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MANUAL FOR DEICING CHEMICALS: APPLICATION PRACTICES

National Environmental Research Center
Office of Research and Development
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December 1974

MANUAL FOR DEICING CHEMICALS:

APPLICATION PRACTICES

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FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment -- air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

The study described here was undertaken to minimize the amount of chemicals used in controlling snow and ice on highways. Practical guidelines are presented for good practices in the application of deicing chemicals.

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ABSTRACT

This report contains the results of a study conducted for the U.S. Environmental Protection Agency to minimize the loss to the environment of chemicals used in controlling snow and ice on highways. Based on the best current practices for highway maintenance as observed during two years of study, practical guidelines are presented for the use of deicing chemicals.

1. Supervisory aspects of proper chemical usage are defined, including organization and personnel training.

2. Efficient snow and ice control requires good judgment and appropriate action. Elements of proper decision-making are discussed, including weather forecasting, setting chemical application rates, and accounting for chemical usage.

3. The backbone of winter road maintenance is equipment. General requirements and major equipment classes are described, including recent improvements and advantages or disadvantages. Methods are given for accurate spreader calibrations.

4. Means are described for developing and enlisting the support of citizens and drivers for winter road maintenance policies.

5. Legal requirements for and constraints on snow and ice control are described.

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Transportation Research Board, Washington, D.C.
U.S. Army Cold Regions Research and Engineering Laboratories, Hanover, New Hampshire
Vermont Department of Highways

CONVERSION TO METRIC UNITS

In this Manual, all units are expressed in U.S. customary units. Conversion to metric units is easily accomplished by use of the following formulae:

Multiply miles by 1.6093 to get kilometers

Multiply tons by .9072 to get metric tons (10^3 kg)

Multiply cubic yards by .7646 to get cubic meters

Multiply pounds by .4536 to get kilograms

Multiply feet by .3048 to get meters

RECOMMENDATIONS AND SUMMARY

THE PROBLEM

State highway departments, turnpike authorities, municipal street departments, and other organizations (shopping centers, hospitals, schools) annually purchase approximately 9 million tons of salt and other deicing chemicals with a total value of about $140,000,000. As the amount of these materials has increased, so too has the concern for what these materials are doing to our environment.

Excessive use of material and loss of material before it can be used effectively provides several causes for concern. Chief among these, from the standpoint of the U.S. Environmental Protection Agency and its counterpart state agencies, is that environmental damage may result from water-borne salt. Much of the salt spread on roads eventually enters the various water courses either as direct run-off or by percolation into the groundwater system. There is evidence of road salt in private and public wells and surface reservoirs.

The U.S. Public Health Service recommends that drinking water not contain more than 250 mg/l of the chloride ion. Water of even low salinity has been known to cause corrosion problems in industrial plants. Although no federal standard for sodium in drinking water exists, one is currently being considered; however, the generally accepted warning level is 20 mg/l for patients restricted to low-sodium diets.

Cost is another concern. Salt and other deicing chemicals are expensive and, for reasons of economy, should be used effectively and sparingly. In addition to the direct costs, there are additional indirect costs that are borne partly by highway agencies in the form of corrosion damage to trucks and equipment and to bridge decks; for the most part, these delayed costs must be paid by other segments of the public in the form of rusted automobiles and degraded drinking water.

For these environmental and economic reasons, it is important that maintenance authorities use no more salt and other chemicals than are absolutely necessary to improve the driving conditions during winter storms. The problem is that excess amounts have been applied routinely. The causes include lack of awareness of the problem, lack of managerial controls over salt usage, lack of calibrated equipment, and lack of understanding and cooperation by the driving public.

Because of a concern for this excessive use of salt and other deicing chemicals, the EPA funded this program to investigate techniques for minimizing the loss to the environment of chemicals used in controlling snow and ice on highways. The charter of this two-year project was to study the best current practices for snow and ice control in highway maintenance and to develop practical guidelines for the use of deicing chemicals. The study immediately ran into two diverse points of view; from the environmentalist's point of view, no chemicals should be used

and, from the point of view of improved driving conditions, an amount equal to or slightly in excess of an as-yet-to-be-determined minimum amount of chemical should be used. A premise of this study is that salt will continue to be used as the principal deicing chemical and that a compromise must be effected between the concerns of the environmentalists and those of the driving public.

A major finding in this study was a discrepancy between the prescribed amounts of deicing material and the amounts that are actually used on the highway surface. Many maintenance managers were aware of this and readily admitted that they were using more material in their operation than was actually prescribed by their maintenance manuals. Those managers who, for economic or environmental reasons, initiated actions to reduce the amount used to the prescribed levels found to their surprise and satisfaction that there was no reduction in the level of service provided by the lesser amounts of deicing chemicals. This finding provides the basis for the recommendations of this manual.

RECOMMENDATIONS

The recommendations of this manual include techniques--both technical and managerial--for reducing the amount of chemical used and discussion of areas in which further research efforts would be beneficial.

Techniques for reducing the amount of chemical used include:

- The use of ground-speed controllers for all spreaders.
- Calibration of spreaders to determine how much material is being used. Two techniques are presented; a yard calibration and an in-service calibration. Rule-of-thumb techniques are also presented for checking calibration and determining when spreaders are not operating at their prescribed rates.
- Establishment of levels of service. Standards for maintaining roads during the winter should vary according to road types and their average daily winter traffic.
- Establishment of a set of application rates for each agency. Guidelines are presented for the amount of chemicals to be applied under varying weather conditions for various classes of roads. Two distinct rates are prescribed: one for the first application and lesser amounts for secondary applications as the storm progresses.
- Starting to plow snow early in each storm and emphasis on plowing rather than salting. Underbody scrapers are recommended for keeping snow-pack from forming.

- Accounting for the amount of salt used on each section of highway or city street. A daily report filled out by each operator--summarizing the amounts of chemical used, the lane miles upon which it is used, and the results obtained--is essential for accurate accounting for chemical usage.

Effective snow and ice control hinges upon the leadership and decision making of the maintenance manager. Therefore, a strong recommendation of this study is that his importance in the organization be recognized and that he be given the training and resources necessary to do his job effectively. This manual is addressed specifically to the needs of maintenance managers at all levels of the organization from road crew foremen right up to superintendents and commissioners.

The major areas where additional research effort must be placed include:

- Improvement in the reliability of ground-speed controllers for metering the amount of deicing chemicals spread onto the roadway.

- Development, through carefully controlled experiments, of a sound basis for prescribing the minimum amount of chemicals and/or abrasives to be applied to road surfaces for various weather and traffic conditions.

THE INTENT OF THIS MANUAL

This manual seeks to help maintenance managers establish an operating balance between two important, but sometimes conflicting, public-policy goals--clear roads and clean water. It supplements the discussion and recommendations in a companion Manual for Deicing Chemicals: Storage and Handling (EPA-670/2-74-033). That manual focused on the relatively easy task of minimizing wastage during shipment and storage. This one addresses the more difficult task of reducing excessive application of salt onto roads and highways.

Above all, this manual is designed to be practical. Its recommendations embody the best current practices, as observed during many weeks spent with highway crews in snow-belt cities and states. Its recommendations recognize that snow conditions, types of equipment, traffic volumes, budgets, and other factors vary widely. It avoids exotic solutions that would require special equipment and large costs. It tries to respect operating requirements, as well as concern for environmental protection.

Some of what this manual recommends is becoming common practice. The several application rates and levels of service found in this manual are based upon, or are direct borrowings of, plans and descriptions reported by highway personnel, the Salt Institute, and researchers in publications, including state maintenance manuals; papers presented to the Transportation Research Board, the North American Snow Conference, the American Public

Works Association, and other technical and professional associations; and corporate and institutional publications.

What, then, is the unique contribution of this manual? Probably, it is valuable in several ways:

- Range. The manual covers all aspects of deicing chemical usage, from laws and regulations to choice of equipment and techniques for educating the driving public.

- Balance. The manual concerns itself equally with technical and managerial issues.

- Perspective. The manual draws upon a range of literature, as well as first-hand observation of field operations.

- Alternatives. The manual presents a range of tools--equipment, techniques, recommendations, and references--so that its users can derive operationally and environmentally satisfactory solutions suited to their particular needs and constraints.

In short, this manual tries to provide a complete, practical, down-to-earth guide for all levels of maintenance managers charged with using deicing chemicals effectively and responsibly.

SUMMARY

In the remainder of this discussion, the major areas covered in the manual are briefly introduced.

PART ONE: LEGAL AND REGULATORY FRAMEWORK

Until recently, maintenance managers have not needed to pay much attention to laws. But now, due to concern about chemical damage to the environment (especially to public drinking water supplies), the legal framework is changing and becoming more restrictive.

Several states have recently taken, or are now considering, laws to curb excessive use of salt. Although federal legislation has not yet addressed deicing chemicals directly, recent or pending laws on water pollution control and safe drinking water reflect growing public concern about damage to water supplies, and thus a potential future problem for highway maintenance managers. Moreover, states are following the federal lead in environmental legislation, including provisions encouraging active participation by citizens in policy planning and execution.

PART TWO: ADMINISTRATION AND SUPERVISION

Job descriptions of maintenance managers should be amended to reflect the broadened scope of their responsibilities beyond the traditional role of maintenance engineers. In light of these changes, maintenance supervisory training should include the basics of groundwater hydrology, environmental aspects of designing and maintaining roads, management techniques for accounting for salt usage, and procedures for complying with federal and state environmental protection laws.

The organization of the maintenance function can significantly influence its operational success. Winter maintenance cannot be managed effectively without considering maintenance requirements during other seasons. In small jurisdictions, one workforce may perform all road functions, including maintenance. But in large cities and states, the organizational position and prominence of maintenance can vary; it may be integrated with the design and construction tasks of field districts or it may be separated, with its own chain of command directly to top management. Maintenance in any context deserves attention and support by top managers in matters of policy, relations with the public, and allocation of budget resources. Maintenance managers who perform well merit recognition and promotion.

PART THREE: OPERATIONS

Several critical elements in successful operation deserve particular attention:

- Weather warning with accuracy. This is the most important tool for decision making. The maintenance manager has access to all weather services — federal, independent (for a fee), local radio-T.V. stations, and neighboring highway departments in the storm's path.
- Planning of operation strategy through setting of appropriate levels of service for winter maintenance.
- Preparation for the winter season through detailed organization of the workforce and intensive crew training.
- Setting of chemical application rates in accordance with weather, traffic, and planned levels of service.
- Paying particular attention to environmentally critical areas through the use of minimum chemical techniques.
- Accounting for chemical usage by road section and analyzing the results obtained.

PART FOUR: EQUIPMENT REQUIREMENTS AND CALIBRATION

Guidelines are presented for the equipment required for snow and ice control operations based on the lane-miles to be serviced, number of interchanges, average spreader and plowing speeds, and levels of service. A variety of trucks, spreaders, blowers, loaders, graders, and plows are shown in photographs, with the text presenting their essential features, as well as advantages and latest innovations.

Ground-speed-controlled spreaders are the most important items of equipment for applying chemicals accurately. These devices allow dispensing only when the truck is in motion, and then only proportional to its speed, thus eliminating the wastage common today with independently controlled spreaders.

Calibration of spreaders is the most important action an agency can take to minimize excessive use of chemicals. Two techniques--yard calibration and in-service (over the road) calibration--are explained step by step, with calculations. Results for each truck are recorded on a card in the cab, for ready reference by the driver. Calibration measures should include not only the amount dispensed, but also the pattern and extent of the spread.

PART FIVE: PUBLIC PARTICIPATION

Three broad approaches exist for reducing excessive reliance on chemicals. The first, technical, is the most familiar and makes up most of this manual. The second, legal, has been emerging in recent years through the efforts of environmentalists and legislators. The third, education and persuasion of the driving public, is presently the least-used tool available to maintenance managers.

Managers can help influence driver behavior, and thus reduce their demands for excessive use of chemicals in several ways: by knowing the facts about chemical usage and environmental damages, by developing citizen awareness of environmental consequences, by showing their own concern, and by enlisting citizen support for sensible maintenance policies and budgets. The techniques described include speeches, press releases, pamphlets, telephone procedures, roadside signs, surveys, hearings, and citizen advisory groups.

These techniques should promote several messages. Citizens starting to drive should ask, "Is this trip really necessary?" Maintenance departments should offer and provide only service that is reasonable; the slogan "June travel in January" raises unreasonable expectations and incurs unreasonable costs. Bare roads are, by themselves, not necessarily safe roads, and maintenance departments are not solely responsible for highway safety. Citizen drivers are obliged to observe laws and regulations devised for the common good, such as laws that limit speed, designate snow routes, and establish levels of service.

PART ONE: LEGAL AND REGULATORY FRAMEWORK

CHAPTER I

LEGAL AND REGULATORY FRAMEWORK

In the past, maintenance managers have probably not had to pay much attention to questions of law and regulations, except to know that municipal ordinances may require citizens to clear sidewalks on their property. However, the legal and regulatory framework relating to snow and ice control is important. Furthermore, it is in the process of changing and developing. These changes will influence the way in which maintenance managers and their organizations work. Good managers must, therefore, be sensitive to them.

The assumption underlying this manual is that deicing chemicals and their use are only one part of a total system. This system may be described as "moving people and goods during bad winter weather." It includes many components, such as roads, cars, winter driving equipment on cars, weather and weather forecasting, snow-fighting organizations, and travelers and their drivers. Experience with this and other environmental problems shows that success depends upon attacking all components of a problem, not just a few. The system has, in addition to technical components treated elsewhere in this manual, important nontechnical components, including the legal-regulatory framework and the behavior of citizen travelers and drivers.

In this chapter, four aspects of the legal-regulatory framework are discussed.

- Common local snow removal ordinances,
- New state laws,
- Related federal laws, and
- Emerging environmental laws and regulations.

COMMON LOCAL SNOW REMOVAL ORDINANCES

Towns, villages, cities, and other municipal jurisdictions receive their writ of authority from one of the 50 states; their enabling legislation authorizes local jurisdictions to enact such ordinances, by-laws and regulations, "not repugnant to law, as they may judge most conducive to their welfare, which shall be binding upon all inhabitants thereof and all persons within their limits." (Massachusetts General Laws Chapter 40, section 21, given as a sample.)

By-laws and ordinances normally related to a variety of functions such as regulating sewers, preserving peace and good order, and protecting

public drinking water supplies. In Massachusetts, towns may pass by-laws for preventing the fall of snow and ice from roofs, for providing for the removal of snow and ice from sidewalks, for requiring owners of buildings near public ways to take measures to prevent snow and ice from falling upon passing persons, and for authorizing the superintendent of streets to remove vehicles hindering the plowing of snow.

As awareness of the environmental side effects of chemicals increases, more local governments will probably enact by-laws or regulations to control their use. They may act independently or within the framework of new laws passed by their states. Ann Arbor, Michigan, acted in 1970, after a series of city-sponsored studies and public meetings, by passing an eight-point policy, which it published in a brochure to all citizen drivers; the complete brochure is reproduced in Chapter VII of this manual.

Maintenance managers should know the relevant laws or by-laws in their state or local jurisdictions. In addition to the by-laws cited above, some states and localities are now enacting environmental protection laws and by-laws that may affect the work of maintenance organizations. Maintenance managers should know their own obligations under these laws, the duties of citizens, and how to invoke the police powers of government to assist their work.

NEW STATE LAWS

Several states have recently taken, or are now considering, laws to protect their environment against contamination by deicing chemicals, New Hampshire anticipated the problem in 1959 and 1965, when its legislature authorized the state highway department to replace roadside wells contaminated by road salt. Two states acted in 1971. Minnesota's legislature enacted a statute which reads in part:

> "(160.215) HIGHWAYS: SNOW REMOVAL: USE OF SALT OR CHEMICALS RESTRICTED. In order to:
>
> (1) Minimize the harmful or corrosive effects of salt or other chemicals upon vehicles, roadways, and vegetation;
>
> (2) Reduce the pollution of waters; and
>
> (3) Reduce the driving hazards resulting from chemicals on windshields; road authorities, including road authorities of cities, villages, and boroughs, responsible for the maintenance of highways or streets during periods when snow and ice are prevalent, shall utilize such salt or other chemicals only at such places as upon hills, at intersections, or upon high speed or arterial roadways where vehicle traction is particularly critical, and only if, in the opinion of the road authorities, removal of snow and ice or reduction of hazardous conditions by blading, plowing, sanding,

including chemicals needed for the free flow of sand, or natural elements cannot be accomplished within a reasonable time."

In Vermont, environmentally-minded legislators proposed legislation to change the state's standard of service from a "bare road" policy to a "safe road" policy. Out of discussion and debate with the Vermont Department of Highways, the following compromise resulted:

"NO. R33. JOINT RESOLUTION RELATING TO THE BARE OR SAFE ROAD POLICY OF THE VERMONT DEPARTMENT OF HIGHWAYS.

Whereas, the state of Vermont has attained and enjoyed over the years the enviable reputation for outstanding maintenance of its state highway system; and

Whereas, this high quality of highway maintenance enhances and promotes the safety of the traveling public as well as the swift and efficient movement of goods into, within and from the state of Vermont; and

Whereas, the state's economy and the continuing well-being of its citizens are dependent, in part, upon the immediate availability and use of the highway network; and

Whereas, the immediate availability and use of the state highway system dictates a bare or safe road surface as soon as possible after inclement weather; and

Whereas, the controlled use of chemicals has been proven from 30 years experience to be an effective method available to attain a bare or safe road surface; and

Whereas, there has been evidence presented indicating that the excessive use of chemicals may be harmful to the environment; now therefore be it

Resolved by the Senate and House of Representatives: That the department of highways is commended for their program of research for less potentially harmful methods of obtaining bare or safe roads, and be it further

Resolved: That the department of highways be exhorted and encouraged to work with the Agency of Environmental Conservation in a continuing effort to discover methods of obtaining bare or safe roads which will be economically feasible and least harmful to the environment, and be it further

Resolved: That the Agency of Environmental Conservation shall work closely with the highway department in accomplishing the foregoing purposes, and be it further

Resolved: That the department of highways should continue to maintain a bare or safe road policy with appropriate adjustments determined advisable as a result of conducted research.

Approved: March 29, 1971."

Two years later, Massachusetts enacted a stronger law, emphasizing storage but also providing authority to regulate application in special areas such as reservoir watersheds. Chapter 1208, Massachusetts Laws of 1973, amended Chapter 85 of the General Laws to include a new section:

"Section 7A. No person shall store sodium chloride, calcium chloride or chemically treated abrasives or other chemicals used for the removal of snow or ice on roads in such a manner or place as to subject a water supply or ground-water supply to the risk of contamination. The department of public health, hereinafter called the department, in consultation with the department of public works, may issue regulations as to place or manner of storage of such chemicals and may, by specific order, in a particular case regulate the place where such chemicals may be used for such purpose. Any violation of this section or any regulation or order issued hereunder shall be punished by a fine not to exceed fifty dollars per day. Any person who uses more than one ton of such chemicals in any calendar year shall report annually to the department on November first, and at such other times as prescribed, the amount of such chemicals used in the previous twelve months specified by road section or other location and the amount of chemicals on hand. Copies of such reports shall be made available upon the request of any concerned state or municipal agency or commission. The department may require studies by competent professional personnel of the probable impact of proposed new or improved highways and the maintenance thereof by use of such chemicals upon reservoirs, ponds, streams, lakes, wetlands and the groundwater aquifers associated with both public and private water sources. Estimates of such chemicals to be applied on proposed roads and other paved areas shall be based upon the most recent records of chemicals actually applied as reported under the provisions of this section. The word "person" as used in this section shall include surveyors of highways, road commissioners, superintendents of streets in towns, commissioners of public works in cities and towns, the chief engineer of the state department of public works, the chief engineer of the Massachusetts Turnpike Authority, the chief administrative officer of state agencies and private persons, including corporations."

"Section 2. The commissioner of the department of public health shall issue guidelines for the reporting of the amount of chemicals used in snow and ice removal, as required by section seven A of chapter eighty-five of the General Laws, inserted

by section one of this act, prior to the effective date of this act."

The reasons which moved Massachusetts to pass this law are described in a recent book.[2]

In mid-1973, a legislative survey by Arthur D. Little[2] of 33 American snow-belt states found that most of them have no statutes or pending bills concerning deicing chemicals. Bills had recently been introduced but had failed to pass in Connecticut and Nevada. In Wisconsin, however, events were following the pattern of Massachusetts, as concern about environmental injury led to legislative hearings, reports, and the drafting of bills. Two strong measures were proposed in Wisconsin's General Assembly in January, 1974. The first, Assembly Bill 1401A, would establish strong controls for use of chemicals:

- Chemicals would have to be stored so as to prevent contamination of land and water.
- Chemicals would have to be used only where vehicle traction is critical, and then only when alternative methods are not adequate.
- Salt spreaders would have to be certified as being in good working order and properly calibrated.
- Snow and ice would not be dumped where the melt would flow into surface waters.
- Local governments would have to file annual reports of chemical use.
- Wisconsin's Highway Commission would have to prepare annually an environmental impact statement about chemical usage anticipated during the next year.
- The Department of Transportation would have to conduct research into alternative methods of snow and ice control.

The second, Assembly Bill 1402A, would require comprehensive study of the environmental effects of deicing chemicals in order to establish a baseline for continued monitoring.

Just as at the local level, maintenance managers at the state level must be aware of environmental protection laws which may affect their operations. In Vermont, for example, the state's water quality authorities require the Department of Highways to request and receive an annual permit before applying deicing chemicals which may degrade drinking water supplies. Similarly in other states, strong laws exist which public health authorities can invoke to protect drinking water supplies. Moreover, additional laws have recently been passed in some states, for

example, to protect coastal and inland wetlands and other natural resources, which may be significant for maintenance operations.

RELATED FEDERAL LAW

Traditionally, the building and maintenance of roads and highways have been activities reserved to state and local governments. So, too, have the regulation of water supplies. However, recent activities in the Congress and by the Environmental Protection Agency foretell a more vigorous Federal role in years to come.

During the 1960's, the obviously declining quality of the nation's waters contributed greatly to the general concern for environmental degradation which became a major political issue in 1970. In 1965, Congress passed the Water Quality Act, which followed the traditional pattern of providing Federal encouragement and funds while leaving the basic initiative to state and local governments. However, they did not act with the desired vigor, and Congress therefore passed in 1972 the far-reaching Federal Water Pollution Control Act Amendments, which shifted leadership to the Federal government, set stringent goals for water quality by the mid-1980's, and authorized vigorous enforcement.

Three aspects of the 1972 law should concern maintenance managers. First, even though the Act does not apply explicitly to drinking water supplies, it does signal a growing and intense national awareness of the limits and fragility of our water resources. The Act applies to surface waters as they are used for fishing, swimming, and other recreation. Historically, surface waters and ground waters have been treated separately, both professionally and legally, even though they are not separated physically; however, it will only be a matter of time before the public recognizes generally the natural linkages between surface and ground waters and the role of deicing chemicals as a pollutant. Second, the Act requires participation by the public.

> Public Law 92-500, Section 101 (e) provides:
>
> "Public participation in the development, revision, and enforcement of any regulation, standard, effluent limitation, plan, or program established by the Administrator or any State under the Act shall be provided for, encouraged, and assisted by the Administrator and the States. The Administrator, in cooperation with the States, shall develop and publish regulations specifying minimum guidelines for public participation in such processes."

Third, the U.S. Environmental Protection Agency and the states are directed to actively seek, encourage, and assist the public in participating in this process of setting water quality requirements and monitoring them. To that end, Congress charged:

> "Information and Education Programs should be devised which will acquaint the public with the complexity of the water

quality control process and provide them with the technical information. To accomplish this, the Environmental Protection Agency should look to the utilization and support of such devices as community workshops and other assistance activities which were developed and utilized so effectively in the implementation of the Clean Air Act." (Legislative history, Public Law 92-500, U.S. Code and Administrative News, 1972, page 3679. The steps chosen by EPA to implement this charge are presented in The Federal Register, Vol. 38, No. 163, August 23, 1973, pp. 22757-8.)

Consistent with the Act, a nationwide series of workshops addressed the more obvious kinds of contamination, such as raw sewage from towns or cities, chemical wastes from factories, and agricultural pesticides drained off from farmlands. They did not yet specifically include deicing chemicals as pollutants, but this will also be only a matter of time.

The systematic public participation required by this Act, as well as regulations governing review of environmental impact statements for highways and other projects, has not yet intruded into the world of maintenance managers. However, as environmental consciousness rises, as knowledge of water quality grows, as the public participation process becomes familiar, and as the potential dangers of deicing chemicals become widely known, maintenance managers can expect demands for public participation to rise, and perhaps even be required by law or regulation. Thus, maintenance managers would do well to follow the techniques that federal and state environmental protection officials develop for implementing public participation in water quality programs. Part Five, Chapter VII of this manual discusses many techniques for encouraging citizen education and cooperation.

In the context of national concern about water quality in general, it is not surprising that Congress is now considering the first federal law on drinking water during this century, the proposed "Safe Drinking Water Act." One bill has already been passed by the Senate; another and reportedly stronger version is being considered, in mid-1974, by the House Commerce Committee. It is not useful here to speculate in detail about the likely contents of the final Act. However, it seems probable that such a law will strengthen federal authority to establish minimum standards of quality for drinking water, standards which could significantly increase the concern of public health authorities about the use of deicing chemicals.

Federal guidelines for state public health authorities already exist in the Drinking Water Standards issued in 1962 by the U.S. Public Health Service. Its recommended maximum level of chloride of 250 mg/l led Massachusetts public health authorities recently to close three public wells and to voice their concern about rising chloride levels in several more. The Standards do not, however, present recommendations concerning sodium, the chemical element which concerns physicians treating patients

for high blood pressure (hypertension) and other diseases of the heart and blood vessels. One reason is that awareness by the medical community of possible harmful effects of sodium was not wide-spread in the early 1960's; but awareness has increased significantly in recent years. Revisions of the Standards are now being considered; the criteria proposed in October 1973 by a public advisory group retain the limit of 250 mg/l of chloride but suggest no level for sodium; however, the final document is reported likely to include, for the first time, a thorough discussion of sodium and its importance. Here again, it is not useful to try to predict the revised standards, and how they might affect maintenance managers. Our purpose, instead, is to draw attention to their significance for maintenance managers.

EMERGING ENVIRONMENTAL LAWS AND REGULATIONS

As the preceding sections suggest, the rate of change in recent years in the field of environmental law and regulation has been rapid. This pace may continue for some time. Therefore, this manual cannot pretend to keep maintenance managers up-to-date on the legal-regulatory framework in all states and local jurisdictions. It can, however, urge maintenance managers to remain aware of these developments which may affect their work.

Some states are currently following the lead of the federal government in passing their own legislation which supplements, and in some cases goes beyond, federal statutes. Maintenance managers should remind general counsels or legislative representatives of highway maintenance organizations (states, local governments, and special districts such as turnpike authorities and park commissions) to review new statutes and regulations and advise how these may affect maintenance operations. For example, some states have adopted environmental policy acts, modeled on the National Environmental Policy Act of 1969, which include provisions written in broad language. Some states have also passed citizen right-of-action statutes which confer upon individual or small groups of citizens legal standing to sue governments for improper performance of duties; previously, the right to allege wrong-doing and to bring suit was limited to persons or organizations which had sustained injuries for which they sought relief and payment of damages. States have also strengthened and broadened the citizen's right to know about governmental operations, including the right of easy access to information contained in public documents. Massachusetts, and perhaps other states, recently amended its constitution to include a broad environmental bill of rights, guaranteeing to citizens the right to enjoy such natural resources as clean air and water. Massachusetts also initiated the "ten-citizen procedure," by which ten or more citizens can petition a government agency to conduct a public hearing, for example, related to implementing a law or setting standards, or petition a court to intervene against a government agency whose actions threatened injury to the environment.

Statutes are not the only source of legal authority. Administering agencies normally issue regulations needed to translate a statute into

effect. The courts are regularly asked to decide cases, which become precedents used in the interpretation of statutes and regulations. One example occurred in Massachusetts in early 1974, when the Commonwealth's Supreme Judicial Court backed the legislature's recent environmental legislation. The case (S-7844, February 27, 1974) arose from a dispute between the City of Boston and the Massachusetts Port Authority (Mass Port). The Authority is a public corporation, created by the state legislature to provide a variety of public services, such as operating the city's airport, following principles of business rather than governmental management; such authorities or special districts, numerous and often economically powerful, exist in many states and cities to operate turnpikes, tunnels, bridges, parks, and airports, many of which have roads requiring wintertime maintenance. One question at issue in this case was whether Mass Port was required, in view of its special status, to comply with certain provisions of recent environmental legislation. The Court ruled unanimously that all authorities must so comply. The lengthy opinion has, as the justices recognized, far-reaching implications, both for other authorities and for future interpretation of certain statutory requirements, such as assessing the environment impact of proposed new construction. The Chief Justice wrote that the result of Mass Port's interpretation would be that "a small group of state authorities would have a unique exemption from the regulatory power of the state, an exemption available to no person or legal entity, public or private." In short, authorities are subject to state laws on environmental matters. Although this decision applies only within Massachusetts, the legal argument supporting it could well be followed by courts in other jurisdictions.

PART TWO: ADMINISTRATION AND SUPERVISION

CHAPTER II

SUPERVISION REQUIREMENTS

The use of deicing chemicals has many technical aspects, and much of this manual focuses on technical questions. However, the problem of proper use of deicing chemicals is not just technical; it is also influenced by such factors as leadership, management or the lack of management, public attitude, and behavior of equipment operators. The many suggestions set forth in this manual depend for their effectiveness, of course, upon the cooperation and outlook of many highway maintenance employees. They take their cues, in both technical and policy matters, from their supervisors who, even to the top level, must clearly endorse and support a policy of using a minimum amount of environmentally harmful chemical materials to improve winter driving conditions. These cues should be explicit and unequivocal. This section points out those aspects of proper chemical use in which supervision is crucial.

Although a number of specific comments and recommendations are made in this manual, one general point should precede all discussions. Leadership in general, and supervision of chemical usage, which is merely one aspect of highway maintenance, is by its nature not a separate commodity or function. It cannot be bought in packages and it cannot be contracted to others. It is not the task of one man only; nor is it a full time task performed by a staff specialist. Instead, responsibility for proper usage of deicing chemicals is only one of the many assignments of maintenance supervisors. Ideally, they should be knowledgeable about a number of specific topics described in this manual. Although those maintenance managers and supervisors who have been trained professionally as engineers may feel more comfortable reading the sections focused on technical questions, their roles as supervisors or managers require them to pay attention to the non-technical aspects of maintenance, especially if they wish to perform their jobs successfully. They should, therefore, probably pay special attention to those parts of this manual with which they feel least familiar.

THE MAINTENANCE MANAGER

Our choice of terms needs a word of explanation. "Maintenance manager" is used throughout this manual to designate the key public works officials exercising decision-making power in the chain of command responsible for controlling snow and ice on winter roads. In a town or small city, the superintendent of roads or public works (who may also be the town manager or administrator) usually functions also as the maintenance manager in direct control of storm operations. The larger the jurisdiction, the more likely is the delegation of this function to a separate and subordinate official who specializes in maintenance, as distinct from engineering, road construction, research and planning, and other functions common to large highway or street departments.

In many or perhaps most cases, maintenance chiefs are professionally trained and experienced as engineers; indeed, in some jurisdictions, they carry the title of "maintenance engineer." But we prefer the term "manager" because it emphasizes that maintenance supervisors must have not just the technical skills associated with the term "engineer" but also several coordinating and judging skills:

- For mobilizing men as well as machines
- For directing complex operations
- For managing budgets
- For representing the maintenance function to various sectors of public, as well as to other functions within the highway or public works department.

Moreover, the title "manager", even when held by an engineer, reflects the change and broadening that normally occurs later in an official's career, as he grows beyond his early technical training and assumes a wider range of responsibilities. Finally, the term recognizes that the use of snow-fighting techniques so as to minimize harm to the environment requires judgments that are not solely engineering in character; they are managerial because they require compromises or trade-offs among competing criteria or goals (such as service to motorists, financial efficiency, environmental protection, and adherence to policy and regulations). Because of such considerations, Connecticut's Bureau of Roads recently adopted the concept and title, for example, "District Maintenance Manager", as part of a general reorganization, noted below.

Sometimes we use "maintenance manager" to refer specifically to <u>the</u> chief maintenance supervisor; at other times, we broaden it to include <u>all</u> supervisors, from commissioners or superintendents to foremen of road crews, whose jobs require some independent exercise of judgment. Whether superior or subordinate in the chain of command, these supervisors influence the total effect of a department's snow and ice control effort, and, therefore, share in the managerial responsibility for success or failure. Which use of the term we intend in each instance will be clear from its context.

This manual is written in phrases familiar to highway maintenance personnel of state or city departments. But it is addressed to maintenance managers responsible for roadways of private organizations as well, including hospitals, universities, schools, cemetaries, and commercial establishments such as shopping plazas, truck depots, and company or factory parking lots. In time, all may find themselves regulated to greater or lesser degree by state or local laws seeking to prevent further chemical contamination of the environment, especially public drinking-water supplies.

The maintenance manager is caught these days in a tough dilemma. First of all, he has the responsibility to maintain the roads in his jurisdiction

in good repair and in driveable conditions. He is caught between the expectations of the driving public who increasingly wants, and often demands, June-in-January roads, and the environmentalists who are concerned with the rapid deterioration of some water supplies through the excessive use of deicing chemicals. Often, the maintenance manager, as an individual and inhabitant of planet earth, shares both of these feelings. As a maintenance manager, however, he is also beholden to his immediate superiors to perform his job within his allotted budget, which is often interpreted in terms of minimum manpower, equipment, energy, and, of course, expensive chemicals such as salt and calcium chloride.

In order to adjust and clarify the duties of managers for responsible use of deicing chemicals, their formal job descriptions should be revised to include the following points:

1. Develop policies and procedures for applying chemicals, to meet environmental as well as engineering requirements, drawing upon expert assistance as necessary from headquarters and research staffs.

2. Develop or assemble environmental baseline data required for planning and possible environmental impact statements. Essential baseline data would include groundwater information and annual reports of its sodium and chloride levels (expressed in "milligrams per liter", which is the same as "parts per million"), which should be obtainable from public health authorities. Without such baseline data as a background, effects of various management practices, for good or for bad, cannot be measured objectively.

3. Be responsible for, or assist in, cooperative relationships with other governmental agencies concerned, for example, about environmental or public health aspects of usage.

4. Ensure proper adherence to policies and procedures, checking, for example, the periodic calibration of spreaders and recording of operating data.

5. Supervise periodic instruction of maintenance workers in environmentally safe handling of salt and other deicing chemicals during loading, application, and cleaning up after storms.

6. Perform frequent on-the-spot inspections during winter operations to observe actual usage practices and take steps to improve sub-standard practices.

7. Design and ensure proper use of the department's system for reporting usage of deicing chemicals, for purposes both of efficient management and of preventing use of salt in excess of established standards.

8. Review periodic chemical usage reports, interpret them as necessary to higher authority, other government agencies, and the general public; when indicated by abnormal reports, take corrective actions to improve usage and handling practices.

9. Consult with design and construction engineers when building or improving roads to ensure consideration of features (e.g., drainage ditches) needed generally to facilitate and specifically to minimize entry of deicing chemicals into the environment.

Supervising maintenance managers are presumed to be mid-career officials, with time to participate in only occasional in-service training courses. Such courses, perhaps a few days in length, should include at least three kinds of teaching techniques: formal instruction, problem-solving exercises, and field observation.

Formal instruction should include consideration of two basic areas: (1) special engineering topics and (2) environmental protection requirements and procedures. Special engineering topics should include groundwater hydrology; environmental aspects of planning, design, construction and maintenance of roads; and winter operations where salt and other chemicals are used. Environmental quality topics would vary from state to state, but generally include discussions of federal and state environmental laws, implementing requirements prescribed by the Federal Highway Administration and the state highway agency, and finally specific procedures for complying with those requirements, for example holding public hearings, developing possible environmental impact statements, developing programs for minimizing chemical usage, and meeting regular reporting requirements.

Formal instruction should always be accompanied by a variety of problem-solving exercises which are tailored to the topics and manner of presentation. For example, trainees might be asked to select and evaluate groundwater hydrological data, to identify and rank techniques for minimizing chemical usage, to draft portions of an environmental impact statement required by a state, or to develop operations procedures which will minimize the use of chemicals.

Formal instruction and problem-solving exercises should be complemented by opportunities for observation in the field. Trainees might visit and inspect DPWs noted for good usage practices; observe or even assist in the instruction of maintenance workers prior to the winter season, observe a department's work on an environmental impact statement, or observe a public or interdepartmental hearing on proposed chemical usage policies.

Although the formal aspects of supervising a maintenance team are important, the practical behavioral problems should not be overlooked. The many requirements and suggestions presented in the manual may suggest that the critical actors, namely the operators and drivers on the road, are ideal

employees--well-motivated, well-paid, taking pride in their work, technically skilled, and concerned only with minimizing environmental effects of chemical use. In reality, these ideal men exist rarely. Moreover, managers in public service have only limited use of those major tools of reward and punishment--pay raises, promotions, and dismissal. However, they can still find ways of motivating their subordinates. In general, they must protect them from pressures and interference from outsiders, fight within the DPW for needed budget and equipment, and represent them vigorously in personnel questions. Managers should improve working conditions in the little ways which count, for example by providing radios in truck cabs, hot coffee and food at depots during nighttime storm operations, and inexpensive help (for example high school boys seeking work) for routine jobs such as breaking up caked salt and sweeping up trucks and pads after loading. Specific employees can be rewarded by assigning them to preferred routes, the newest equipment, and more desirable jobs. Managers should tour their areas regularly during storms, both to inspect operations and to provide that personal, on-the-spot leadership required by any team working under pressure. By techniques such as these, managers can help to overcome deficiencies in equipment and budget while influencing the behavior of their subordinates.

ORGANIZATIONAL CONTEXT

To plunge right into the heart of our problem and all of its technical aspects is tempting. But first, it is both useful and necessary to review its context; indeed, the problem has arisen largely because we have concentrated on technical improvements in maintenance while paying little or no attention to its effects on its environmental context. Other aspects of context are equally important. Vermont's Commissioner of Highways, John T. Gray, argues that the management of winter maintenance cannot be examined intelligently without considering maintenance management during other seasons. For example, unlike managers of private businesses, managers of government agencies are subject to civil service regulations which, in effect, restrict their flexibility in hiring and laying off workers as seasonal needs change. Moreover, efficiency requires that equipment be purchased, wherever possible, for multiple uses and during all seasons.

Equally important for the function of maintenance is its organizational context. Maintenance, whether performed by an all-around crew in small towns or by a special division within a state's DPW, both influences and is influenced by other parts of its parent organization, such as personnel, purchasing, construction, planning, and financial management. Moreover, beyond its own department, it influences and is influenced by other agencies of government, including the town manager or mayor or governor, the town meeting or city council or state legislature, the budget or fiscal office, and lately the public health or natural resources authorities. A significant part of any manager's job is to understand the relationships between his division and other organizational units and to manage them effectively.

Figure 1 represents how the maintenance function fits within the government of a town or a small city. Wintertime maintenance is performed by a small organization, which also handles all other road building tasks. For large cities, of course, the organizational structure resembles that of states, where size dictates separate field districts and specialization of functions.

Figure 2 shows schematically two kinds of organization at the state level. The difference is in how functions are organized in the field districts. First, the left-hand side of Figure 2 shows the integrated field district, in which maintenance is only one of several functions, all supervised by the District Engineer, who reports directly to the Chief Engineer; in this structure, policies and technical assistance from state headquarters reach the District Maintenance Engineer only through his District Engineer, who may or may not be sympathetic to the problems and requirements of wintertime maintenance. Second and by contrast, the right-hand side of Figure 2 shows a state organization where maintenance is organized separately. This structure was adopted recently by Connecticut's Bureau of Highways. Previously, Maintenance was grouped with and often subordinate to Design and Construction, despite the fact that it now requires the largest proportion of personnel and a substantial budget. The preeminence of Design and Construction probably reflected the expansion of highway building during the 1960's, especially construction of the interstate system, which therefore naturally offered more opportunities for promotion. By contrast, the maintenance function suffered in various ways, especially in haphazard personnel promotion practices. With the reorganization in 1972, Connecticut first restricted transfers among divisions to lower level jobs only and second, promoted maintenance managers only from within the newly separated Maintenance Division. No form of organization is free of problems of coordination. Often, organizational charts and their formal chains-of-command are merely ideal and rational pictures; in practice, leadership and effective communication ebbs and flows in response to physical proximity, personal compatibility, and other influences. However, the separate structure shown in Figure 2 moves the maintenance function closer to the top manager of the highway department; it thereby offers better chances of success in competition for budget and personnel; and it presumably also offers better career opportunities, always an important attraction for men of talent.

The symbolism of this separated form of organization should not be overlooked. It emphasizes that long-term maintenance can be as important as initial layout and construction of roads, even though it is a routine housekeeping function. Moreover, it suggests that maintenance policies are a concern of top management, and that their understanding and support is important for success. Finally, it places the maintenance manager somewhat closer to his ultimate customers, the various groups within the driving public.

Figure 3 presents the organizational context in a different way. It centers on the maintenance manager, whether in a small or large jurisdiction. It retains the hierarchy or chain of command above and below him. But it

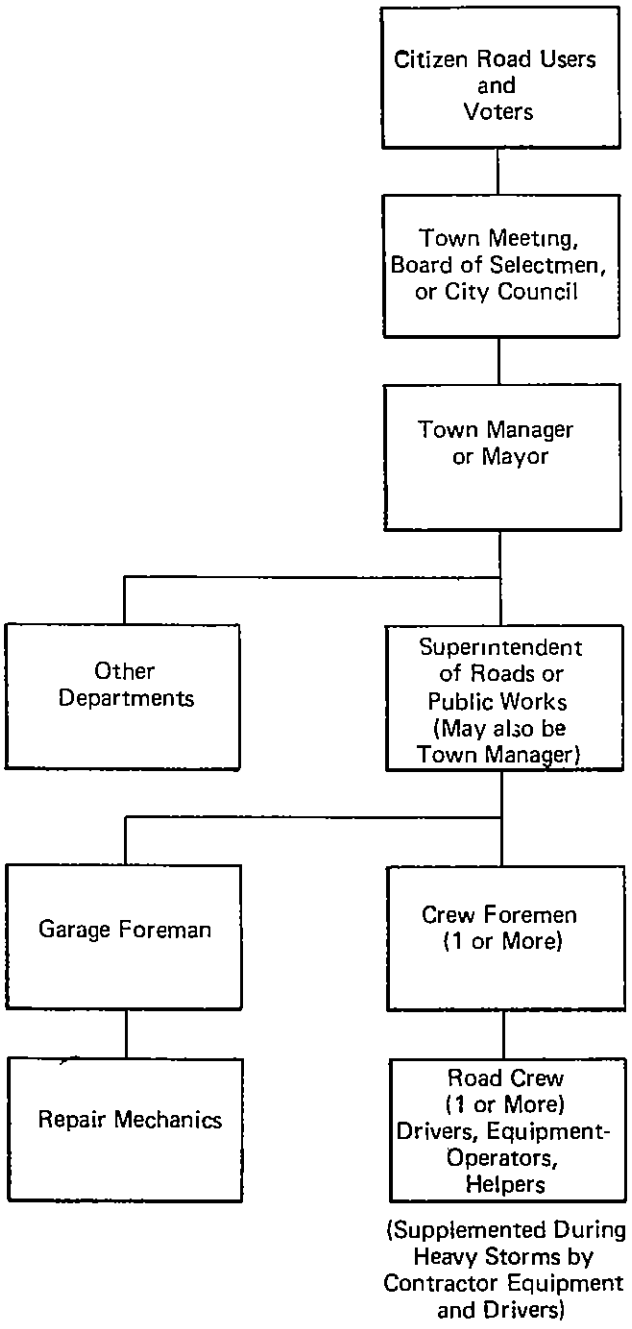
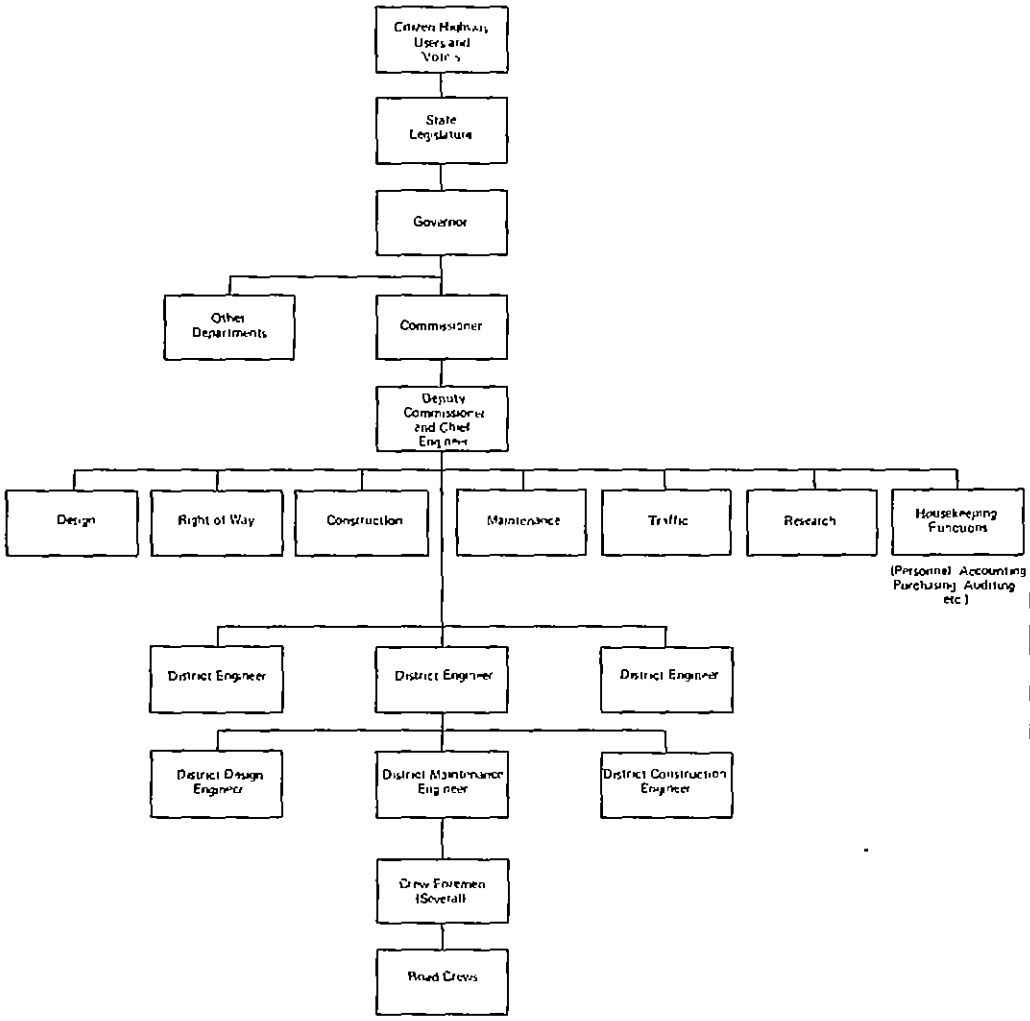
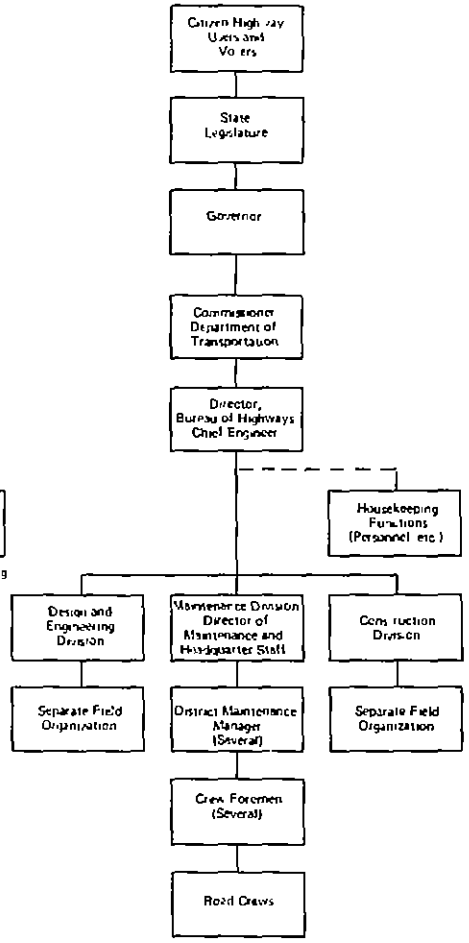


FIGURE 1 ORGANIZATION OF TOWN OR CITY MAINTENANCE FUNCTION
(Winter Maintenance only One of Many Functions Performed by a Small Staff)



INTEGRATED FIELD DISTRICTS, INCLUDING MAINTENANCE FUNCTION, IN A STATE HIGHWAY DEPARTMENT



SEPARATE FIELD MAINTENANCE DISTRICTS WITHIN A STATE HIGHWAY DEPARTMENT

FIGURE 2 ORGANIZATIONS OF STATE HIGHWAY DEPARTMENTS

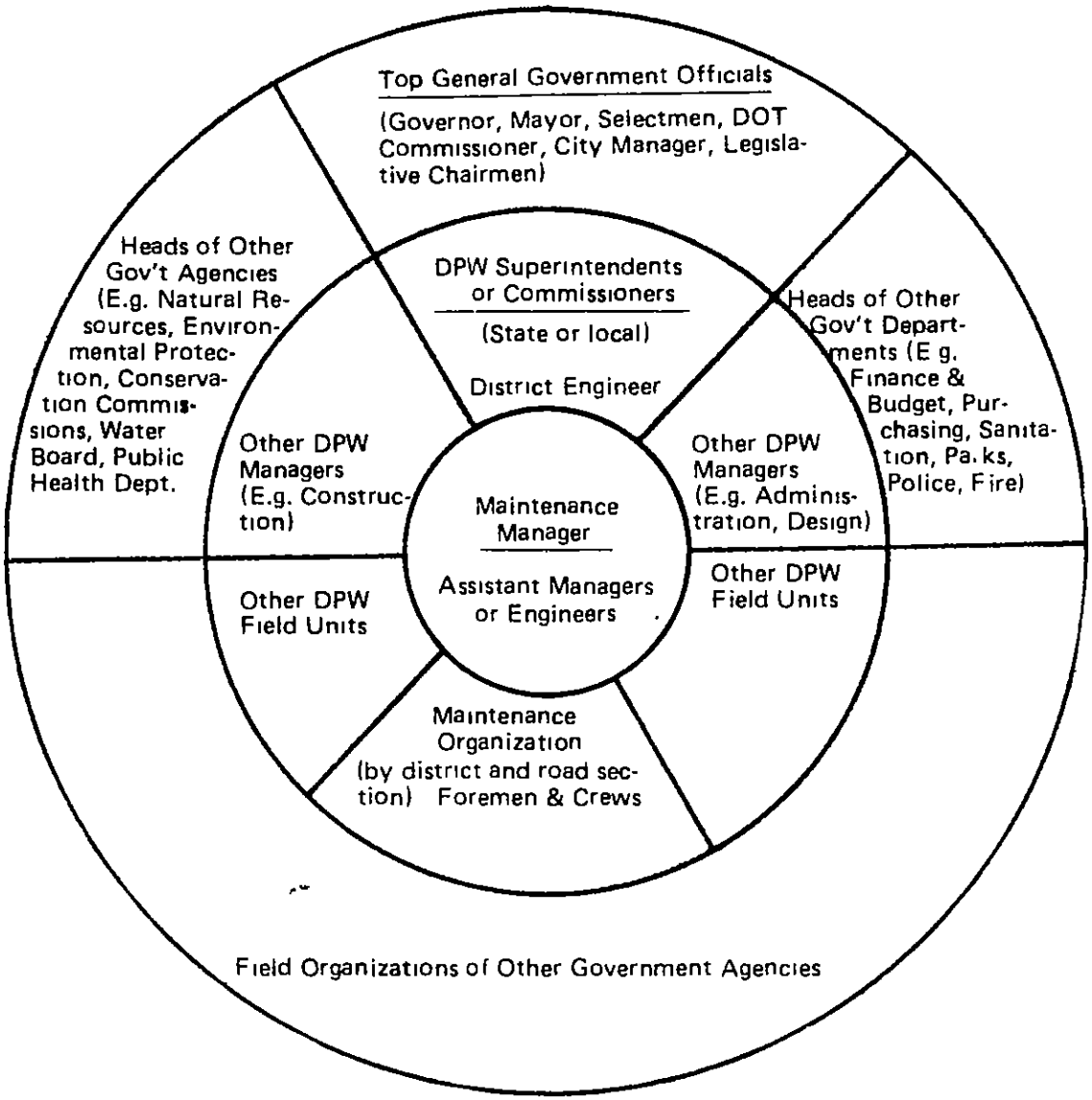


FIGURE 3 ORGANIZATIONAL CONTEXT AS VIEWED BY THE MAINTENANCE MANAGER

also suggests how relationships radiate out from him to other organizational units, both within the DPW and in other government agencies. Later in Part Five, Chapter VII, we shall add more concentric circles to suggest the maintenance manager's relationships with other important groups outside of government.

Although this manual seeks to report best current practices observed in a variety of highway and public works departments, its generalized format is not intended to obscure the realities of differences among various jurisdictions--state, county, city, town, and private institutions. Although geographical size and organizational structure vary, the principles of responsible chemical usage remain basically the same.

Large cities, for example, resemble states in needing a departmental organization with distinct and specialized units, and a chain of command. Although a city's area may have somewhat less variation in weather than a state, differing conditions within short distances remain a problem. A city's more compact area can allow close and more frequent personal inspections by managers, and thus somewhat tighter supervision of chemical usage during winter storms. However, truck drivers must still be left some discretion in applying chemicals according to local conditions.

Small cities and towns offer the best conditions for personal observation and control by the maintenance manager, who may also be the DPW superintendent and even town manager. However, such managers may be subject to more personal and direct pressures, from influential merchants, as well as from environmental advocates and from DPW road workers. Moreover, they may lack the specialized equipment and training available to large city or state departments. But their more intimate knowledge of a smaller area may permit them to strike a better balance among such competing goals as high-quality service, low-cost operations, and environmental protection.

Despite the variations imposed by these differences among jurisdictions, it is important that service on roads passing through more than one jurisdiction be consistent. This is to avoid sharp changes in road conditions, which may surprise motorists and help cause accidents.

PART THREE: OPERATIONS

CHAPTER III

TOOLS FOR DECISION-MAKING

Maintenance managers responsible for snow and ice control are faced with a number of decisions when storms become imminent. In most instances, these decisions must be made in the face of conditions that re continually changing and under pressure from local interest groups. To assist in making these decisions, these maintenance managers must have the best possible, up-to-date information about the storm and traffic conditions. The starting point for all such decisions is the weather forecast.

WEATHER WARNING

The most important asset of maintenance managers is a dependable source of knowledge about the timing, magnitude, and duration of each storm so that men, equipment, and material can be deployed and used in the most efficient way. Each organization must establish to its own satisfaction, a procedure or combination of techniques for finding out what the weather will do in their jurisdiction. Sources of information for alerting snow and ice control operations are numerous:

- National Weather Service of the National Oceanic and Atmospheric Administration (NOAA);
- Independent Weather Forecasting Services, such as Northeast Weather Service in Bedford, Mass., and Murray and Trettle in Chicago, Ill.;
- Local Television and Radio Station Meteorologists;
- Independent Meteorologists; and
- Neighboring snow and ice control groups located along the storm's path.

All weather services have access to the same meteorologic data. It is the interpretation of these data, and translation of them into useful weather forecasts which is crucial.

National Weather Service of NOAA

The federal government provides weather forecasting services through the National Weather Service, NOAA, U.S. Department of Commerce, (formerly the U.S. Weather Bureau). Weather Service offices, maintained at most municipal airports, provide generalized hourly weather forecasts for the immediate surrounding area. These forecasts are communicated in three different ways.

- Telephone: usually a recorded transcription is updated hourly. Since the forecast format is usually the same, it is convenient to formulate a data sheet onto which the weather data can be transferred when a telephone call is made. Sometimes local radio and television stations receive forecasts directly from the National Weather Service at specified times during the day. Other stations use only selected parts of the National Weather Service forecast.

- Continuous transmission over VHF/FM radio stations at 162.55 or 162.40 Megahertz. A special receiver is required for these transmissions. These stations are located only in large metropolitan areas and have an effective transmission range of only 40-60 miles. Forecasts are repeated every 4-6 min and are revised every 2-3 hrs.

- An aviation-oriented forecast by the Federal Aviation Administration (surface weather is also reported) through a transcribed weather broadcast service (TWEB): broadcasts are in the 200-400 Kilohertz AM frequency range depending on location (although a special receiver is required, a small portable radio can be easily modified to receive these signals[3]).

Independent Meteorologic Forecasting Services

Many organizations subscribe to an independent meteorologic forecasting service that provides up-to-the-minute weather information. The independent meteorologic service can provide several important services above and beyond that provided by the National Weather Service:

- Individualized forecasting for specific localities. The National Weather Service covers only large areas within the immediate vicinity of the forecasting offices.

- Updated forecasts on an hourly or more frequent basis depending upon how a storm is developing.

- Direct telephone contact by the subscribers with the meteorologists who are making the forecast at any time night or day, 24 hours per day, seven days a week.

As with any large meteorologic service, continuous weather observations and data are received over connections to the government weather teletype network and the facsimilie network. Situations are spotted as they develop, and according to the judgment of the forecaster, warnings are issued to subscribers as necessary. Some subscribers receive regularly scheduled weather forecasts, others on an unscheduled basis depending upon the weather. The typical weather forecast for snow and ice warning