



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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### PROJECT COST:

\$146,000



Hand-collecting trash along high-ways in the Twin Cities area costs more than \$2 million per year.

# Designing a Machine for Picking Up Litter Along Minnesota Highways

## What Was the Need?

Collecting trash by hand along grassy highway shoulders and medians in the Twin Cities metropolitan area costs about \$2 million per year. “Harvesting” trash in this manner is a time-consuming task that also presents serious safety hazards for Mn/DOT workers. Although there are machines that can remove trash from flat, smooth, paved surfaces, none have been designed to pick up litter from grassy areas or slopes without removing grass or clippings. Designing an off-road trash harvester would make the process of picking up trash easier, safer, faster and more cost-effective. In addition, fewer employees would be needed for trash pickup, freeing up some of them for other assignments.

By 2006, Mn/DOT had completed Phase I of a project to develop an automated alternative. Investigators researched existing machines, technologies and components, and developed an initial set of machine specifications, including dimensions, operational speed and stability.

## What Was Our Goal?

The objective of this research was to complete the project already begun to mechanize the trash-collection process by finishing the design and building a prototype of an off-road machine that was easily maneuvered and could pick up most kinds of trash from grassy rights of way, including hillsides, with minimal removal of grass.

## What Did We Do?

With the completion of Phase I of the study, Mn/DOT had decided the trash-harvesting machine would be designed to pick up the most common types of trash, including paper, aluminum cans and plastic bottles, plastic, tire parts, and automotive debris such as mufflers and hubcaps.

To begin, investigators developed a computer-aided design model of the full-scale harvester to optimize each of the individual components. Mechanical features that were evaluated and tested in both short and tall grass included a hay rake, tine system and vacuum system. The trash harvester was also designed to be capable of sweeping with a capacity of 3.5 acres per hour.

Investigators determined that a shredder-and-blower system was too hazardous for the operator. Instead, a conveyor system was selected for moving the trash to the storage unit at the back of the machine. A Holden tractor is the core of the harvester and provides the hydraulic power; its robust, articulated frame provides a very tight turning radius. The frame of the pickup unit at the front end of the machine was constructed from regular carbon steel tubes; different sections and wall thicknesses were used to make it strong but light. Where needed, cross braces and thicker material were added to further improve the rigidity and integrity of the frame.

In the final prototype, the pickup unit lifts and collects the trash using a combination of tines and a rotary broom. Brushes and tines mounted on a reel push the trash onto a conveyor belt, which dumps it in the storage unit at the back of the machine. Investigators field-tested the unit on unmown meadow grass at a farm.

*“With additional modifications, the trash harvester will be a safer and more cost-effective way to keep Minnesota highways clean.”*

–Jonathan Chaplin,  
Associate Professor,  
University of Minnesota  
Department of  
Bioproducts and  
Biosystems Engineering

*“We hope the trash harvester will be improved to the point where it eventually becomes a standard piece of Mn/DOT equipment.”*

–Sue Lodahl,  
Director, Mn/DOT  
Research Services Section

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The trash-harvester prototype developed for this study has a Holden tractor for its core. The front pickup unit lowers onto the tines to scoop up litter and sweep it to a conveyor belt on the right side.

### What Did We Learn?

Although the initial field tests were very promising, the prototype did not fully meet Mn/DOT expectations. It did not collect 100 percent of the paper, bottles and soda cans in its path. Considerable trash, especially aluminum cans, became stuck between the lifting tines. At other times, the trash harvester pushed some of the litter to the sides instead of pulling it into the machine.

The investigators provided recommendations for future models:

- The trash harvester’s multiaxis, three-point hitch, which was designed to allow fine adjustments to the lifting mechanism, is probably more complex than needed for this type of machine and could be simplified.
- Another potential design improvement would be an automated control system for adjusting the height of the lifters.
- In the prototype, the forward visibility of the operator is restricted by the shield around the rotating tines; this component could be redesigned. The shielding, however, is necessary to prevent bystanders from becoming entangled in the gathering unit.
- The size of the dump bin on the back of the harvester was limited by the position of the conveyor and perhaps could be enlarged in a future design.

### What’s Next?

Because of mixed test results in the field, Mn/DOT has decided not to commercialize this particular trash-harvester prototype. This initial project has, however, provided a solid base from which to perform additional research, design and testing as funding permits.

Mn/DOT officials hope to implement the investigators’ design recommendations and further improve and field-test the trash harvester to enable its standard use. Ideally, re-designs on the harvester will enable it to also perform other roadside land-management operations such as mowing and reseeding.

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*This Technical Summary pertains to Report 2008-21, “Development of a Trash Harvester for Mn/DOT—Phase II,” published July 2008. The full report can be accessed at <http://www.lrrb.org/PDF/200821.pdf>. The report on Phase I of this research is available at <http://www.lrrb.org/PDF/200611.pdf>.*