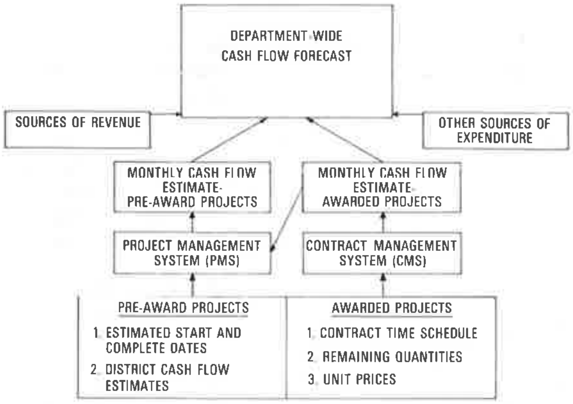
Figure 5. General overview of cash forecasting process.



already been awarded will be calculated by the CMS from the information contained in the construction contract. The CMS combines the contract time schedule with the remaining quantities for the various line items and their corresponding unit prices to convert these data into a schedule of monthly cash needs for the next 24 months for each contract. These data are also made available to the PMS.

FUTURE PLANS

As mentioned above, the Department is engaged in a continuing effort to improve the interfaces between the highway-related information systems so that redundant data can be minimized and sources of inconsistencies removed. Other improvements are also planned. The Department has retained a consulting firm to assist in the development of a Fiscal Management Information Systems Plan. The recommendations of this plan will help fill the "void" in the upper portion of Figure 3 that depicts a shortage of suitable information systems for top management.

Another area in the early stages of development involves systems that maintain data on the entire continuum of the highway network. These inventory systems are much more difficult to develop than the project-specific systems discussed in this paper. No individual interfaces have yet been planned between the inventory-type systems and the project-type systems, but it seems reasonable to expect that as-built project data would be used to update the highway inventory systems.

CONCLUSIONS

PennDOT has made significant improvements in recent years in the development and use of its information systems. Substantial benefits have resulted from integrating the highway-related management systems.

Personnel at all levels in the Department have found that the integrated systems approach enables them to work with data at the level of detail required for their own tasks. However, data summarized to a more detailed or less detailed level can be made available to them if required.

The Department has continued to increase its operational productivity and the information systems are reducing the time required to accomplish many of the tasks associated with planning, designing, and administering construction on highway projects. They also provide a means for estimating cash flow requirements for construction contracts.

Managing the highway program is not going to get any easier so it is imperative that the Department continue to make progress in the area of integrating its highway-related information systems. The support provided by responsive systems will permit managers to make informed decisions on scheduling the efficient use of dwindling resources. This is an extremely important aspect of the Department's commitment to provide a vastly improved state transportation program.

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Development of Priority Program for Roadside Hazard Abatement

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A computerized roadside hazard inventory was developed for the major county roadways in Oakland County, Michigan. The study included the development of a priority program used to rank roadside hazards for removal or protection. This program included various safety factors that have an impact on the relative hazardousness of roadside obstacles and other features that obstruct the "clear recovery area" along a roadway. A weighting scheme was used to aggregate the safety factors. The procedure is designed to be applicable to all highway operating agencies, especially those with access to a computer. The entire data file has been computerized in such a way as to be capable of aggregating and summarizing information concerning various roadside hazards. The data system can be updated as necessary, thus it is kept current at all times. The system can be used to rank roadside hazards according to their relative priority factors. It can

also be merged with fixed-object accident data and roadway geometric data currently on file to augment the system's analysis capabilities. Finally, multidisciplinary teams can review each of the highest-priority hazards and/or locations and can determine possible countermeasures.

Knowledge of the location and relative hazardousness of roadside hazards is essential if engineers are to effectively improve the safety of the roadway and its environment. Efforts to remove or protect roadside hazards generally result from public complaint, construction projects and/or traffic accidents and not a planned, ongoing program. This approach often results in sporadic work efforts and ignores many severe hazards. Substantial litigation expenses and settlements are often incurred by operating highway agencies because a planned correction program for roadside hazard abatement generally does not exist.

If roadside hazard data are continuously collected and maintained, engineers will be able to prepare realistic short- and long-range improvement plans, develop optimal correction programs, and maintain a safer roadway environment for the motoring public--traditional efforts to address the problems of roadside obstacles that have not been allowed. They require significant time and labor and may not produce the most cost-effective results because a priority program is not used.

The approach outlined in this report deviates from the traditional method of roadside hazard abatement. A computerized inventory file of roadside hazards was compiled from an existing set of photologs, and each hazard was ranked according to the potential hazardousness it presents. Non-accident indicators were used to develop the priority scheme. The use of non-accident indicators supplants the reactionary nature of past approaches, wherein a hazard is removed or protected after an accident has occurred, with a priority scheme based on the relative probabilities of collisions occurring with obstacles.

Although non-accident indicators are used to rank roadside obstacles according to their potential hazardousness, the approach presented in this report allows the integration of computerized accident data and roadway geometric data with the computerized inventory file of roadside hazards. This capability provides for more complete analysis of roadside hazards.

This paper describes the priority scheme used in the development of a roadside hazard abatement project in Michigan. First, the study site and characteristics are outlined. Next, the ranking scheme is explained, followed by a discussion of the data-collection process. Finally, the use of this scheme and its implications for project management are explained.

STUDY AREA

The study area for this project was Oakland County, Michigan, which is part of the tri-county Detroit Metropolitan Area. The roadways included 1206 km (750 miles) of paved county roads and 482 km (300 miles) of unpaved county roads under the jurisdiction of the Oakland County Road Commission (OCRC). The program did not include subdivision streets. All inventoried roadways were classified as county primary or county local.

PRIORITY SCHEME

Previous research efforts regarding roadside hazards indicate a need for a program of this type (1). Attempts have been made to define the potential hazardousness of roadside hazards and to rank these hazards according to some priority scheme, but these previous efforts did not use many variables that influence the potential hazardousness of roadside hazards (2-5).

In this study, the criteria used to determine the relative hazardousness of roadside hazards included the following:

1. Whether or not the roadway is curbed,
2. The presence of horizontal curves (inside or outside),
3. The presence of vertical curves (+ or - grade),
4. The rigidity of the object [see Table 1 (4)],
5. Average daily traffic,
6. Speed limit,
7. Distance from pavement edge, and
8. Roadway type (county primary, local, etc.).

Each of these criteria was assigned an appropriate evaluative rating of hazardousness ranging from 0 to 5 points (Table 2).

The overall priority factor, which was defined as a function of these criteria, included the following weighting scheme: curbing = 2; curve section (outside) = 5; curve section (inside) = 3; grade section (+) = 3; grade section (-) = 4; rigidity = 5; average daily traffic = 3; speed limit = 3; distance from pavement = 5; and roadway type = 2. The priority factor (PF) was then defined as a function of the hazardousness ratings and the corresponding weighting factors; i.e.,

$$PF = \sum_{i=1}^{n} H_i V_i \qquad (1)$$

or

$$PF = H_1 V_1 + H_2 V_2 + H_3 + H_4 V_4 + H_5 V_5 + H_6 V_6 + H_7 V_7 + H_8 V_8 \qquad (2)$$

where

V_1 = curb rating,
V_2 = curve rating,
V_3 = grade rating,
V_4 = rigidity rating,
V_5 = average daily traffic rating,
V_6 = speed limit rating,
V_7 = distance from pavement edge rating,
V_8 = roadway type rating, and
$H_1 \ldots\ldots H_8$ = corresponding weights (as described earlier).

The higher the value of the priority factor for a hazard, the greater is its relative hazardousness. Thus, those hazards with a high PF should be protected or removed first in order to reduce the hazard exposure to the motoring public and, ideally, the liability exposure of the agency with roadway jurisdiction.

DATA COLLECTION

The data base for this project was compiled through the use of existing photologs of OCRC roads. The individual frames of the photologs were reviewed by using a photoviewer with a special grid overlay that provided the reviewer with lateral distance measurement capabilities. The relevant data were coded onto a form specifically prepared for this purpose (Figure 1). The coded data were then typed into a computer terminal by using an interactive program that prompts the analyst to input the appropriate data. The following data were extracted from the photologs: street name, hazard type, district number, street type, direction of travel, side of street, curbed or uncurbed, distance from curb, and

Table 1. Severity factors for fixed objects of varying rigidity.

Fixed Object	Factor	Fixed Object	Factor
Utility poles (wood)	4	Hydrant	3
Supports-rigid (steel)	4	Signposts	1
Supports-breakaway	1	Trees (diameter in in)	
Guardrail	3	Greater than 13	5
Bridge abutment/wall face	3	11-12	4
		8-10	3
Bridge abutment and pier end	5	5-7	2
		2-4	1
Bridge rail faces	1	Rocks and boulders (diameter in ft)	
GM barrier	1		
Bridge rail end	5	Greater than 3	5
Fill slopes		2-3	4
2:1	5	1-2	2
3:1	4	Less than 1	1
4:1	3	Steel beams, concrete posts, etc.	3
5:1	2		
6:1	1	Wood posts (in)	
Cut slopes		8 x 8	2
0.5:1-1:1	5	6 x 6	2
1.5:1	4	4 x 4	1
2:1	3	Guy wire	3
3:1	2	Wood posts	
4:1 or flatter	1	6 x 8-in guardrail	2
		7-in round marker post	2

date of filming. Information related to road grade, object rigidity, traffic volume, and speed limit was obtained from other sources and merged with these data.

SYSTEM CAPABILITIES

On completion of the data-collection activities, computer software was developed to provide various safety analysis capabilities. In general, the software provided four functions: dump, search, update, and statistical analyses. Each of these functions is described below.

Dump

The dump function produces a printout of the complete roadside hazard inventory file (Figure 2). The output includes all of the variables necessary to determine the PF for each roadside hazard. Approximately 110 000 roadside hazards are cataloged alphabetically by road name. Each record (i.e., roadside hazard) is assigned a line number and a "milepoint" for easy reference.

Table 2. Hazardousness ratings.

Criteria	0	1	2	3	4	5
Curbed or uncurbed		Curbed	Uncurbed			
Curve section (°)	Straight	1-5	6-10	11-15	16-20	21+
Grade section (%)	Flat	1-3	4-6	7-9	10-12	13+
Rigidity		-[a]				
Average daily traffic		1000 or less	1001-8000	8001-15 000	15 001-20 000	20 000 or greater
Speed limit (mph)		25	30-35	40-45	50	55
Distance from pavement edge (ft)	Greater than 30	30-21	20-11	6-10	3-5	2 or less
Roadway type		Subdivision	Collector subdivision		Local	Primary

[a]See Table 1.

Figure 1. Data coding form.

District # ____ Street Type ____ D.O.T. ____ Viewer ____

Resolution ____ Date of Filming ____ Roll # ____ Page # ____

Main Street ____ Date Viewed ____

Cross Street	Obstacle Type	Frame ± Foot	Side of Street	Curb/ No Curb	Distance from Curb

Figure 2. Inventory sample printout.

```
* MAIN STREET NAME - HADLEY RD        *     WEIGHTING: CURB=2  CURV-O=5  CURV-I=3  +GRADE=3  -GRADE=4
*PR.# 0454200                         *                DIG=5     ADT=3   SPDLIM=7  DISTPV=5   RTYPE=2
```

SEQUENCE	CROSS STREET	DIST & DIR	MILE POINT	SIDE OF ST	CRBT	HORIZONTAL GEOMETRICS	VER GEO	RIGI	ADT	SPEED LIMIT	DIST PVMT	ROAD TYPE	OBSTACLE CODE	REPL INDEX
04159800	KENT RD	867 S	5.05	EAST	U		+02	1	399	U45	3	PRI	TREE2	54
04159900	KENT RD	623 S	5.09	EAST	U		+02	1	399	U45	2	PRI	TREE2	59
04160000	KENT RD	575 S	5.10	EAST	U		+02	1	399	U45	3	PRI	SPOST	54
04160100	KENT RD	575 S	5.10	WEST	U		+02	1	399	U45	6	PRI	TREE2	49
04160200	KENT RD	543 S	5.11	EAST	U		+01	1	399	U45	4	PRI	TREE2	54
04160300	KENT RD	513 S	5.11	WEST	U		+01	2	399	U45	2	PRI	MAILBOX	64
04160400	KENT RD	450 S	5.12	WEST	U		+01	2	399	U45	3	PRI	MAILBOX	59
04160500	KENT RD	417 S	5.13	WEST	U		+01	3	399	U45	5	PRI	FILL-END	64
04160600	KENT RD	206 S	5.17	WEST	U		+01	3	399	U45	5	PRI	FILL-BEG	64
04160700	KENT RD	153 S	5.18	WEST	U		+01	1	399	U45	5	PRI	TREE2	54
04160800	KENT RD	105 S	5.19	EAST	U		+01	1	399	U45	10	PRI	TREE2	49
04160900	KENT RD	125 S	5.19	WEST	U		+01	1	399	U45	6	PRI	TREE2	49
04161000	KENT RD	47 S	5.20	EAST	U		+01	3	399	U45	3	PRI	GUARDR-BEG	64
04161100	KENT RD	77 S	5.20	WEST	U		+01	3	399	U45	3	PRI	CONC	64
04161200	KENT RD	66 N	5.22	EAST	U	006 W 0955 000	-01	3	399	U45	3	PRI	GUARDR-END	71
04161300	KENT RD	96 N	5.23	WEST	U	006 W 0955 000	-01	3	399	U45	2	PRI	CONC	80
04161400	KENT RD	106 N	5.23	EAST	U	006 W 0955 000	-01	1	399	U45	4	PRI	TREE2	61
04161500	KENT RD	159 N	5.24	WEST	U	006 W 0955 000	-01	1	399	U45	6	PRI	TREE2	60
04161600	KENT RD	189 N	5.25	EAST	U	006 W 0955 000	-01	1	399	U45	6	PRI	TREE2	56
04161700	KENT RD	259 N	5.26	WEST	U	006 W 0955 000	-01	1	399	U45	8	PRI	TREE2	60
04161800	KENT RD	448 N	5.29	EAST	U	006 W 0955 000	-01	1	399	U45	5	PRI	TREE2	61
04161900	KENT RD	481 N	5.30	EAST	U	006 W 0955 000	-01	3	399	U45	4	PRI	FILL-BEG	71
04162000	KENT RD	486 N	5.30	WEST	U	006 W 0955 000	-01	3	399	U45	5	PRI	FILL-END	75

Search

The search function produces a printout of data records conforming to specific parameters supplied by the system user. Any variable or combination of variables in the data file can be specified for a search. For example, if a user wishes to search the file for all records containing trees with diameters greater than 1 ft on horizontal curves of greater than 6 degrees, a printout containing all such records will be produced.

Update

An important aspect of this information system is that the data can be updated. As changes or improvements are made (e.g., a hazard is removed, protected, etc.), the inventory data can be altered or deleted, or a new record can be inserted. Historical records are also maintained so that changes can be monitored over time and to ensure that the data are correct. The update process involves completing a form (Figure 3) and inputting the new data to the files.

Statistical Analyses

In order to perform analyses that aid the OCRC in developing a roadside hazard abatement program, the inventory data can be manipulated and merged with other data files. The Statistical Package for the Social Sciences (SPSS) (6,7) is used to perform these analyses. The SPSS package provides various capabilities for the analysis of the inventory data. Individual data records can be analyzed or aggregate statistics can be generated. Capabilities range from frequency distributions and cross tabulations to multivariate regression analysis.

SYSTEM USE IN PROJECT MANAGEMENT

The dump, search, and update functions of this information system provide OCRC staff with up-to-date information necessary to the decisionmaking process. However, the statistical analysis capabilities of the system provide management tools that enable the development of a systematic program of roadside hazard abatement.

The statistical analysis capabilities allow the user to rank all roadside hazards by priority factor. In this manner, those roadside hazards that present the greatest potential for accident occurrences are treated with priority.

Decisions regarding the types of treatment (e.g., removal, relocation, protection, etc.) that are chosen for roadside hazard abatement can also be facilitated with this system. By altering one or more of the variables influencing the priority factor for a particular roadside hazard, various alternative treatments can be simulated and new priority factors will be calculated. The most effective treatment alternative is the one resulting in the lowest priority factor. Treatment costs can then be applied to determine the relative cost effectivensss of the alternatives. In this manner, the analyst can make decisions such as whether a guardrail should be installed on a particular fill slope or whether the slope should be leveled.

It is also possible to determine critical levels for each of the variables through the application of SPSS. These critical levels can then help in establishing policies for such activities as tree planting and landscaping, utility pole placement and installation, or guardrail maintenance and installation.

An additional feature of this inventory is that it can be merged with an existing accident data file and a newly completed roadway geometrics file, augmenting the analysis capabilities of the system. All roadside hazards are assigned to a particular roadway with a unique primary road number. The accident and roadway geometric files are also organized according to these primary road numbers, thus giving the files a common denominator. Individual roadside hazards, roadway features, and traffic accidents are assigned to specific milepoints for common reference within each primary road subfile. Therefore, the analyst is capable of reviewing all accident data and roadway geometric data for a location with a roadside hazard. Or, the analyst

Figure 3. Roadside obstacle update form.

Please Print

Complete Only Those Items Where a Change has Occurred

PROJECT PERMIT WORK ORDER (Circle One) No.________

Process Code A (Alter) I (Insert) D (Delete)	☐	1
Card Sequence	[1]	2
Beginning Line Number	☐☐☐☐☐☐☐☐	4 - 11
Ending Line Number	☐☐☐☐☐☐☐☐	13 – 20
Main Street Name	☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	21 - 35
Cross Street Name	☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐	36 – 50
Distance from Cross Street	☐☐☐☐	51 - 54
Direction from Cross Street (N, S, E, W)	☐	55
Side of Street (N, S, E, W)	☐	56
Presence of Curbing (U, C)	☐	57
Obstacle Rigidity (Refer to Users Guide)	☐	58
Distance from Pavement (Feet)	☐☐☐	59 – 61
Road Type (Sub, Col, Loc, Pri)	☐☐☐	62 – 64

Process Code	☐	1
Card Sequence	[2]	2
Beginning Line Number	☐☐☐☐☐☐☐☐	4 – 11
Ending Line Number	☐☐☐☐☐☐☐☐	13 – 20
Obstacle Type (Refer to Users Guide)	☐☐☐☐☐☐☐☐☐☐	21 – 30
Speed Limit (P or U)	☐☐☐	31 – 33
Horizontal Geometrics (Refer to Users Guide)	☐☐☐☐☐☐☐☐☐☐☐☐	34 – 45
Verticle Geometrics (Refer to Users Guide)	☐☐☐☐	46 – 49
Passing Zone (Refer to Users Guide)	☐☐☐	50 – 52
Date of Initial Surfacing	☐☐	53 – 54
Traffic Volume (ADT)	☐☐☐☐☐	55 – 59
MALI PR Number	☐☐☐☐☐☐☐	60 – 66
MALI Milepoint	☐☐☐☐☐☐	67 – 72

Figure 4. Rocks in right-of-way.

OAKLAND COUNTY ROAD COMMISSION OBSTACLE REPORT 12/04/81 PAGE 2
TIA75U0R

MAIN STREET NAME - GREENFIELD RD
PRIMARY ROAD NUMBER =0648301

WEIGHTING CURB=2 CURV-0=5 CURV-1=3 +GRADE=3 -GRADE=4
RIG=5 ADT=3 SPDLIM=3 DISTPV=5 RTYPE=2

SEQUENCE	OBSTACLE LOCATION: CROSS STREET	DIST & DIR	MILE POINT	SIDE OF ST	CRB	ROADWAY CHARACTERISTICS: HORIZONTAL GEOMETRICS	VER GEO	RIG	ADT	SPEED LIMIT	DIST PVMT	ROAD TYPE	OBSTACLE CODE	PRTY FACTR
03072200	MEADOWOOD	254 S	3.17	WEST	C			5	39,955	P40	10	PRI	ROCK3	76
03073300	11 MILE RD	277 S	3.25	WEST	C			5	39,955	P40	10	PRI	ROCK3	76
03080400	WILTSHIRE	439 S	3.90	WEST	C		-01	5	30,013	P40	6	PRI	ROCK3	80
03801400	WILTSHIRE	90 S	3.96	WEST	C			5	30,013	P40	6	PRI	ROCK3	76

can review the roadway geometrics and the roadside hazards associated with specific fixed-object accidents. In combination, these files provide a comprehensive roadway information system for the OCRC.

ILLUSTRATIONS OF SYSTEM USAGE

Rocks in Right-of-Way

In the past, the OCRC has assigned a full-time staff person to inspect all county roadways for potentially hazardous conditions. One activity performed by this inspector was to report potentially hazardous obstacles within the road right-of-way. It was often the case that residents would place large rocks and other objects near the roadway in an attempt to keep vehicles from encroaching on their lawns and property. Many of these objects were placed where occurrences of off-road accidents were common. The safety implications of placing objects in such vulnerable locations are obvious.

In order to reduce labor costs and institute a systematic procedure for the correction of roadside hazards voluntarily placed within the right-of-way, a search program was run to identify such locations. The following command was issued to the computer:

```
TIA750BR0001SEARCH
TIA750BR0002OBSTACLE TYPE EQ ROCK3
TIA750BR0003DIST FRM RDWY LSS 010
TIA750BR0004VOLUME GTR 8000
TIA750BR0005FINISHED
```

This command printed data records (Figure 4) for all rocks, 3 or more ft in diameter, less than 10 ft from the pavement edge, and on roadways with greater than 8000 average daily traffic. Following identification of these hazards, investigation efforts were planned. Subsequent to investigation, letters requesting removal of the rocks are sent to the property owners.

Guardrail Maintenance Program

The OCRC maintains more than 2500 miles of county roadways. It, therefore, needs a systematic procedure for inspecting and maintaining guardrail on these county roadways.

A procedure of this type requires that the condition of all guardrail on the OCRC system be known. Furthermore, all of the guardrail locations must meet the current design standards. Finally, the effectiveness of the guardrail must be assumed to be reduced if it has been involved in a collision. Therefore, it is necessary to find guardrail locations where a fixed-object accident has occurred.

The data files (i.e., roadside hazard and accident data) must be merged to compile the necessary information. The following SPSS commands can be issued:

```
SELECT IF [(OBS34 EQ 0102 OR OBS34 EQ 0103) AND ACC10
   EQ 06]
REPORT FORMAT  = LIST, MARGINS (1,100)/
       STRING  = MSTN (OBSN01 OBSN02 OBSN03 OBSN04)
                 CRSTN (OBSN05 OBSN06 OBSN07 OBSN08)/
       VARS    = OBS05 'DISTANCE' 'FROM' 'IN FEET'
                 (12)
                 OBS06 'DIRECTION' 'FROM' 'INTERSEC-
                 TION' (12)
                 CRSTN 'CROSS STREET NAME'
                 OBS29 'PRIORITY' 'FACTOR'
       CHEAD   = 'DAMAGED GUARDRAIL'/
       BREAK   = MSTN 'MAIN STREET NAME' (LABEL)/
       SUMMARY = VALIDN MAX (OBS29)
```

This run will produce a listing of all guardrail locations where a fixed-object accident has occurred. For each case, the main street name, the guardrail location, and priority factor associated with the guardrail will be printed.

Once these locations are determined, repair crews can be assigned to repair the damaged guardrail. The schedule of repairs can be determined by the priority factor associated with each case. Those guardrail locations with the highest priority factors should be given priority for repair.

Other Uses

In addition to the two uses explained previously, OCRC is using the roadside hazard information system for other activities. The system provides the basis for an organized tree removal program. The search-and-sort capabilities of the system facilitate such programs. Another typical use of this system is a bridge railing maintenance and upgrading program. When merged with the accident and roadway information files, the system is useful in the development of safety improvement plans for various types of projects. With greater usage of the system, other applications, which will enhance the safety of OCRC roadways, will certainly be divulged.

CONCLUSION

The procedures described in this report provide an alternative to the current methods of roadside hazard abatement. With its computer application, this system provides the basis for many planning and operational activities with a low expenditure of man-hours.

The priority scheme for quantifying the relative hazardousness of roadside hazards allows the OCRC to systematically review those roadside hazards that present the greatest risk to the traveling public and the agency. The simplicity of this scheme permits its application to any highway agency or system, and its flexibility allows other agencies to adapt it to fit their own needs and priorities.

The information system is capable of providing current data regarding roadside hazards and can be merged with accident and roadway geometric data files to augment its data base. The search and statistical functions available with this system provide the OCRC with analysis capabilities that help in developing cost-effective safety treatments for various safety deficiencies. The result is a systematic program for enhancing the safety of OCRC roadways.

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