

Developing an Effective Shoulder and Centerline Rumble Strips/Stripes Policy to Accommodate All Roadway Users



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Introduction

The primary goal of the recently issued Wyoming Strategic Highway Safety Plan (SHSP) is to reduce fatal and serious injury crashes. Among six identified emphasis areas in the Wyoming SHSP 2012 (1), lane and road departure crashes received the first priority. Lane departure crashes include single-vehicle-run-off-road crashes (SVROR), opposite direction sideswipe and head-on crashes. It is worth mentioning that these types of crashes are considered the most severe crashes and often dominated by sleep deprivation/fatigue, and distracted driving (2, 3, 4, and 5). According to the FHWA (6), 53 percent of annual fatal crashes are attributed to lane and road departures. The Wyoming SHSP 2012 indicated that lane departure crashes comprised 72 percent of all severe crashes for the years 2008 – 2010. While lane departure crashes are mostly driven by drivers' errors, reduction of the frequency and severity can be achieved by more forgiving roadside and specific countermeasures. Rumble strips/ stripes are used by many states as a relatively low cost proven safety countermeasure to reduce or prevent lane departure crashes through providing a vibrotactile or audible warning to inattentive motorists. Shoulder and centerline rumble strips/ stripes have a demonstrable impact on reducing the frequency of Single Vehicle Run-Off-Road (SVROR) crashes, opposite direction side-swipe and head-on crashes (7, 8, 9, and 10). According to the Highway Safety Manual 2010 (11), rumble strips are proven to reduce lane departure crashes by 10 percent to 93 percent on different types of roadways.

Although the advantages of rumble strips were generally found to outweigh the disadvantages, several issues and concerns have been identified by the FHWA regarding the implementation of rumble strips; noise, maintenance, and the effects on bicyclists and motorcyclists are among the most discussed concerns in the literature. Noise caused by vehicles driving on rumble strips may affect surrounding residents; many agencies consider noise and environmental impacts before implementing rumble strips near residential or in urban areas (12, 13, 14, and 15). Many states reported that maintenance of rumble strips installed on pavement in good condition does not need any additional requirements; however, snow removal could be an issue. While several

studies showed that special considerations should be made to alleviate the adverse effects that rumble strips may pose on bicyclists (15, 16, 17, 18, 19, 20, 21, and 22), a number of studies indicated that no major concerns were identified on the effect of rumble strips on motorcyclists (23, 24, and 25).

The main goal of this project is to develop an effective policy of shoulder and centerline rumble strips/ stripes in the state of Wyoming to enhance motor vehicle safety while accommodating all road users (i.e., bicyclists and motorcyclists) to the highest practical extent. Moreover, several concerns regarding the use of rumble strips/ stripes including; construction, maintenance, and noise will be addressed.

Background

Rumble strips are raised or grooved patterns placed on paved surfaces of roadway shoulders or centerlines. When these rumble strips are painted with retro-reflective coating to make them more visible, they are referred to as rumble stripes as shown in Figure 1.

Rumble strips are categorized into three basic types;

1. Shoulder Rumble Strips (SRS) / Edge Line Rumble Stripes (ELRS),
2. Center Line Rumble Strips or Stripes (CLRS), and
3. Transverse Rumble Strips or Stripes (TRS).

Shoulder Rumble Strips are a series of raised or milled longitudinal safety features that are installed near the outside edge of paved roadways with the purpose of alerting inattentive drivers when they are departing from the travel lane (26). Shoulder rumble strips are placed on roadways to basically improve roadway safety that is related to unintentional drift over the road edge. Occasionally, a type of shoulder rumble strip is built by placing the rumble strips exactly at the edge of the travel lane and coating them with edge line pavement markings and this type is called Edge Line Rumble Stripes.

Center Line Rumble Strips (CLRS) are also a series of raised or milled longitudinal safety features but unlike Shoulder Rumble Strips, they are located at or near the centerline of a paved

roadway (27). CLRS are installed to improve roadway safety in relation to inattentive drivers drifting across the centerline.

Transverse Rumble Strips (TRS) consist of a series of raised or milled safety features crossing the roadway surface to provide a timely and audible warning for drivers when approaching a spot where a deceleration or a stop action is required (28).

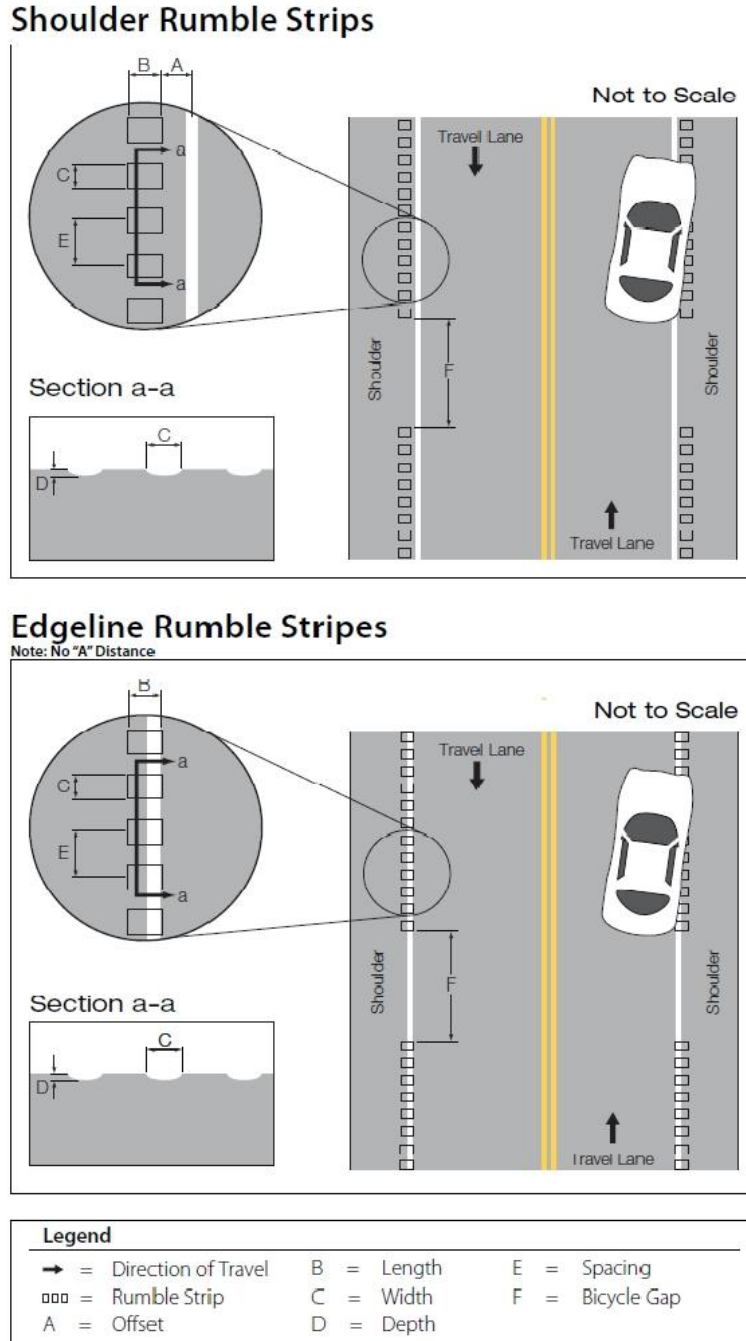


Figure 1: Layout of Shoulder Rumble Strips/ Stripes (Source: <http://safety.fhwa.dot.gov>)

The Federal Highway Administration considers the various rumble strips as effective in counteracting risks posed by inattentive drivers. The various documents concluded that the Shoulder Rumble Strips, the Center Line Rumble Strips, and the Transverse Rumble Strips

contribute significantly to a reduction in roadway crashes resulting from unfocused or distracted drivers (26, 27, and 28).

The FHWA requires the design and installation of rumble strips that accommodate all road users. Cyclists are uniquely identified as being negatively affected most by rumble strips because in situations where rumble strips are constructed on the shoulder without leaving room for cyclists, the cyclists are forced to ride on the travel lanes where they are exposed to dangers from vehicular traffic. To prevent or reduce the negative impact of rumble strips on cyclists and other road users, the American Association of State Highway and Transportation Officials (AASHTO), FHWA and some State Departments of Transportation (DOTs) have provided some guidelines for installing rumble strips on roadways (29).

Several research and studies have been carried out on rumble strip/stripes that acknowledge their efficiency as capable deterrents of some crash types. National Cooperative Highway Research Program (NCHRP) (29) documents statistically significant reductions in single run-off-road injury crashes with the implementation of shoulder or edge rumble strips. A reduction of 10 to 24 percent was recorded on rural freeways, and 26 to 46 percent on two-lane rural roads. Similar studies on drift-off-road crashes in Michigan and New York also recorded crash reductions of 38 and 79 percent respectively. For centerline rumble strips, statistically significant reductions in injury crashes of 38 to 50 percent was recorded for rural areas, and 37 to 91 percent for urban two lane roads. Studies in Iowa and Minnesota also indicated a significant reduction in severe injury crashes at minor road stop-controlled intersections (28).

Beyond the prevention of crashes, the installation of rumble strips was also identified as being an effective mean of locating the travel lane during extreme weather conditions that result in low visibility (26). The vibration and noise made by the rumble strips check drivers from driving off the travel lane during low visibility.

The FHWA (30) also listed longitudinal rumble strips and stripes on 2-lane roads as one of nine proven safety countermeasures.

In a bid to reduce the number of critical crashes on Wyoming’s highways, the Wyoming Strategic Highway Safety Plan (SHSP) analyzed Wyoming State crash data to identify six areas where there are opportunities to reduce critical crashes. The identified areas were Roadway Departure Crashes, Use of Safety Restraints, Impaired Driving, Speeding, Young Drivers, and Curve Crashes. Of the six areas determined from the data, lane departure consistently produced the highest number of crashes from 2002 to 2010 as illustrated in Figure 2.

Crashes associated with lane departures/run-off-the-road result from driver fatigue, impaired driving, speeding, and distracted driving. These crashes were determined to have contributed to 72 percent of all critical crashes. In a bid to reduce the occurrence of these types of crashes, one of the recommendations by the Wyoming SHSP was to continue the implementation of the rumble strip policy on highways.

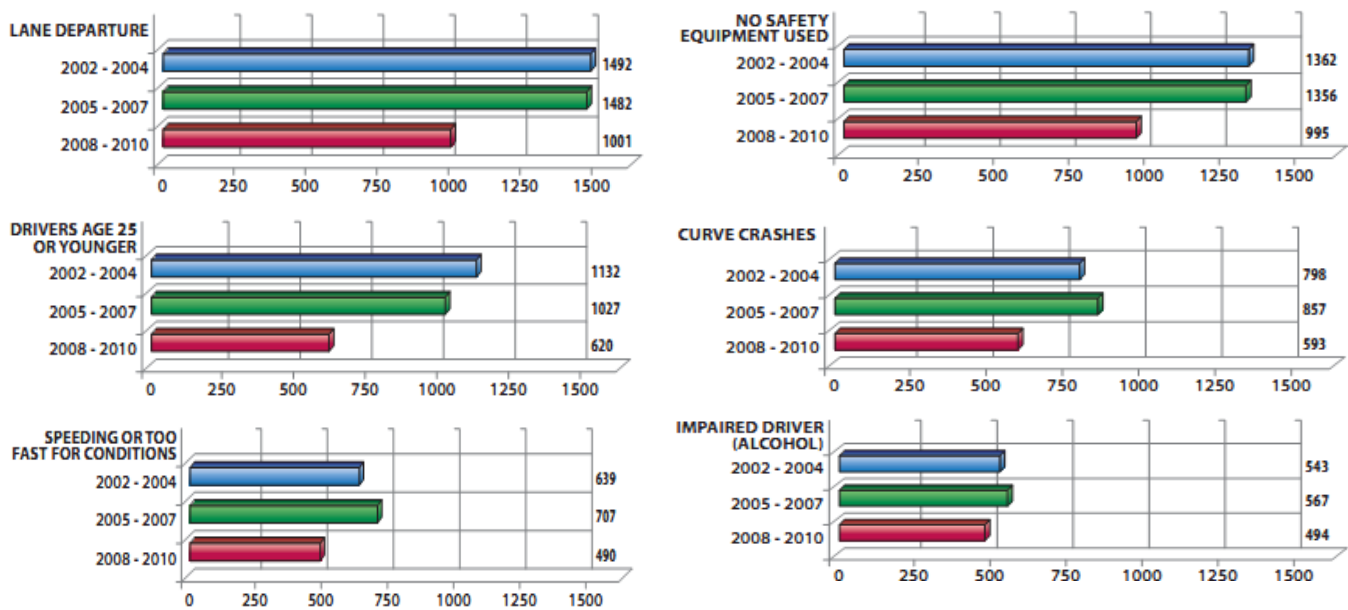


Figure 2: Crash Emphasis Areas Based on Wyoming Crash Data (Source: Wyoming Strategic Highway Safety Plan, 2012)

Study Benefits

The Wyoming Strategic Highway Safety Plan recognized the importance of rumble strips in improving safety on roadways and therefore recommended continued implementation of rumble

strips/ stripes. However, rumble strips may pose some concerns to residents, bicyclists and motorcyclists that may become more serious with the increased implementation of rumble strips. The objective of this study is to develop recommendations, guidelines, and policies for the implementation of rumble strips/ stripes that ensures that there is a significant reduction of negative impact to road users even with increased usage of rumble strips by WYDOT.

This research proposal was presented to WYDOT Safety Management System Committee which recommended forwarding the proposal to the RAC for potential funding.

Project Goals

As shown in Figure 3, two main goals are to be achieved in this study to provide recommendations for rumble strip/ stripes implementation in the State of Wyoming. The first goal is to review and amend the existing practices and policies as well as providing guidelines to update the Standard Plans of rumble strip/ stripes implementation. The second goal of the study is to determine the preferences and practices of surrounding states in the Rocky Mountains and Plains Region as well as to catalogue the concerns and preferences of residence, cyclists, and motorcyclists with regards to rumble strips.

To achieve the first goal, a review of practices and recommendations of various transportation agencies, including WYDOT, the Departments of Transportation of various States and Federal agencies in the US and Canada considering the following factors:

- policy and installation warrants,
- implementation guidelines and placement standards,
- rumble strip designs; milled, rolled, dimension and offset, and safety trends,
- effectiveness in reducing crashes,
- effect on roadway users; drivers, bicyclists and motorcycle riders,
- effects on nearby residents in urban areas,
- noise and Environmental effects, and
- impacts on road maintenance, drainage, and snow removal.

Road users' responses to rumble strips can be examined through a variety of approaches including questionnaire surveys, simulations and real-life experiments. Questionnaire surveys are considered relatively affordable compared to the aforementioned approaches. The second goal will be achieved through a self-reported (stated preference) surveys which will be conducted to examine residence, bicyclists, and motorcyclists responses and/ or experiences with rumble strips.

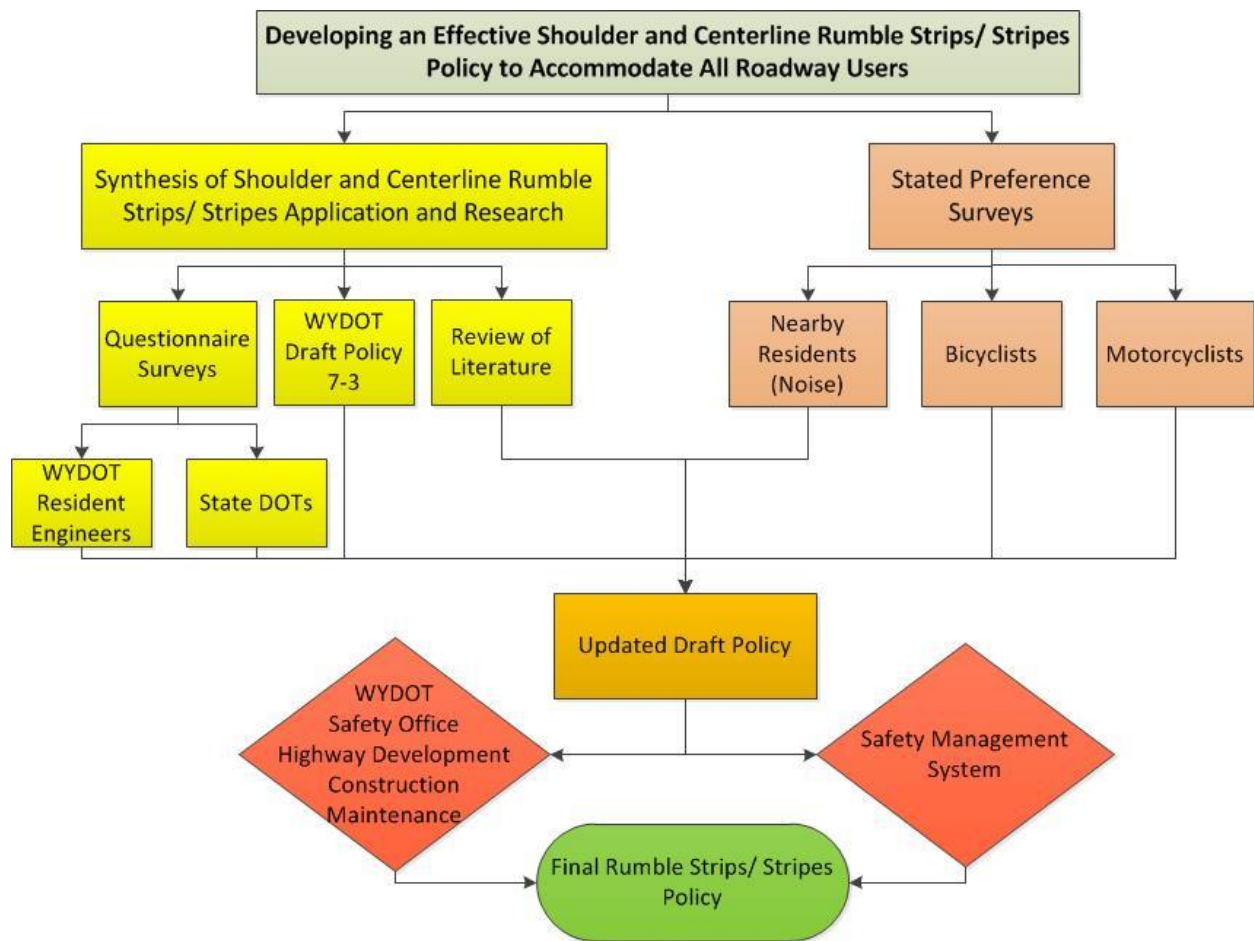


Figure 3: Project Flowchart

Project Tasks

The expected *Tasks* for completing this research study are:

1. *Synthesis of existing rumble strips/ stripes use*

This will be conducted by reviewing best practices, policies, and guidelines provided in previous NCHRP reports, recent syntheses documents, the Highway Safety Manual 2010, and recent research publications in the U.S. and Canada.

2. *Questionnaire survey for Wyoming DOT*

A Questionnaire survey will be prepared and carried out to get feedback from WYDOT engineers affected by the implementation of rumble strips/ stripes policy. As a minimum, the survey will be distributed to WYDOT District engineers as well as engineers from the Safety, Highway Development, Construction and Maintenance.

3. *Questionnaire survey for surrounding state DOTs*

Questionnaire survey will be disseminated to surrounding state DOTs to review their latest policies on implementing rumble strips/ stripes. WYDOT's rumble strip and stripe designs will be compared to other DOTs designs having different width, depth, or pattern. Practices and lessons learned to provide rumble strips and stripes that are more acceptable for bicyclists and other road users of the system of surrounding DOTs will be reviewed and compared to the WYDOT's draft operating policy on rumble strips/ stripes (31).

4. *Design a Stated-Preference surveys for residents, bicyclists and motorcyclists*

A self-reported (stated preference) questionnaire surveys will be designed to evaluate the impact of rumble strips/ stripes on various users including nearby residents, bicyclists and motorcyclists. Questions pertaining to the demographic characteristics, users' familiarity, concerns, behavior/ responses and concerns with rumble strips/ stripes in different capacities will be considered.

5. *Distribution of Stated-Preference surveys*

Questionnaire surveys will be distributed through three survey methods; handout, interactive and online survey to achieve satisfactory sample size.

6. *Analysis of surveys responses*

Responses from various users will be analyzed using different statistical approaches and recommendations will be provided.

7. *Lessons Learned and Recommendations*

Provide guidance for the design and application of shoulder and centerline rumble strips as an effective low cost crash reduction treatment, while addressing several unresolved issues for motorcyclists, bicyclists, and nearby residents.

8. *Implementation and Technology Transfer*

The final findings, recommendations, and guidelines will be presented to the Safety Management System Committee, which will determine if a revision to the Wyoming Standard Plans and draft policy number 7-3 will be made. If the standards are changed, those changes would apply to all new rumble strips construction on Wyoming highways. The approved final version of the policy will be also shared with local governments around the state. In addition, the research results will be disseminated through technical paper publications and presentations in academic venues and press releases using media outlets. The technology transfer activities in this project will benefit both the scientific community and authorities responsible for traffic safety and decision making, and will be a key to the implementation of rumble strips/ stripes in the state of Wyoming.

Deliverables

Quarterly progress report will be submitted. In addition, any major achievement, i.e., the completion of tasks will be reported to the project managers. A recommendation for WYDOT policy on rumble strips/ stripes, draft final report and a final report incorporating the project managers' comments and corrections would be submitted at the end of the project.

Project Kickoff Meeting

A kick-off meeting shall be scheduled to occur within the first 30 days of execution by the university. The preferred method for the kick-off meeting is via teleconference or video conference. As a minimum, the project manager and the principal investigator will attend. The Research Center staff must be advised of the meeting and given the option to attend. Other parties may be invited, as appropriate. The subject of the meeting will be to review and discuss the project's tasks, schedule, milestones, deliverables, reporting requirements, and deployment plan. A summary of the kick-off meeting shall be included in the first progress report.

Progress Reports

The university will submit quarterly progress reports to the Research Center. The first report will cover the activity that occurred in the 90 days following the issuance of the task work order.

Draft Final Report

The Draft Final Report is due 90 days prior to the end date of the task work order. The draft final report will be submitted to the WYDOT Research Center. It should be edited for technical accuracy, grammar, clarity, organization, and format prior to submission to the Department for technical approval.

Final Report

Once the draft final report has been approved, the university shall prepare the final report. The university will deliver a CD or DVD containing the final report in PDF as well as MS Word format.

Project Closeout Presentations

The findings of this study will be presented to the SMS committee as well the WYDOT RAC at the conclusion of the project.

Timeline

It is envisioned that total time required for the project including the submission of the final report would be 16 months beginning January 1st, 2014. The synthesis and questionnaire surveys for the surrounding state DOTs will be carried out over the first 12 months to insure up-to-date information. The stated-preference surveys design for different road users will start in the second quarter after identifying key-questions and concerns from the literature regarding the increase of the implementation of rumble strips/ stripes.

Table 1: Work Plan Schedule

Research Task	Month															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Task 1																
Synthesis	■	■	■	■	■	■	■	■	■	■	■	■				
Task 2																
WYDOT Questionnaire Survey	■	■	■	■												
Task 3																
DOTs Questionnaire Survey	■	■	■	■	■	■	■	■	■	■	■	■				
Task 4																
Road Users Surveys Design				■	■	■	■	■								
Task 5																
Surveys Distribution							■	■	■	■	■					
Task 6																
Surveys Analyses									■	■	■	■				
Task 7																
Recommendations										■	■	■	■			
Task 8																
Technology Transfer														■	■	
Documentation and Deliverables Schedule			■			■			■			■	■			■
 Quarter Reports Draft Final Report Final Report																

Budget

As shown in Table 2, the total cost of the project is \$89,672. That cost will cover all data collection and analysis activities as well as technology transfer. In addition, it will cover the salaries of one graduate student, and two faculty members.

Table 2: Project Budget

Rumble Strips		
University of Wyoming		
January 1, 2014 - April 30, 2015		
CATEGORY	Budgeted Amount	Explanatory Notes
Faculty Salaries: Ahmed and Ksaibati	\$ 22,000	
Administrative Staff Salaries	\$ -	
Engineer Salaries	\$ -	
Student Salaries	\$ 23,500	
Staff Benefits	\$ 12,110	
Total Salaries and Benefits	\$ 57,610	
Permanent Equipment	\$ 1,950	Computer
Expendable Property, Supplies, and Services	\$ 4,000	Survey costs and final report
Domestic Travel	\$ 4,500	Data collection and presentations to insure proper technology transfer
Foreign Travel	\$ -	
Other Direct Costs (specify)	\$ 8,000	Student tuition; excluded from overhead
Total Other Direct Costs	\$ 18,450	
F&A (Indirect) Costs	\$ 13,612	
TOTAL COSTS	\$ 89,672	

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