, rather they just work right through their lunch time. This would be an agreed upon provision of their union contract. A program of this nature would have advantages for the workers and for the efficient operation of the Rubbish Division. The workers would be allowed to set their own pace, and if they choose to work quickly, they could have most of their afternnons free. The Rubbish Division would gain the equivalent of a full day's work for a full day's pay as opposed to the present six hours work for eight hours pay. The Division would also be able to collect every day's work on schedule. When the work through incentive program was tried in the past by the Public Works Department, it was found that the men worked quicker, and the rubbish was picked up on schedule, but the program was stopped when union opposition developed because the work through program was thought unfair to the workers outside of the Rubbish Division. A possible strategy to resolve the conflict might be to re-assign the rubbish workers after finishing collection for the day to an essential, but easy job (e.g., public relations - "bag your trash", sweeping sidewalks, washing trucks, etc.)

It is suggested that the work-through incentive program, if adopted, be coordinated with a special scheduling program for each

of the daily sections. Ideally, each day's work, Monday through Thursday, would be divided into some given number of sectors, and each sector would be assigned an equal number of trucks and men under one foreman. The present situation in the Rubbish Division would suggest that the optimal number of sectors in a days work would be five since there are fifteen trucks, excluding the business route truck, which could be divided into sector groups of three trucks each. However, two new foremen would be required under this plan, consequently, a modified plan has been developed which would only require the hiring of one new foreman. Under this modified plan, each day's work would be divided into four sectors. Three sectors would wach be assigned four trucks and sufficient men to man the trucks under one foreman. The other sector would be assigned three trucks and workers under foreman. Each set of trucks and men would constitute a group. The area of the four sectors would be divided proportionately to compensate for the group of three trucks. If one truck in the group broke down and was to be out for an extended period of time, the personnel from the truck in repair would be reassigned to the other trucks in their group and the work would continue until their group sector was completed. When the group sector was completed, all members of the group would be done for the day. On Friday, all sixteen trucks and crews would word as one group under the co-supervisors of the Rubbish Division. This would allow the Division the

necessary freedom to insure that all the collection work for the week has been completed. Friday would also be on a work through basis, but the trucks would all finish together when all the week's work is complete to the satisfaction of the supervisors. If this program is implemented, it is suggested that the co-supervisors of the Rubbish Division be given the job of determining the daily four sectors, and the make-up of the crews to be assigned to each section. However, it is recommended that the sections within each day's work be divided along geographical boundaries. A sample division is included in this report. (Figures 11, 12, 13, 14, 15) It is also recommended that all drivers be assigned to the same truck every day, and that they be assigned the same routes every week. This will help the drivers get a better feel for their truck, and a better feel for their routes. It can be assumed that once a driver has a good feek for his routes, he will be able to develop the most efficient means for working that route.

The use of temporary employees in the Rubbish Division does not help the continuity or the efficiency of the Division. Once a temporary employee is finally starting to get a feel for the work and the various areas, it is time for him to leave, and someone else comes in and takes his place. It might be argued that this frequent turnover allows the Rubbish Division to replace a worker who is getting bored and sloppy with a fresh alert man. The workers, the supervisory

Figure 11 - Monday Rubbish Collection Area - 4 sectors
City of Cambridge

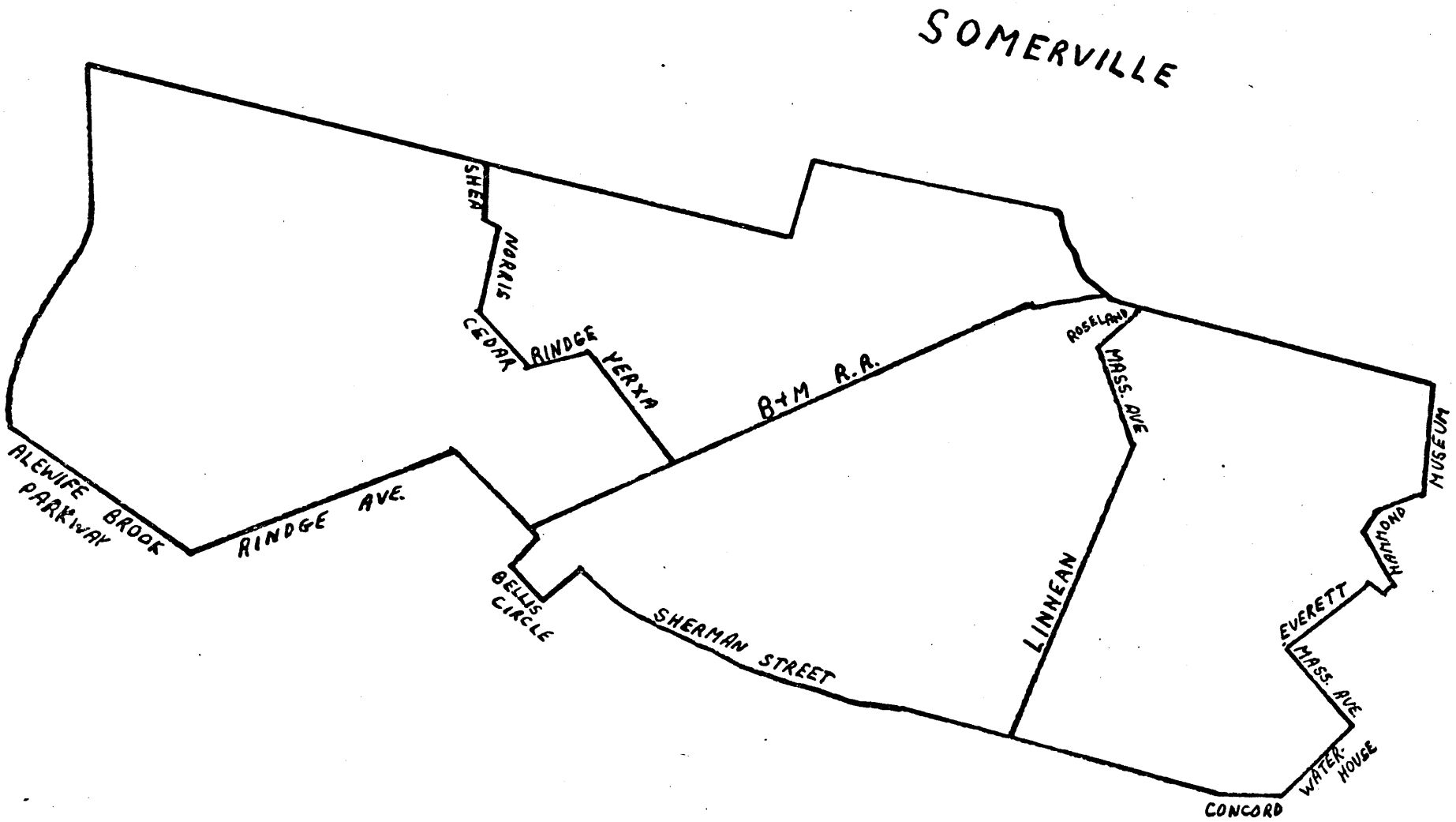
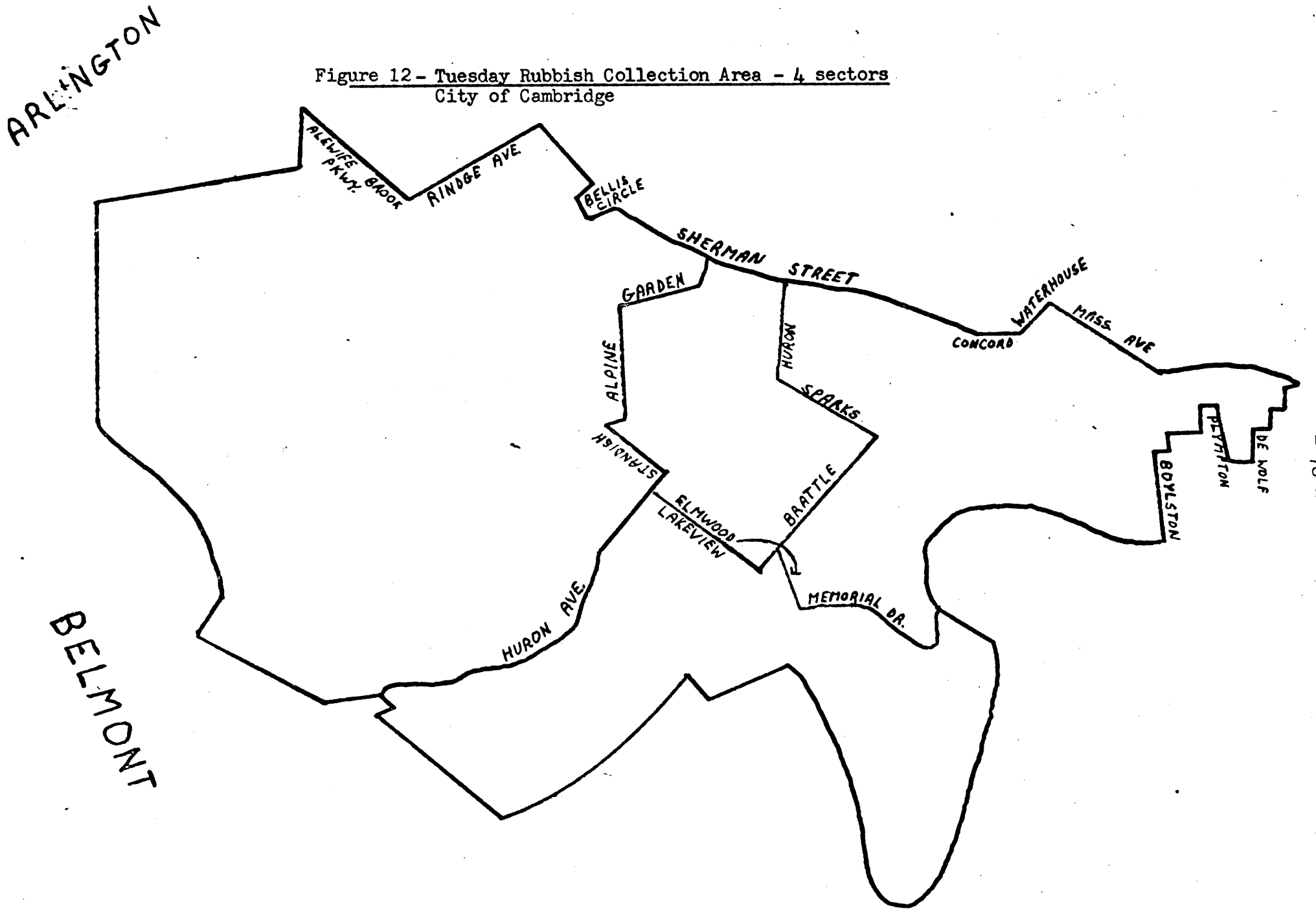


Figure 12 - Tuesday Rubbish Collection Area - 4 sectors
City of Cambridge



SOMERVILLE

Figure 13 - Wednesday Rubbish Collection Area - 4 sectors
City of Cambridge

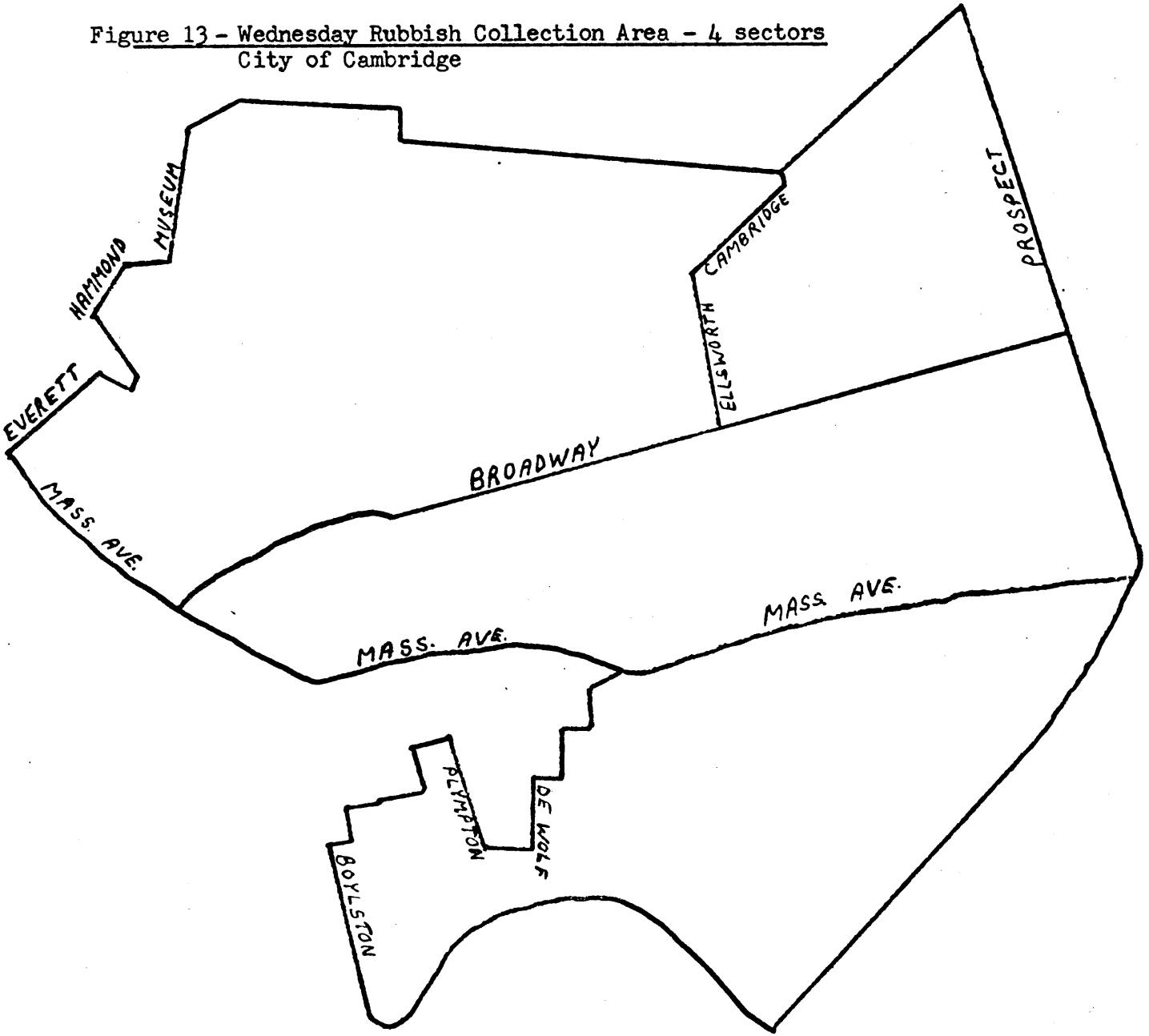


Figure 14 - Thursday Rubbish Collection Area - 4 sectors
City of Cambridge

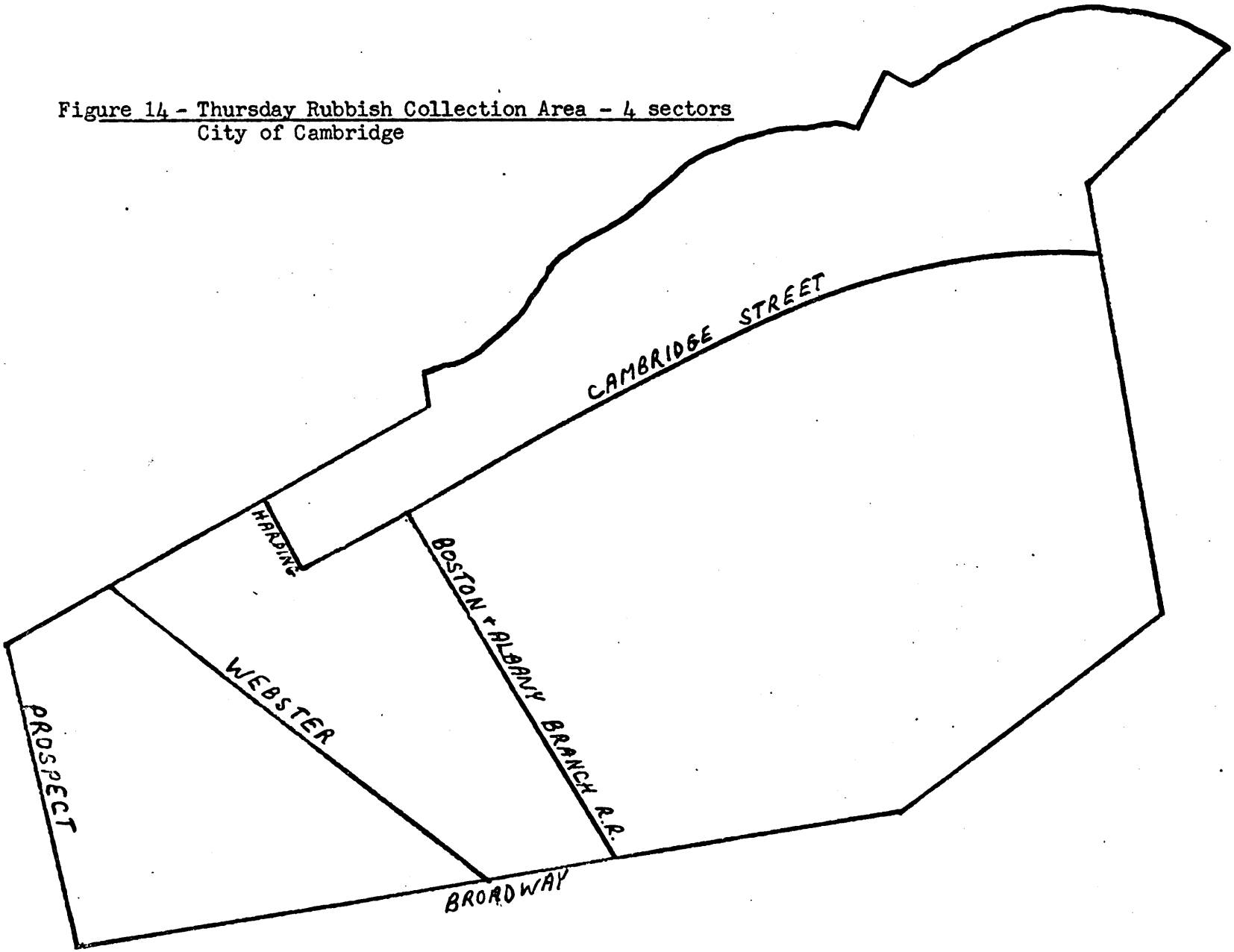
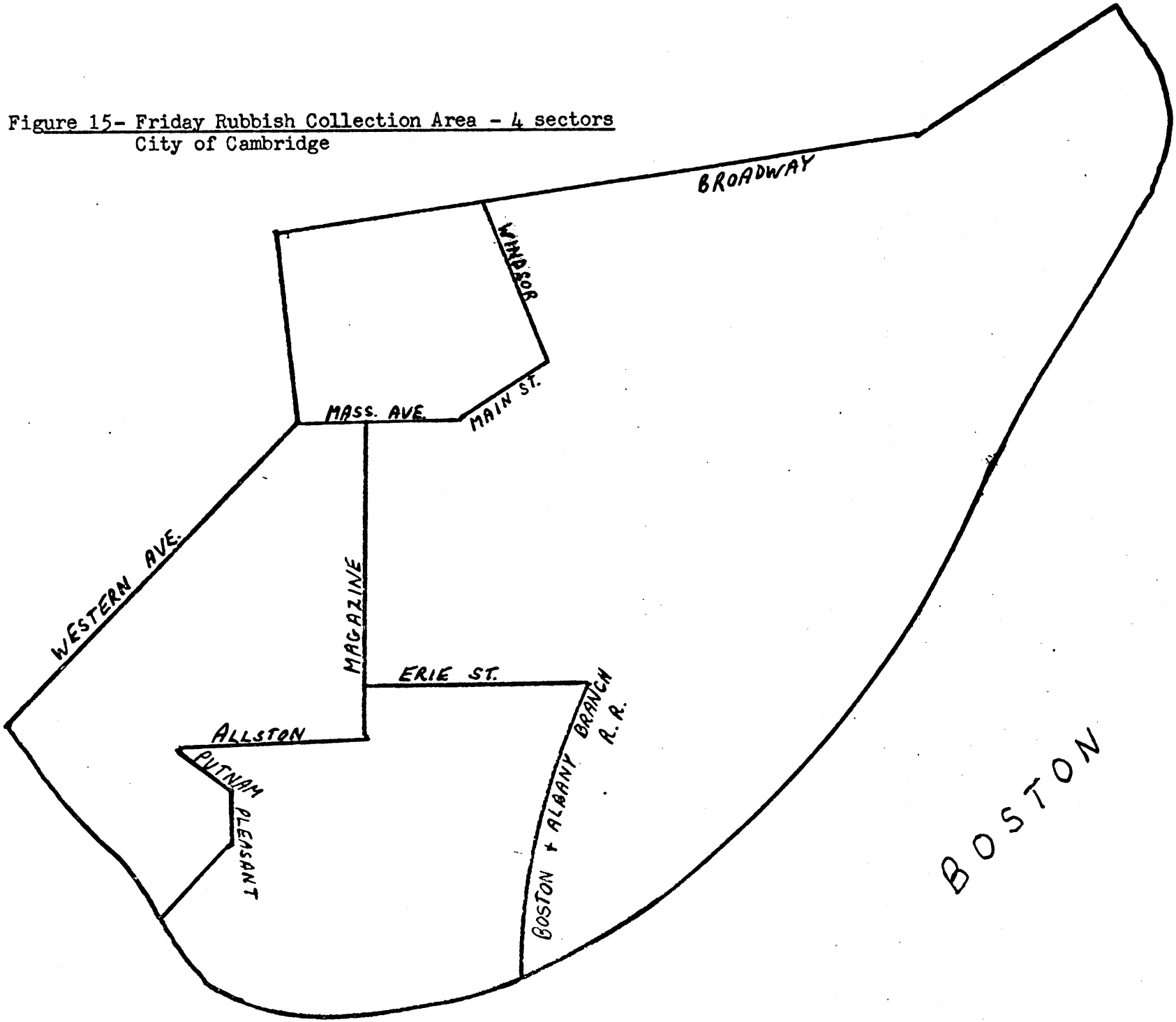


Figure 15- Friday Rubbish Collection Area - 4 sectors
City of Cambridge



personnel, and our observations do not support this contention. For political reasons, temporary employees are used as much as possible, and in any position where it is feasible. It is recommended that temporary employees be used to fill as few positions as possible in the Rubbish Division. Additionally, temporary or even new permanent employees should not be assigned as drivers on the trucks since they have virtually no familiarity with the rubbish routes. When a truck has a new employee driving and temporary employees loading, it is bound to miss some of the more obscure stops on its route.

Another problem for the Rubbish Division is the amount of time required to pick up the rubbish from large apartemnts and the various housing projects. A great deal of time and effort could be saved if all apartments over five family units and all housing projects within the city were to install large rubbish containers. Medium-sized buildings with insufficient rubbish output to maintain a container themselves could share them with other medium-sized buildings. We understand that the city presently has one truck capable of emptying the large containers, and has the necessary authorization to order two more. Therefore, it is suggested that the city initiate a legislative campaign to have large apartments, medium-sized buildings, and all housing projects install large rubbish

containers at their own expense, and the Public Works Department should place the order for the necessary trucks. It has been suggested that containers present the potential for vandalism. This may be true, but the personnel of The Rubbish Division feel that the potential savings to the city would outweigh the possible damages that might result from occasional fires. Safeguards are available; some containers have tops and lockable doors, others can be put in an enclosure that prevents vandals from obtaining access to them.

Under the present system, one truck and its crew, and one foreman spend nearly all their time on just the business route. Many establishments have their rubbish collected by the city, and it is conceivable that this is full time work for one truck. The Rubbish Division does not collect from all businesses because some have a rubbish output greater than the Division can handle. However, it is not necessary for one foreman to spend his full time on this activity. It is recommended that the Department of Public Works go back to the decal program for collection of rubbish from businesses. This would allow a much longer term billing procedure, and save both the businessman's time and the Rubbish Division's resources. It is suggested that the billing be done quarterly by a secretary in Public Works. It is suggested that if a decision is made to go back to the

decal program, the Chamber of Commerce should be included in all discussions of implementation.

There are presently two co-supervisors and three foremen involved in the collection process. The implementation of the suggestions in this report would require the hiring or promotion of a new foreman. In addition, it is understood that some of the personnel in the Rubbish Division are reaching retirment age. Therefore, it is recommended that the procedure used to fill these vacancies be one of promotion from within the Rubbish Division. This can result in two major benefits: 1) an additional force for motivating the employees since there will be a cahnce for advancement, and 2) the new foremen will already be familiar with the practices in the Division, and the various routes that are followed by all the trucks. All foremen should be equipped with radios to facilitate better communication among the supervisory personnel as the day's work progresses.

A relatively new phenomenon in the collection of rubbish is the use by the homeowner of plastic bags rather than trash cans. The use of large plastic bags is a sanitary and convenient way of disposing of all types of rubbish. Plastic bags also aid in the collection process since the worker only has to make one trip from the curb to the truck. With cans, the worker has to move cans to the truck, shake them, and return them to the curb. If only plastic bags

were used along any route, the time saved would be considerable. It is recommended that a special experiment be conducted to confirm this. The criteria for the success of the experiment would include some of the following measures: less spillage, worker satisfaction, time savings, resident response, and Rubbish Division reaction to the program. If this experimental program proved successful, the notion of using only plastic bags could be extended over the rest of the city with a tremendous savings to the city.

No matter how fool-proof a system is devised, there are still bound to be complaints from places where the rubbish was not collected. To handle this contingency, it is recommended that a dump truck be equipped with a radio to handle all complaints. This would allow the prompt handling of a complaint with a minimum of effort on the part of the supervisors of the Rubbish Division, and one of the packer trucks would not have to be diverted from its regular route to handle a complaint as is the case at present. When not on complaint calls, this truck could be used to supplement the regular work force in particularly heavy areas, or in the collecting of bulky objects.

STATUS QUO - SNOW REMOVAL [12]

The City of Cambridge is subject to an average of fifty inches of snowfall during the three to four winter months. This average is deceptive in that one winter may be mild and see very little snowfall, while another winter may be harsh and see a great deal. It is nearly impossible to predict the nature of the winter period before it actually happens. Snow creates a series of traffic problems; emergency vehicles cannot get through to their destination, and food and fuel deliveries can be interrupted if the streets are not cleared.

The responsibility for keeping the Cambridge streets safe and clear of snow during the winter months is that of the Public Works Department, the Traffic and Parking Department, and the Police Department. The removal of snow from streets is of such importance that it takes precedence over almost all routine matters of city government. As a result, when snow begins to fall, an emergency is declared, and most of the available resources of the city, including the attention of the City Manager, and all personnel in non-critical positions in the Public Works Department, the Traffic and Parking Department, and the Police Department, go into the effort to keep traffic flowing regularly. The Traffic and Parking Department is responsible for establishing traffic and parking rules for this emergency period.

They do this by establishing emergency arteries which are supposed to carry the bulk of the traffic during snow time. These emergency arteries are supposed to be plowed first to make sure travel is possible throughout the city. The Traffic and Parking Department will also set up other emergency parking provisions, if any, based on an analysis of the previous winter's emergency parking provisions. Then, Traffic and Parking will authorize the Police Department to enforce these parking and traffic regulations. For the Police, this means the coordiantion of a towing program and a responsibility to see that the emergency situations are handled quickly and correctly. Towing is handled by a private contractor who works with the Police on a year-round basis. Before towing, a car must be properly ticketed when it is in violation of the traffic and parking regulations. It has been an established practice that cars are taken to the contractor's lot until the car is claimed, and the fine is paid. The Police, sometimes in consultation with Public Works personnel, determine which cars need to be towed for snow clearing to proceed. The Public Works Department is responsible for plowing the snow, and placing salt and/or sand. To handle this responsibility, Public Works fields a staff of foremen, and makes use of contractor services to quickly remove the snow from the streets.

To enable the Public Works Department to work effectively during the winter months, a great deal of pre-season preparations

must be made. These preparations involve the city's purchasing agent who must procure what the city needs during the winter months. Once the purchasing agent is informed by Public Works, he will advertise for the needed men, equipment and materials. This determination is made by the Public Works Department on the basis of an evaluation of last year's performance including the number of storms that occured, the depth of snow, and the number of pieces of contracted equipment needed during snow season. This advertising for snow removal equipment services takes the form of a notice in the newspapers and sets of specifications that are available on request. The purchasing agent will receive bids for the services of the various types of snow removal equipment from the contractors at prices that have a maximum set by the Public Utilities Commission. From bids submitted at or below the acceptable limit established by Public Works, the purchasing agent will create a list that has the contractor's name and equipment that is available. This list is then forwarded to the Public Works Department. The city also contracts with various weather services so as to get an accurate ongoing picture of what the weather is going to be like on a daily basis during the winter. One of these weather contracts is with the United States Weather Bureau, others are with local area weathermen. The idea is to predict the weather so the city will know when to mobilize for a snow emergency. The cost for this service is low, and past

performance indicates that these weather reports have substantially helped the city in determining the proper course of action to take when the snow starts to fall. Soon before the snow season, city-owned trucks that can be used as snow plows are fitted with frames that will allow a blade to be attached to the truck. The preparation time also sees a series of meetings between Public Works, the Police, and Traffic and Parking to improve communication and coordination during snow time.

When the city receives a forecast of snow, the Police, Traffic, and Public Works go on alert. When the snow reaches 2 inches, a snow emergency is declared. The Traffic and Parking Department declares over radio and television if possible that there will be no parking along emergency arteries. The Police Department is then informed that a snow emergency exists, and begins the process of ticketing and towing cars that are parked in restricted areas. The large number of cars parked illegally during snow time precludes towing all of them. Rather, the Police tow those cars which will hinder the plowing and clearing process the most such as those that are double parked or near major intersections. In the meantime, Public Works has begun the process of contacting the contractors on the list who have promised to have snow removal equipment available. Within one hour of being called, the contractor, his equipment, and his

drivers are supposed to check in at the Public Works Yard. Upon checking in at the yard, the driver is assigned to one of five foremen. Each of these foremen is responsible for all the plowing done in an area to which he is assigned. These areas roughly correspond with the rubbish areas. When a foreman is assigned a truck and driver, he will give the driver a list of streets within his area of supervision to be plowed. Not all plowing work is done only through contractors; the Public Works Department can supply up to twenty-five trucks that can be used as plows. These Public Works plows are integrated into the work program as needed; the net result is that Public Works has at its disposal a large fleet of equipment for one purpose, to clear the streets of snow and make them safe for travel.

The first objective during a snow emergency is to clear the main streets and emergency arteries of snow. Once this is completed, the plows can then begin the work of clearing the secondary streets as necessary. If one of the secondary streets is very narrow as many of the streets in Cambridge are now, the plow will only be able to clear one lane for traffic. Many of these narrow streets have cars parked along both sides. This is a dangerous situation during snow storms since it is difficult to plow a narrow street anyway. When plowng, a driver will almost always try to plow in the same direction

as the traffic flows. This means that cars parked along the right side of the street will be plowed in by snow. The condition of the street will be plowed in by the snow. The condition of the street will also affect how adequately the street is plowed. Many of the older Cambridge streets have several castings (manhole or valve pit covers) that are one or two inches above the surface of the pavement, the plows are forced to run with their blades a few inches off the pavement on these streets to avoid hitting these obstructions. If a plow were to hit a manhole cover, a piece of metal could be taken out of the blade, the manhole cover could be damaged, or the truck itself might be damaged. The blades of snow plows are spring loaded to avoid this type of damage, but many plow owners and drivers are not willing to take the risk of plow damage on the poorer roads. The result is that in many cases the plows do little good. If they are plowing only two or three inches of snow, and the blade is two or three inches off the ground, little snow is plowed.

When most of the main streets and arteries have been plowed and are reasonably clear, the Public Works Department will begin hauling snow from these streets. The snow is loaded onto dump trucks by front-end loaders, and in the past, has been taken to the city dump and to the sea-ward side of the Charles River Dam. The snow is hauled away from the main streets and squares to allow greater access to these areas by the flow of traffic. Hauling the snow also helps

to prevent the formation of ice in these areas if a thaw and subsequent freeze should occur.

The Public Works Department also uses salt on the streets after snow has fallen to hasten the melting process. The streets usually salted are the mian streets and the squares since these streets have the most traffic and have a greater tendency for accidents to occur as a result. The salt used is presently stored in the Public Works Garage, and during snow time it is loaded onto Public Works salting trucks by front-end loaders. In some instances sand is also used in icy areas. The use of sand allows for greater traction, and the consequent safety for vehicles using these icy streets.

A snow emergency is only declared if a large amount of snow is expected which will intefere with the use of the streets all over the city. If only a couple of inches of snow fall, the Public Works Department does not do any extensive plowing, but most of the streets are salted. It is felt that the combination of salt, some sand, and the heat from cars is sufficient to care for a minor storm's snow.

RECOMMENDATIONS - SNOW REMOVAL

This section contains the recommendations for a snow removal program in Cambridge. The goal for any snow removal program should be the prompt and effective removal of snow from all the city streets. This should be done in such a manner as to re-establish regular traffic flow throughout the city as soon as possible. The program should cause a minimum of inconvenience to the citizens of the city during the plowing and hauling process, and it should attempt to minimize expense to the city for the entire process.

This snow removal program can only be acheived with total cooperation between the various city departments responsible for the snow removal effort. This cooperation between the departments is necessary because the foremost problem in snow removal is the presence of cars on the streets. If no cars were parked on the streets, the problems of snow removal would be a simple one of assigning routes to plows and seeing that they did a good job. However, this is not the case. Cars park on the streets in great numbers, and the efforts of the Police, Traffic and Parking, and Public Works Departments are necessary to remove them.

In some parts of the city, massive street parking prohibition is clearly unfeasible. However, other alternatives for removing cars from the streets have been tried with little success. The most prominent of these alternatives is off-street parking on sites such

as parks, playgrounds, yards, municipal and private parking lots, shopping center parking lots, and almost any other place a large number of cars can be reasonably parked. The notion of parking on these type of sites has certain inherent limitations. One is the problem of access to cars parked on these sites after they are all snowed-in. Another problem is the damage that cars driven into parks and playgrounds can do to the grass, and the grounds in general. Shopping centers like to have their parking lots cleared of snow immedaitely after it falls for the convenience of their customers. Consequently, in the past, they have not been willing to allow the city to use their parking lots for free for off-street parking during snow time. The City should investigate the use of these lots as a paying customer (i.e., rent the space for short periods of tiem). These problems and others make it necessary for the city to find other solutions to the problem of off-street parking in heavily congested areas during snow time.

To give the plows greater access to the streets, it is recommended that where parking restrictions are feasible, parking be restricted to one side of the street. On one-way streets, this should be the left side of the street in terms of traffic flow. This policy would allow plows to clear two lanes on all streets as opposed to the present system in which they sometimes have difficulty in

clearing one lane. On one-way streets parking on the left would allow the plows to plow to the right and not plow the snow against the parked cars as they presently do in many cases. This will mean that snow is pushed on to the right-hand curb and sidewalk. This may not be an ideal solution, but it will keep the streets cleaner longer since people will not have to do as much digging to clear their cars and consequently will be throwing less snow back into the road, and snow removal will be facilitated since snow for the road will just be in one windrow at the right-hand curb. Prompt, efficient, and effective removal would mean that the sidewalks would only be blocked for a short period of tiem. The sidewalk clearing process would be facilitated if the city were to use several very small plows, expressly for the purpose of clearing the sidewalks.

Many streets in the city are already posted with sufficient parking restrictions that are related to snow removal, but these restrictions are not enforced as they should be. The enforcement of parking regulations during snow time is one of the most critical aspects of the entire snow removal process. If the regulations are not enforced, the citizens will not take the parking restrictions seriously, and the plowing process will be hindered by parked cars along the streets. To be able to do this enforcement, the Police need more men, more cars, and more money for overtime salaries.

Under the present system for plowing and hauling, there are five sections in the city with a foreman for each to oversee the activities within his sector. These sectors are too large to permit adequate supervision of the plowing activities within them. It is recommended that the city be divided into ten sectors for snow removal purposes. Each of the ten new secotrs would have a foreman, and as plows reported for work they would be assigned to a foreman who would assign the plow some work within his sector. It is suggested that plows be assigned to the same foreman and the same streets every time they report in for work. This would allow the drivers an opportunity to get to know an area well, and the foreman would know the capabilities of the driver. It is also suggested that new drivers be given maps of the sector they will be working in to help familiarize them with the areas.

The specifications for snow removal contractors call for all their plowing equipment to come equipped with both ballast and chains. Most contractors presently do not follow these specifications, and in fact, expect Public Works to provide them with ballast. It is suggested that this practice be discontinued, and any contracted snow removal equipment be required to come already loaded with ballast, and with chains in place. This will save the city both time and money, since the contractors can be plowing instead of spending time waiting to be loaded with ballast. Prices for contracted plowing should not increase due to this requirement, since ballast and chains

are currently covered under the present contract, and contractors would not have to go to very much expense to see that their equipment met these standards.

The plowing operation should be a smooth and continous one. Plowing should begin when the snow has started to fall, and continue until all the streets in the city have been cleared. It is suggested that if possible, a large part of this work should take place at night since the traffic is lighter then. Many cars also leave the city streets at night; this would be an excellent opportunity to plow back to the curb on all major streets. This would help insure snow-free streets, and little chance for ice formation for longer periods of time.

The hauling operation should be a complementary part of the snow removal operation. In other words, plowing should continue while the hauling operation follows on the just plowed streets. As the entire operation progresses, smaller trucks should be used to clean the narrow streets and alleys. These trucks should have sufficient capabilities to do this work. (i.e. four-wheel drive, chains, and ballast) At some future point when the ash trucks are of sufficient quality to permit it, it is suggested that these trucks be fitted with plows and work as plows exclusively along the main streets. This would insure that all main streets would be cleared and the field foreman would be able to concentrate on the secondary streets

in their respective sectors. Another suggestion would greatly improve the present situation, but it is not immediately feasible, it is the idea of lowering all manhole covers to grade so the plows do not have to plow with raised blades. This would allow a more efficient cleaning of the streets, and would result in less ice formation.

The salting operation is presently conducted out of the main Public Works Yard. This makes good sense in terms of a centralized operation, but the space necessary for this operation might be put to better use. It is suggested that the salt be stored at the city incinerator, and the salt opreation be run out of there. The centralizing characteristics could still be retained with the installation of radios at the incinerator. The incinerator also has the advantage of a crane being readily accessible for the loading of salt into the salting trucks.

In the past, as snow was hauled, it was taken to the city dump for dumping. The dump is now being closed to this kind of use, and this creates a problem for the hauling operation. There are three possible solutions to this problem for the city. One is to find another large land area with sufficient drainage and owned by the city to allow for the dumping of snow. The second is the purchase or rental of melting equipment. The third solution is to dump the snow on land adjacent to the Charles River, and let the runoff go right into the river. All three solutions are viable for the City of Cambridge,

but the first two each have several points against them. There is no piece of land in Cambridge that really has the necessary qualities for a snow dumping site. The second solution requires a functioning sewer-storm drain system to handle the great volumes of melt water, and Cambridge does not have a system that can handle the output of a melter. Therefore, it is recommended that the City investigate the possibility of dumping snow on land adjacent to the Charles River. The Magazine Beach area is ideally suited for this purpose. There is, however, the question of river pollution. This needs to be investigated with the Metropolitan District Commission (MDC) to see if this is a potential hindrance to the use of the Magazine Beach site for dumping snow.

An important part of any snow removal program is the cooperation of the public. This can only be accomplished if the citizenry is informed of all rules, regulations, and practices concerning snow removal in the city. Therefore, it is recommended that an intensive publicity program be undertaken during the fall. This should especially inform the public about parking restrictions that will be implemented and enforced during snow time.

This concludes the snow removal program recommendations for the City of Cambridge.

Analysis of System Constraints

The problems facing the Public Works Department on the surface appear to be technological and management problems, but upon further examination, the problems are seen to be representatives of the wider social, political, economic, physical, and labor problems inherent in Cambridge government. The problems form a network of constraints which act to limit the options of the Department.

The Public Works Department employs a large number of people, the large majority of whom are Cambridge residents. These people constitute a sizable voting force under the proportional representation election system of Cambridge. This is a vote that some councillors can count on since they are responsible for originally getting a large portion of Public Works employees their jobs. The use of patronage in Cambridge has several implications for the Public Works Department. For patronage purposes, it is useful to have as many jobs as possible to be filled. Massachusetts civil service law defines a position called temporary employee. Temporary employees are not subject to civil service examinations, but they may only be employed by the city for a limited period of time ranging from 30 to 90 days each year. The pressure for patronage opportunities forces the Public Works Department to make extensive use of temporary employees. In political terms, this means a city councillor could have a minimum of four and

a maximum of twelve vote commitments where he would only have one if a permanent employee had the position. Temporary employees are used to partially staff the vactor, rubbish trucks, and the sidewalk routes in the cleaning division. The need for jobs also creates a resistance to change or eliminate any services in the Public Works Department at a political level. The continued uneconomical separate collection of rubbish and garbage is an example of this. Another problem with patronage appointments is the fact that some people put to work in this manner are unqualified for the position they hold, though this is not a major problem since most temporary employees are placed in positions that require few skills.

The other side of the political coin is that city councillors represent some constituency that requires and expect the efficient provision of municipal environmental services. The councillors are charged with seeing that this happens, but usually they can not or do not want to make it happen. Although in a legal position by the city charter to set policy, indecisiveness and a lack of pertinent data has caused the policy-making function of the city council to slip to the City Manager in most cases. The city councillors also know that in many cases major efficiencies in the Public Works Department can only be acheived at the expense of the patronage program.

It should be pointed out that there is also a social concern

argument for patronage, as there is a labor argument for the job practices of the Public Works Department. The social argument for patronage appointments, especially for temporary employess, is that a job with the city for some people is a form of social welfare. In other words, the people put on the payroll would normally be unable to get a regular job in the private sector, and would therefore, be getting unemployment or welfare payments. Working for the city, the temporary employees can get some money and provide a service for the city at the same time. There is also a psychological argument that in giving people employment who would otherwise be on the welfare rolls gives them a sense of self-worth, gives them some job training, and eventually offers the motivation to find a better job in the public or private sector.

The Public Works Department finds itself caught in a maze of bureaucratic civil service regulations which decrease the flexibility of job descriptions, and make it difficult to fire an employee who is abusing his position. The flexibility of Public Works programs is further reduced by a strong labor union of the Public Works employees which is always ready to jump on any deviation from the long accepted pattern of doing things. The Public Works union also has very strong ties to the upper echelon of Cambridge politicians, and is a tacit participant in the patronage activities within the Public Works

Department. The result of these labor constraints can be seen in a recent attempt to eliminate barrel rolling as a service to the residents of Cambridge. The union, without first getting a full understanding of the proposal, saw it as an attempt to get rid of jobs and quickly contacted their political friends who saw that the move was stopped. Past attempts to implement a work-through program in the Rubbish Division have met a similar fate. (The work-through program may not be a good example, sonce there are grounds for justifiable complaints from workers in other divisions who must work a full eight hour day.) An example of civil service and job description interference cam be found in the Sewer Division. The current job description for the operator of the orange peel states that this job should be filled by a laborer. The orange peel is clearly a complex piece of equipment, and it is the opinion of the personnel of the Sewer Division that the operation of the orange peel should be done by a mechanical equipment operator, the next highest salary level after laborer. The result of this job description discrepancy is a poor performance by some of the personnel assigned to the orange peel as a protest action.

The city, and the Public Works Department subsequently, finds itself caught between a set of economic constraints. The citizens of Cambridge want their tax rate to be as low as possible,

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while they also want a sufficient level of municipal services. Like most other goods and services today, the cost for municipal services is continuing to rise. These high costs are those associated with the rising costs for the labor and equipment necessary to provide service at a sufficient level. The current sentiment in the policy making circles of Cambridge has been that citizens get more upset if thier taxes go up, than they do if their streets don't get cleaned. The result for the Public Works Department has been a steady decline in the quality of the equipment available over the last several years. The consequences are those already described in the catch basin cleaning and rubbish collection operations where catch basins are cleaned only once every two or three years, and rubbish is left standing on the curb when the packer trucks break down. These same economic constraints are partially responsible for the lack of off-street parking facilities for the residents of Cambridge. There is a substantial need for these facilities, but the cost for their construction would be high. The financing for a project of this nature would probably have to come from general funds, and the tax rate would probably rise again to support this expenditure, but the decision has been made not to raise the tax rate so the facilities will not be built.

The physical nature of Cambridge also imposes a series of constraints on the Public Works operstion in the city. The major

physical constraints are the number of cars in the city, the size of the streets, the population density, the intensive land use of the city, and the extremes in weather. There are more cars registered in Cambridge than there is legal on-street parking space for them (in part due to the high population density). This immediately creates problems for any program which has parking restrictions as one of its facets. The large number of cars in the city also hinder the speed of normal traffic flow, and creates problems for slow moving vehicles like street cleaners or packer trucks. The problem for snow plows is worse since they usually work at night when there is greatly reduced visibility, and consequently more likelihood of hitting an on-coming car. The size of the streets just make the parking and traffic problems worse. The larger vehicles of the Public Works Department have difficulty navigating the smaller streets of Cambridge. The very high population density of Cambridge east of Harvard Square necessitaites a higher use rate of the physical facilities of the city. The streets and sidewalks get dirtier faster, more rubbish is generated, the catch basins fill up quickly, and the need to quickly remove the snow is intensified to keep the flow of goods and services to the residents of the city constant. The intensive land use of the city increases the problems created by a high population density, especially in terms of rubbish per unit area. The weather, both irregular occurences and the seasonal variations, make the provision of

services to the residents of the city more difficult. When snow falls, the catch basins and streets can not be cleaned, rubbish is more difficult to collect, and snow has to be plowed and hauled. When it rains, catch basins back up and must be cleaned out to prevent flooding. Thus, the weather in itself creates a series of probelms which Public Works mest deal with directly.

From the constraints described here and their impact on the services offered by the Public Works Department, it can be seen that the problems the various divisions face must be solved as well as possible within the Public Works structure, and in the larger system of the Cambridge on the more fundamental levels indicated by the constraints discussed here.

Implementation Analysis

The four sections of the status quo descriptions and suggested recommendations for the catch basin cleaning, street cleaning, rubbish collection, and snow removal operations for the Public Works Department were submitted to the Cambridge City Council during September of 1973 for action. As of May 1974, changes have occurred in each of these four divisions due largely to the actions of the new Commissioner of Public Works. The City Council has taken little action towards these four reports in keeping with their seeming inability to establish new policies or turn recommendations into reality. On the other hand, their inaction may be due to a political reticence to handle a subject fraught with so many political overtones for them.

The Sewer Division has not implemented a catch basin preventive maintenance program to date. No new machines have been purchased for the Division, and orange peels have fallen into further disrepair. The Public Works Department is trying to salvage the orange peel machines by rebuilding one good machine out of two bad ones. An acetate covered catch basin map has been made, and a file card system with one card for each catch basin has also been created. However, neither of these record keeping divices has been implemented. In the past several months, several additional catch

basins have backed up, and have caused substantail property damage. these accidents might not have occurred had the catch basin preventive maintenance plan been implemented. The economic canstraints on the system have been responsible for the inability to implement the plan since new machines for catch basin cleaning have not been able to be bought, and no new men have been added to the Division to save money.

A comprehensive, city-wide street cleaning program (a modification of the plan recommended in this report) has been recently implemented. The new program divides the city into ten sectors which are swept entirely once a month. Each of the sectors is assigned two days, one odd and one even, and the odd side of the street is swept on the odd day, and the even side of the street is swept on the even day. Temporary signs are posted throughout the sector on the streets to be cleaned one week ahead of the scheduled cleaning. Residents are asked to voluntarily move their cars off the streets, but if they don't, the cars will be towed in a very effective towing campaign established by the Police, Public Works, and Traffic and Parking for this new street cleaning program. Voluntary cooperation with the parking restrictions has been hailed as "tremendous" by all parties concerned. The Public Works Department has not leased their machines to the contractor, rather the machines are now run at night in the industrial and retail sections of the city. This program has also proven very effective. A full scale publicity campaign has accompanied

the implementation of this new program possibly accounting for its major success to some degree. The program has also been successful because it has run into none of the major constraints discussed earlier. The physical problems are reduced to a minimum by the fact that cars only have to be moved once a month, and that is acceptable to most people faced with the problem of moving their car.

The rubbish collection program has been virtually unchanged. Economic, political, and labor constraints have all worked together to prevent many of the needed changes from taking place. New equipment that has been ordered has not arrived (possibly because of the energy crisis and the already long backlog of orders facing the packer truck company). Political and labor constraints have prevented the implementation of the work-through program. The reserve fleet of packer trucks will not be possible to acheive until the new equipment arrives. Two administrative changes have occurred, though, which should help the rubbish collection program somewhat. A preventive maintenance program has been started on all the packer trucks. The trucks are serviced at night, and thereby left free to work during the day. This preventive maintenance program has reduced the frequency of breakdowns. The other change is that the daily collection section boundaries have been slightly altered to reduce

the workload on Monday, and create an equivalent shift back through the daily sections so that the work load on Friday is increased. Some large buildings have also installed the large rubbish containers which are picked up by the one container truck available at Public Works.

The snow removal program has been changed to conform with several of the recommendations made in the report. This was possible owing to the fact that the program is not really constrained by the factors that have hindered progress in the other programs. Money is available for snow removal, labor does not really enter because the service of private contractors is primarily used, and consequently many of the political elements are missing from the snow removal program. The major set of problems still affecting the snow removal program are the physical ones. However, again, a well-coordinated effort between the Police, Public Works, and Traffic and Parking has resulted in a much improved plowing performance by Public Works. (For the first time in several years, the Cambridge City Council went on record this year complimenting the city departments on their excellent performance with the new snow removal program.) The time needed for clearing all the streets of Cambridge was at an all-time low during the winter season, a winter of several storms requiring plowing. Public Works did provide ballast to the contractors as has been customary in the past; it was felt that the time required for this

purpose was not very great, and worth the good will it provided between Public Works and the contractors.

Thus, the recommendations of the report that were confronted with the major system constraints were largely unimplementable, while those recommendations that suggested minor management changes have found their way into reality for the most part. This reemphasizes the need to take the major system constraints into account, and deal with them directly when trying to affect change.

FOOTNOTES

A. , " Plastic Garbage Bags get Key Test " Chemical and Engineering News, May 19, 1969

B. Drake et al. Analysis of Public Systems The M.I.T. Press Cambridge, Mass. 1972

C. , Municipal Public Works Administration , The International City Managers' Association, Fifth Edition, 1957

D. Ibid.

E. Ibid.

1. The information concerning the Sewer Division was obtained from Mr. Jeremiah Lucey, Head of the Sewer Division

2. This illustration is from a set of drawings by Charles Maquire, Associates for the construction of the North Charles Relief Sewer

3. Cambridge Public Works Department records

4. The information concerning the Street Cleaning program was obtained from Mr. Anthony Celluci and Mr. Thomas Stackpole

5. Cambridge City Ordinances - Parking Section

6. The information concerning this section (Rubbish) comes from Mr. Anthony Borelli and Mr. William Kervick

7. Cambridge City Ordinances - Rubbish Section

8. Included in this number are the personnel in the "ash-rolling" department of the Rubbish Division. This includes two working foremen and sixteen laborers and chauffeurs. The "rollers", as they are commonly known, move the rubbish and garbage containers from residents' back yards to the curb for collection. This service is not provided as a matter of course; a citizen must call and have his name added to the list of homes the rollers service. This report will not concern itself with the rolling operation since this service is optional to the citizens and does not have a major effect on the efficiency of the rubbish collection operation. Further reference to the Ash or Rubbish Division should be understood to mean only the collection aspects of the Division

9. Rubbish is usually measured in tons. This is accomplished by observing a tare, or empty weight, of each packer truck and comparing it to its full weight at dumping time. Because rubbish does not have a uniform density, the volume of a ton may vary widely. However, current measurement practices do not allow for measuring by the cubic foot, and these numbers are consequently not available. If they were available, routing might be accomplished by assigning a truck to a section where it will get a full volume capacity load. Yet, this is presently the case anyways in some sections of the city under the present system.

10. , Municipal Refuse Disposal , American Public Works Association, Institute for Solid Wastes. 1970, Public Administration Service

11. "Work-through" is a term coined by the Public Works Department, but it is also referred to in a study by Professor Marks of MIT Department of Civil Engineering entitled " Cambridge Municipal Service Systems Study"

12. The information concerning the snow removal program was obtained from Mr. Anthony Borelli and Mr. James Thompson

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5. Lockwood, Robert K. Snow Removal and Ice Control in Urban Areas ; American Public Works Association Research Project No. 114, Volume 1, 1970

6. Marks, David H. Cambridge Municipal Service Study MIT Department of Civil Engineering, Cambridge, Mass. January, 1971

7. Wilson, David G., Editor. "Summer Study on the Management of Solid Wastes." Urban Systems Laboratory, M.I.T. September 1968

8. , 1973-1974 Annual Budget, City of Cambridge