The Equipment and Personnel Task Force of the New Jersey Department of Transportation met periodically over an eight-month period and during that time developed formulas applicable to spreading by State forces, plowing by both State and contractual forces, distributing manpower to spread on a shift basis and applying a distribution percentage to the assignment of new trucks whether they be replacements or new equipment.

The Chief Engineer, Construction & Maintenance, New Jersey Department of Transportation, directed that a Task Force be formed with the Chief of the Bureau of Maintenance to act as chairperson for the purpose of developing the required equipment and manpower allocation needed for snow removal and ice control operations.

The questions to be answered by the Task Force were the following:

What equipment and manpower is required for winter maintenance operations, snow removal and ice control to meet New Jersey's policy of "wet pavement as soon as economically feasible after the storm?"

How can the department develop an equitable allocation of existing equipment to meet regional demands with reference to the number, type and age distribution of the truck fleet?

In response to these questions, formulas were developed for de-icing spreading, snow plowing, distributing manpower, and allocating new highway trucks.

Formula for Spreading

The basic concept of the following formula is to complete the initial statewide spreading application of chemical de-icers within one and one-half hours. Taken into account in this formula is the speed of the vehicle (spreading and not spreading), the presence of both long two-lane sections and short multi-lane sections, and the additional time consumed for spreading on ramps:

\[ S = 0.4C + 0.9 [L + 2.5R] \]

\[ S = \text{adjusted lane miles spread} \]
\[ C = \text{center line miles} \]
\[ L = \text{roadway lane miles} \]
\[ R = \text{ramp lane miles} \]

The above formula is further modified to reflect the age of the existing fleet. The data supplied indicated an average 80% up time for our truck fleet. This formula is as follows:

\[ (S') = (S) \times 1.25 \]

Once \((S')\) has been determined the following truck formulas can be used. The mix of trucks is adjusted to meet the requirements of each foreman's section:

\[ T_{2.5} = \frac{S'}{22} \rightarrow \text{Total of 2.5-ton trucks needed to spread (S')} \]
\[ T_{6} = \frac{S'}{36} \rightarrow \text{Total of 6-ton trucks needed to spread (S')} \]
\[ T_{10} = \frac{S'}{62} \rightarrow \text{Total of 10-ton trucks needed to spread (S')} \]

The criterion used for the number of loaders required for spreading operations is equal to the sum of mainline lane miles plus the ramp lane miles divided by 150:

\[ \text{Number of loaders required} = \frac{L+R}{150} \]

Formula for Plowing

Similar to the spreading operations, a plowing formula was developed on the premise of completing one entire clearing of snow from the roadway within a two-hour time period. The formula is as follows:

\[ P = \frac{L + E + 2.5R}{7.5t} \]

\[ P = \text{number of plow trucks required} \]
\[ L = \text{lane miles} \]
\[ E = \text{shoulder miles (over 5' in width)} \]
\[ R = \text{ramp lane miles} \]
\[ t = 2 \text{ hours} \]
This formula allows for the increasing of plowing time which in effect decreases the number of plowing trucks required. This is of considerable importance because of the increasing difficulty of hiring private contractors to plow snow in certain areas of the State. This formula will allow the Department to formulate a policy as to the amount of time acceptable to clear the roadway of snow.

As a result of the application of this formula, it became evident that certain areas in Region 4 (see Fig. 1) cannot economically meet the two-hour plowing time criterion. There are no contractors available in this area and it is not economically feasible to purchase additional trucks to meet this need. A more realistic period of three or four hours should be established for this area.

Personnel Requirements for Snow Operations

Personnel requirements are based on one man to a truck on a twelve-hour rotational shift basis. Taken into account is benefit time and attrition, because turnover of employees is a way of life in Maintenance and should be recognized as such:

\[ N = (A) + (B) + (W) \]

- **N** = employees required
- **A** = personnel required to man the spreading vehicles based on the adjusted spread (S) plus loader operators. (For a 24-hour coverage - multiply the personnel by 2)
- **B** = the benefit time which is 20% x (A)
- **W** = the attrition which is 8% x (A).

Truck Assignments

A distribution percentage was established for each region for 2 1/2-ton, 5-ton and 10-ton dump trucks. Taken into consideration was the use of 2 1/2-ton, 5-man cabs, needed in regular maintenance functions. Using this percentage, new trucks will now be assigned according to the set percentage. This will create an equitable fleet age distribution for each region.

Summary

The previous information is a valuable tool in budgeting, especially in the area where new highways are opening to traffic. By applying the above formulations, additional equipment and manpower required for winter operations can be determined when the project is in the design stage. To keep a program such as the one established, it will be necessary to perform periodic reviews to include additional mileage in the inventory, crew headquarter relocations, additional crews, and any physical or policy changes that would affect the data.

Conclusions

This study indicated that:

1. There exists a shortage in the total number of trucks and loaders available for snow emergency operations.
2. There were inequities in the existing distribution of trucks for snow and ice control operations. These inequities were both inter-Regional and intra-Regional.
3. While the average distribution by age appeared equitable, there exists some uneven distribution of vehicles for any one model year.
4. The problem of equipment "down-time" could be initiating a more realistic replacement cycle for dump trucks. We are currently on an eight-year replacement cycle.
5. The need for contract "snow plowing" to supplement our fleet is justified.
6. Due to the inability to obtain adequate contract plowing services to some areas of the state, a decision will have to be made either to: a) accept a longer period of time for the pavement to be cleared of snow, or b) "over-equip" those sections with state trucks in order that they may complete plowing operations within the specified time.
7. The need for hired loaders was verified.
8. Taking into consideration split shifts and employee benefit time, we are approximately 100 men short for statewide spreading operations.

Action Taken

1. Trucks will be reallocated based on spreading and plowing formulas developed by this committee subject to total available trucks.
2. The need for light graders and rollers, used to regrade unpaved shoulders and unpaved institutional roads, has decreased to a level that allows the cross-trading of 21 light graders and 2 rollers in the replacement program for trucks.
3. The age of the truck fleet will be adjusted so that in future years each Region will receive an allocation of new trucks based on the percentage of the total trucks of that class in each Region.

4. Some contractor plowing sections have been adjusted based on the data formulated in this report.

5. Funds were re-appropriated into equipment procurement accounts to purchase twenty additional six-ton dump trucks.

Further Recommendations

1. There should be periodic reviews as new inventory is added to the roadway system.

2. The data developed by this study should be used for budget purposes to document shortages that still exist.

3. A computer program based on this study should be established with inventory updating capabilities. The output documents should be made available semi-annually on a timely basis to coincide with the budget preparation and preparation for the snow season.

4. Top management should be advised that there are certain areas in the state where contract plowing services are not adequate. In these areas it will require a longer period of time for Department equipment to remove snow from the pavement.

5. An Equipment Review and Development Committee should be established. The purpose of this committee would be to provide field recommendations for new equipment purchases. Members of this committee would represent the Bureau of Maintenance, Bureau of Equipment and each of the Regions.