Running Head: TARGET HAZARD EVALUATION IN MARYSVILLE WA

# Analysis of objective and subjective approaches to target hazard evaluation in Marysville, WA

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# CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, idea, expression, or writings of another.

Signed: _____

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## Abstract

The problem was our subjective target hazard assessment method. The evaluative research purposes were: identify target hazard identification and evaluation tools, and compare our target hazard risk categories to RHAVE results.

The research questions were: What methods are comparable fire departments using for identification and prioritization of target hazards? What results are obtained through objective assessment of our target hazards? How do our target hazard priorities compare with those obtained by an objective assessment method? What methods of target hazard identification and prioritization should be recommended for future use?

The procedures used interviews and RHAVE software. The results were large differences in risk categories between RHAVE and subjective officer judgment. Use of subjective methods and RHAVE was recommended.

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## Introduction

Each community in the United States has to cope with a wide variety of perils, including those fire and life safety hazards that are commonly delegated to local fire departments to deal with. As a community grows, will the risk of losses from these hazards grow as well? Can fire departments help to shed some light on this question through the collection and analysis of local data? Statistics from locally obtainable sources and an analytical look at this data might help illuminate the nature of hazards facing a community, and quantify the degree of risk these hazards pose. Fire service leaders can make the best decisions to manage risk from hazards when armed with such information.

In discussing the impacts of decisions made in today's fire service, renowned fire safety champion Ronny J. Coleman (2004) has commented:

> "We in the fire service face hundreds, if not thousands, of decisions every year. Some must be made at the time of a crisis, such as those an incident commander makes on the fireground. But most decisions are made under far less stressful conditions. They have to do with budget issues, personnel matters and program management, to name a few. Many of these decisions have far greater consequences than those that occur on the fireground. An interesting aspect of these decisions is that fire service managers often don't have a chance to revisit them. Most decisions are based on previous ones, with the net result being that organizations tend to evolve over time without re-evaluating the basic reasons why they could or should be doing things" (p. 34).

Coleman alludes to the facts that not only are split second life or death decisions made in emergency situations, but also made routinely on a day-to-day basis. Collectively the decisions

made by fire service leaders have tremendous impact on shaping outcomes, the course of events, and ultimate safety of all our lives.

While all decisions made in the fire service should reflect our mission to increase public safety from fire, the elimination of all risk is not possible. In discussing safety in the fire service, the authors of the National Fire Protection Association (NFPA) Fire Protection Handbook (Handbook) state that the cost of safety must be weighed against the cost of risk in the development of fire safety program priorities (NFPA, 2003a). They explain that the acceptable level of risk in a community varies with the value placed on safety from risk. Each community must decide for itself what their acceptable level of risk is. The degree of willingness that there is in a community to pay for safety, as opposed to the willingness to accept hazards, determines the level of acceptable risk for a community. In this way each community defines what level of risk they are willing to accept.

In making these kinds of decisions the Handbook authors claim that it is critical to include a formal fire risk assessment, one based on reliable data. They state that this always needs to start with identification of the hazards that lead to risk. The authors pose several questions that data should be used to answer: What problems need to be addressed? Have risks of specific problems increased or decreased? What hazards should be targeted? The goal is to identify which safety problems are big enough to worry about. They suggest that through data analysis it is possible to identify and target areas of high risk and high hazard; and that limited resources for pre-fire planning activities should be targeted at these areas instead of using a shotgun approach. The authors emphasize the importance of using analysis of data to identify which of many competing demands for limited resources to give higher priority to.

In discussing risk management specifically, the NFPA recommends that a fire department risk management program should include strategic planning to establish acceptable risk levels, service levels, and risk reduction objectives (NFPA, 2004b). They emphasize that fire departments should inspect high hazard properties, conduct pre-incident planning for hazards, and provide programs to reduce risks; all of this must start with risk assessment to identify, analyze, and prioritize risks.

In Marysville Fire District (MFD) much data is gathered, collected, and analyzed every year. Incident details are recorded, training is documented, fire inspections are reported, and public education events are counted. Data is used to publish annual reports, evaluate response times, analyze trends types of emergency responses, track annual fire losses, account for budget items, debate personnel needs, and to establish program priorities among a host of competing demands for limited resources. However, data for risk reduction efforts in MFD is not gathered and used as well as it could be (VanBeek, 2008). We do not have sufficient pre-incident plans to give incident managers all the information they could use in making critical decisions on the fireground. No formal community risk assessment process has ever been completed in MFD, target hazard locations have not been adequately identified, and an up-to-date strategic plan is long overdue. Without these things, without making the best use of data to make decisions, can we be assured that the best decisions are being made with regard to fire safety in our community?

The importance of planning and preparing for incidents at target hazards is well documented. The United States Fire Administration (USFA) student manual for their National Fire Academy (NFA) course titled Executive Analysis of Fire Service Operations in Emergency Management (EAFSOEM) states that many communities are underprepared for the actual risks

they face (USFA, 2007a). The extra preparation needed for target hazards is discussed. Target hazards are defined as significant hazards; those that can strain fire department response capability. It is suggested that a well constructed assessment of risk is the essential first step towards management of these hazards. It is emphasized that the assessment process is very important in getting community members and leaders to see the problems facing the fire department.

In a journal article discussing the difficulties fire departments sometimes have recognizing target hazards, the many types of locations where a hazardous event would leave a large economic, political or physical loss to the community are detailed (Hart, 2001). The author explains that each fire department must decide on what should be considered a target hazard, then identify them, gather useful data for each, and develop pre-incident plans. He emphasizes that target hazard sites often go unrecognized, but need to be identified because they require a greater degree of pre-incident planning than normal locations.

Our fire officers are only partially armed for battle at target hazard locations. Kept in MFD emergency apparatus is a *Site Plan Book*. The collection of plans in this notebook available to responding fire officers do not fully meet guidelines of NFPA pre-incident planning recommendations (NFPA, 2003b). No MFD policies or procedures exist for a process to identify target hazards. The past practice has been an informal and subjective process. Research is critically needed to improve the target hazard identification and evaluation process in MFD.

The specific problem addressed in this Applied Research Project (ARP) is that the current high risk hazards in MFD were identified and prioritized by a subjective method. It is not known how the results of this compare with what would be obtained by a more objective method, or if

any different method or combination of methods used by other departments should be considered for our use instead.

The purpose of this ARP was to assess our current process for identification and evaluation of high risk occupancies in MFD. More specifically: to identify other viable methods of target hazard identification and evaluation, to compare our current list of high risk occupancies to that obtained through a more objective evaluation of the same occupancies, and to recommend changes, if indicated for improvement, to our process for identification and prioritization of target hazards.

Original research was conducted for this ARP using the evaluative research method, which necessarily involved a systematic process of collecting and analyzing data in order to make decisions and draw conclusions. This investigation utilized interviews with officers at comparable fire departments to identify target hazard evaluation tools that are being used locally. An objective evaluation method was applied to our target hazards and results used to reprioritize these hazards. Results of this evaluation were compared to those of our current subjective method. The following four research questions were addressed in this ARP:

1. What methods are fire departments comparable to MFD using for identification and prioritization of target hazards?

2. What prioritized results are obtained through objective assessment of MFD target hazards?

3. How do MFD target hazard priorities compare with those obtained by an objective assessment method?

4. What methods of target hazard identification and prioritization should be recommended for future MFD use?

## Background and Significance

Marysville Fire District is located along the I-5 corridor in Snohomish County, on the west side of the State of Washington, in the United States. The land area encompassed and protected by MFD is approximately fifty-five square miles. This area includes all of the City of Marysville, the unincorporated Sunnyside and Lakewood communities, the Smokey Point neighborhood of the City of Arlington, and a large portion of the Tulalip Indian Reservation. The MFD area is situated between rural tulip fields of Skagit County to the north, urban King County and the Seattle metropolitan area to the south, Cascade mountain range foothills to the east, and the Puget Sound arm of the Pacific Ocean to the west.

Marysville Fire District has grown from three smaller and separate fire departments to the larger and unified MFD of today. The fire district was initially formed in 1992 as a result of a contractual agreement between the City of Marysville and Snohomish County Fire District No.12, which nearly surrounds the city. This agreement merged the city's fire department and the county fire district into one larger jointly operated fire district. MFD grew again in 1998 through another merge, with neighboring Snohomish County Fire District No. 20 being consolidated into Fire District No. 12. Currently MFD operates out of five staffed stations (stations 61, 62, 63, 65 and 66).

The Marysville area has experienced rapid commercial, industrial, and residential growth over recent years. Could this growth have introduced more high priority hazards that have not yet been identified or evaluated? The local building inventory presents many challenges: from small residential homes to high rise hotels, from manufacturing facilities with large quantities of hazardous materials to mom and pop grocery stores. Within the last five years, major new

businesses to MFD include: Tulalip Casino Hotel, Seattle Premium Outlets, Costco, Target, Kohl's, Winco, Holiday Inn, Harley Davidson, Best Buy, Office Depot, Petco, and two more Starbucks! Besides some caffeine jitters, there must be some increased hazards and risk that come with all this growth. Has MFD's program for target hazard identification and evaluation kept pace with this growth?

The population of the diverse Marysville area has also grown, and is currently estimated to be sixty-six thousand residents. Three measures of MFD growth over past years are summarized in Table 1.

Table 1. *Marysville Fire District Growth Measures by Type and Year*

| Type of Growth Measure | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Population of MFD[a] | 61 | 63 | 64 | 65 | 66 | 66 | 66 |
| Number of MFD Personnel | 137 | 133 | 127 | 124 | 122 | 120 | 115 |
| Assessed Value of MFD[b] | $4.0 | $4.1 | $4.2 | $4.8 | $5.5 | $6.9 | $8.4 |

[a] Population in thousands. [b] Assessed Value in billions

While the size of the population and assessed value protected by MFD has increased, the number of MFD personnel has decreased. The population increased nearly ten percent from 2002 to 2008, and is expected to increase another fifty percent by 2025 (City of Marysville, 2007). How will this growth increase hazards, risks, and impact the need to provide emergency response services? With greater numbers of people at risk in MFD, it is more important now than ever to reassess and prioritize the areas target hazards.

The demand for MFD services has grown. No longer providing only fire suppression, the district now provides a variety of emergency services to the community. Services provided

include: fire suppression, emergency medical, hazardous materials, and technical rescue. The *Marysville Fire District Annual Report* for each of the past seven years (MFD, 2003-2009) shows the number of emergency responses increasing each year. Emergency incident response statistics for recent years are summarized in Table 2.

Table 2. *Number of Marysville Fire District Emergency Incidents by Type and Year*

| Type of Incident | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 |
|---|---|---|---|---|---|---|---|
| Emergency Medical | 5421 | 5749 | 6321 | 6751 | 7309 | 8333 | 8995 |
| Fire | 735 | 779 | 934 | 1062 | 1127 | 998 | 1067 |
| Other | 1234 | 1309 | 602 | 193 | 412 | 544 | 528 |
| Yearly totals | 7390 | 7837 | 7857 | 8006 | 8848 | 9875 | 10590 |

These numbers show the frequency of emergency incidents has increased over this seven year period. Although the greatest increase has been in emergency medical incidents, fire incidents increased by forty-five percent. The fire problem seems to be growing at a much faster rate than the population in Marysville. If the population does grow by another fifty percent as expected by 2025, and if the increase in emergency incidents is similarly greater, then the number of incidents could be expected to grow by an even larger amount, perhaps doubling the number. Has MFD planned to handle twenty thousand emergency incidents annually in 2025? With resources being stretched thinner it is more important now than ever to reassess and prioritize our target hazards.

How do other fire departments gather and maintain useful information about their target hazards? Perhaps answering this question can lead to valuable improvements in the process used at MFD without having to reinvent the wheel.

Several examples from 2008 highlight the need for improvements: There are several hundred sites in MFD that should have operational permits due to increased hazards of occupancies at those locations, but do not due to lack of a required permit program. A vacant position in Fire Prevention at MFD for most of the year, combined with increased inspection demands from many construction projects, led to schools and most other target hazards getting no inspections. A flammable vapor explosion in a dip tank at an H (high hazard) occupancy led to the hospitalization of two workers. The dip tank had been installed without proper permits and inspections. A fire in an elevator lobby of a high rise led to a large loss that may have been partially prevented with better pre-incident planning and training at the facility. The examples point out a critical need for improved hazard identification, hazard evaluation, and pre-incident planning for target hazards in MFD.

The current lack of a target hazard program does not bode well for the future. Continuing to do things the same as in the past invites trouble. The probable future impact of having no target hazard list, of having a less than adequately process for target hazard identification and evaluation, is more of the same. Improvements to these areas go hand-in-hand with improvements to annual inspections for hazards, permit processes, pre-incident planning, training, response coverage, and safety.

In dealing with a wide variety of hazards in MFD, the problem of how to identify and evaluate the risk of multiple hazards may be approached in many different ways. Questions to consider include: How can a more in depth analysis of local data be accomplished? What additional information needs to be known? What new tools can be developed for this? Where to focus limited resources for risk reduction? How to identify high risk groups and target high risk locations? How to forecast possible future risks? What does the past predict for the future? With

questions like these unanswered, the potential perils from unmitigated risk in our community continue.

In response to increased growth of the MFD area, increased demand for services, concerns about unequal service levels at different locations in MFD, and to begin development of a plan to help set goals for levels of services, a Standards of Coverage for Emergency Response Draft Document (SOC) was developed five years ago. In the SOC it is stated that "it is the community, through its elected officials, that dictate the standard of cover that will be adopted by a community." The SOC goes on to state "these decisions…should be made only after rigorous study of local needs and resources." (MFD, 2004, p. 28). The Risk Assessment section of the SOC explains that quantification of risk can be either subjective or objective. Subjective risk quantification involves use of unclear data, non-expert perceptions, or anecdotal evidence; whereas objective risk quantification involves analytical use of statistical information, research-based evidence, and other clearly factual data. The SOC infers that an objective analysis of risk is needed to develop sound standards of coverage. This was not completed.

Our SOC is no longer up-to-date, and is still in draft form five years later. The document was neither finalized, nor adopted by MFD elected officials. The SOC discusses the safe deployment of resources, and makes recommendations for improvements to establish an effective response force. Changes that have taken place in response areas since production of the SOC include: opening of the first high-rise hotel with a large casino area, a large warehouse store, a retail mall complex with one-hundred-plus tenants, and the opening of new station 66. Is further research needed to complete a Standards of Coverage document, plans for improvements, and safe deployment of resources?

The SOC is no longer as useful as it could be in helping MFD leadership make sound decisions regarding emergency response standards. Specific high risk locations, or target hazards, are listed in the SOC on a station-by-station first due response area basis. In the five years since work began to identify target hazards for inclusion in the SOC, so much change has taken place in the MFD response area that further study of the draft target hazards, along with potential new target hazards is warranted and is a large part of what is now needed to complete an up-to-date standards of coverage document.

Without up-to-date coverage standards, without improved plans in place for safe deployment of resources, without good objective knowledge of current target hazard priorities, safety of the MFD community and its firefighters may be compromised. This presents a potentially serious problem. Good sound information is needed by MFD and community leaders to base decisions on for new and improved policies and standards. Without such information, decisions will be based on subjective and unfounded information, with questionable results obtained.

The process used to create the draft target hazard list for the SOC was very informal, and used strictly subjective methods (J. Cole, personal communication, November 17, 2008). An initial list was compiled based on an inventory of pages in our existing *Site Plan Book* (many site plans in this notebook were last updated in 1996, 1997, and 1998). Input was sought from captains at each station. Then brainstorming sessions were used to arrive at a prioritized list using several different criteria, some of which included: type of occupancy, number and or mobility of potential occupants, and potential hazardous processes or substances at the occupancy.

The accuracy of the result of the SOC risk assessment process is questionable. Specific concerns include: (a) No mention of infrastructure such as city hall, municipal court, jail facilities, or post offices. (b) Inclusion of an outlying telecommunication switch facility as a low hazard, with no mention of an existing major central switch facility. (c) The same apartments listed twice, as a medium hazard in one station's area and a low hazard in another's. (d) Inconsistencies between response area hazards, such as several grocery stores listed as medium hazards in two stations' areas, with similar grocery stores lacking from another's. It appears that a uniform criterion for target hazard identification and evaluation was not followed.

An analytical look at hazards and risk in our community can be accomplished through a variety of methods. The NFPA Handbook states that both qualitative and quantitative analysis tools can be employed (NFPA, 2003a). Qualitative methods are considered subjective, while quantitative methods are considered objective. The Handbook explains that risk assessment involves both data analysis plus the further step of evaluation, where the value or importance of risks is determined. The authors state that this always needs to start with identification of the hazards that lead to risk.

Lots of questions need to be answered to fully illuminate the problems of a wide range of community hazards and risks in MFD. This ARP can only be the beginning of a process aimed at getting some answers. Beginning and continuing a comprehensive target hazard program, based on objective and quantifiable information, will bring many benefits to MFD. Hazardous buildings in the community will be more fully and accurately identified. Risks at these buildings will be analyzed. Appropriate pre-incident planning can occur. The target hazards will be prioritized to make best use of limited resources. Locations to target specific risk reduction efforts will be known instead of guessed at. Risk to the MFD community, and to their

firefighters, will be reduced. The mission of MFD includes providing quality emergency response and prevention services to the community. The primary purpose of this research, to objectively evaluate MFD target hazards, directly supports this mission by providing information needed to make good decisions towards providing quality services.

The phrase “Everyone goes home!” is instilled in attendees at the NFA. This ARP is linked to the EAFSOEM course at the NFA and directly relates to Unit 4 of this course which covers community risk assessment. The course coverage of an objective of this unit dealing with community risk assessment and critical hazard assessment gave strong direction to the topic and procedures of this ARP.

This ARP topic supports several operational objectives of the United States Fire Administration (USFA), which aim to reduce the loss of life from fire in children, the elderly, and firefighters, and to promote within communities comprehensive multi-hazard risk-reduction planning. Risks to children, elderly, and firefighters in MFD may be reduced, risk reduction planning in our community may be promoted, and these USFA objectives met by utilizing the findings of this ARP to guide the planning and implementation of an improved target hazard program in MFD. This will reduce risks within our community and to our firefighters, and help to reach the goal that everyone goes home safe from harm. Furthermore, through the addition of this ARP to the body of collected research at the NFA library, this ARP can reach much farther than the bounds of MFD in accomplishing the USFA objectives.

## Literature Review

A literature search was conducted for the purpose of surveying the breadth and depth of current knowledge related to the research questions of this ARP. Significant findings include literature from: Non-fire service resources, NFPA documents, NFA course guides and manuals,

ARP reports published by the NFA, materials from fire departments nationwide, as well as locally obtained information.

Several publications from outside of the fire service were located which provided relevant background and research information. Topics covered include: hazard evaluation in the chemical industry, and assessment for homeland security and Red Cross needs. The Center for Chemical Process Safety (2008) discusses many different methods and tools in their guide to hazard evaluation procedures used in the chemical industry. The authors emphasize the objective use of quantitative data, and the subjective use of qualitative judgments of team members based on past experience. The use of software, matrices, and relative ranking methods are among the many qualitative and quantitative techniques presented. Each hazard analysis technique is said to have its own unique set of strengths and weaknesses.

In a journal article discussing vulnerability assessment of critical infrastructures for homeland security, the authors suggests that the best method for assessing vulnerability of critical infrastructures may be a blended approach of both scientific and non-scientific methods (McCreight & Renda-Tanali, 2007). Scientific methods include objective quantitative measurement with numeric data, with non-scientific being very subjective relying more on qualitative observation and past experience. An example of non-scientific is results from discussion by an assembled team of experts. Scientific could involve engineering analysis with mathematical models. The authors claim that the measuring or quantification of hazard severity is critical to vulnerability assessment, and that no standard method exists so local governments are left to adopt their own approach. They caution against believing scientific methods to be superior simply due to their objective numerical data basis. An approach that makes sense and can be understood by citizens and community leaders is what matters the most. Similarly, the

U.S. Department of Homeland Security (DHS) *National Preparedness Guidelines* (DHS, 2007) suggest local officials should prioritize their critical infrastructure assets using a standardized risk assessment process, and that the specific methods used be tailored to local needs. Concerning hazard mitigation planning it was discovered that local governmental jurisdictions must formally adopt hazard mitigation plans, and that to be eligible for grant funding federal regulations require local plans be updated at least every five years, to reflect changes in community development and in priorities (DHS, 2008).

In a Red Cross handbook covering vulnerability assessment techniques, both qualitative and quantitative methods of risk assessment are discussed. The authors argue that vulnerability assessment is neither qualitative nor quantitative but rather a combination of both. Of the many assessment tools described, many, if not all, could be useful in various fire department risk and vulnerability assessment processes (International Federation of Red Cross and Red Crescent Societies, 2007).

The non-fire service sources recommend the use of multiple assessment methods, including both quantitative and qualitative. Many techniques are presented and could be adapted to fire service use. The methods of quantitative software use, along with qualitative use of matrixes and relative rankings appeared most immediately applicable to fire service use and inclusion in this ARP.

In the Commission on Fire Accreditation International (CFAI) guide to fire department standards of response coverage, a software application called *Risk, Hazard and Value Evaluation* (RHAVE) is introduced, explained, and recommended for this use (CFAI, 2003). This software is available at no cost. In addition to RHAVE the authors mention use of risk matrix, and expert

opinion of fire officers based on historical response data, as other methods commonly used in community risk assessment.

Several NFPA publications were obtained which provided much useful information to this ARP. The *Fire Protection Handbook* (NFPA, 2003a) states that it is critical to perform a formal fire risk assessment, one based on reliable historical data. The Handbook authors state that risk analysis always needs to start with identification of the hazards that lead to risk, then consideration of the probability and possible severity of the hazards. The authors explain that fire risk analysis involves estimation of the probability of an event happening, along with a measure of severity of the event. A fire risk assessment involves a risk analysis plus the further step of a risk evaluation, where the value or importance of risks is determined. Details on the use of a subjective two-dimensional risk matrix to perform a qualitative risk assessment are detailed in Section 3 Chapter 11 "Simplified Fire Risk Calculations" of the Handbook. An example of simply listing high risk locations, without some measure of the probability, is said to not constitute risk analysis. On the topic of subjective versus objective methods the authors state that most risk analysis methods do rely on some subjective opinion, and that it is needed to certain degrees.

In their coverage of pre-incident planning the Handbook authors mention that these plans are desirable for all target hazards. The pre-incident process starts with prioritization of buildings to be planned, followed by information gathering and analysis of the data. The use of their basic structure report form is suggested; and the use of a computer fire model called *HAZARD* is mentioned. They recommend models be used whenever possible, supplemented by expert opinion. A prioritization scheme of high-hazard, medium-hazard, and low-hazard occupancies, along with rural operations, is outlined.

In their treatment of fire incident data and use of statistics, the handbook authors cover measures of risk, trend analysis, and several ways to approach the analysis of fire data. Where geographical information system (GIS) data is available a location-based analysis provides a new approach that the authors say make it much more possible to identify trends and areas of high risk in a community. Regardless of the method of analysis used, the authors emphasize the importance of using analysis of data to identify which of many competing demands for limited resources to give higher priority to.

In discussing fire department information systems, the handbook authors state that handwritten forms, files, and file cabinets are still the method used to keep and store fire prevention records in many communities. This makes it very difficult to gather information on hazards in the community. Regarding the use of computer applications, they state that many communities have used them to manage fire prevention information and found computerized information systems are more complete and accurate. These systems save time, and provide useful data for decision makers. A fire prevention information system can be used to support a risk analysis process by facilitating record keeping on the type, quantity, frequency, and location of hazards. Records are needed to evaluate the effectiveness of risk reduction programs, and useful for budgetary reasons. It is important to have an efficient and up-to-date records management system. The handbook authors claim that no aspect of fire department record keeping is in need of improvement more than in fire prevention.

To summarize, the NFPA Handbook helped identify many components of a comprehensive risk analysis process, including: Data analysis techniques, identification of high risk areas, use of a risk matrix, target hazard prioritization, and possible use of GIS technology.

The NFPA (2007a) guide to fire risk assessment includes discussion of qualitative, quantitative, and semi-quantitative methods. Methods covered range from risk matrices to computational models. In selecting methods to use in assessments the authors suggested considerations include: stakeholder objectives, scope of assessment, acceptance criteria, decision makers, and available resources or constraints.

The NFPA (2004a) standard on provision of emergency services discusses risk, and plans for management of risk. The standard requires fire departments to develop programs for the regular assessment of potential hazardous situations, with special attention paid to high hazard locations. The appendix to this standard suggests that RHAVE can be used in community risk planning.

The NFPA (2004b) recommended practice for risk management explains that the risk management process should begin with risk assessment to identify, analyze, and prioritize risks. The risk assessment should be reviewed and updated regularly, as changes occur, and whenever indicated by post-incident analysis. Risk management should include strategic planning to establish acceptable levels of risks, service levels to provide, and risk reduction objectives. In support of a risk management process, fire departments should inspect properties with a focus on those identified as high hazard locations, conduct pre-fire planning for hazards, and implement public education programs to reduce risks.

The Fire Protection Research Foundation guide to developing risk-based documents establishes a process for employing fire risk analysis methods in decision making (NFPA, 2007b). For most analyses, qualitative or semi-quantitative approaches to risk assessment will suffice. For more complex situations, or where stakeholder concern is high, a more quantitative assessment may be needed. The guide explains that typically a qualitative method is used first to

eliminate acceptable risks from further analysis, and to identify more significant risks for further analysis of consequence and frequency. If a risk-informed decision can be made using simple qualitative risk assessment methods, there is no need to use more complex methods. When such a decision cannot be made, then more time consuming and data intensive quantitative risk assessment methods should be used.

The NFPA codes, standards, and recommended practices encompass fire service best practices. As such the documents reviewed lend strong support to the specific use of risk matrix and RHAVE software for community risk analysis, and were influential in the procedures used in this ARP.

In a European review of fire risk assessment methods for use in situations involving a strong cultural heritage factor a range of methods from qualitative to quantitative were examined (Streuve, 2003). Methods included checklists, ranking systems, and software applications. The author reported that checklists are often used in conjunction with code compliance to identify hazards; their advantage is being the fastest to use in identifying risk. Ranking systems are very simple, but can range widely in quality; they have an advantage in being relatively easy to understand for people outside the analysis process. Computer software is often used with quantitative methods, which can involve use of more time and greater cost, but are most informative. The author reviewed both FRAME and FiRECAM software among many others, but did not make any specific recommendation. The NFPA Handbook (2003a) also mentioned both of these software applications, but did not recommend either for fire service use.

In a large nation-wide study of fire resource deployment and firefighter safety it was reported that a scientifically-based community risk assessment is needed for fire service and community leaders to make sound decisions (Averill, Moore-Merrell, Notarianni, Santos &

Barowy, 2008). The study team intended to use VISION software for risk analysis, but found error in the software. They reported their intent to develop a new software model for risk assessment from the ground up. The authors also planned to work with VISION producers to update a new version of that software.

The NFA EAFSOEM course student manual states that most communities have based their emergency response on a perceived level of risk, not on an actual risk level determined by analytical methods, and that many communities are underprepared for the actual risks they face (USFA, 2007a). It is suggested in the manual that a well constructed assessment of risk is the essential first step towards management of hazards. Target hazards are defined as significant hazards; those that can strain the fire department response capability. Target hazards could include hospitals, schools, churches, storage facilities, military sites, or manufacturing plants for example. A comprehensive FEMA hazard list is included. A series of subjective matrixes are suggested for initial hazard identification, vulnerability assessment, and risk rating. The manual discusses use of qualitative versus quantitative measurements in risk rating, suggesting that complex statistical measures are not essential, and emphasizes there is more than one way to assess risk. The methods chosen should help open up the process to community members and leaders, helping them to see the problems facing the fire department.

In the NFA's course manual for its community risk reduction class a model is presented for a process to reduce risk in a community (USFA, 2007b). Within the risk assessment component of the model are the tasks of: identify hazards, assess vulnerability, and establish priorities. In the manual six activities for assessing community risk are explained. This serves as a six step model to follow for a comprehensive process to identify and assess the hazards and vulnerabilities in a community. The manual relies heavily on the use of several matrices in the

analysis process. For assessment in the context of fire problems the critical target hazards need to be identified and analyzed to determine what makes them a critical risk and what would the consequences to the community be from a fire at the facility. Both NFA manuals emphasized the use of simple matrix analysis, and the importance of fire service and community partnership in the risk reduction process.

Twenty recent ARPs were found that were deemed significant to this research. Topics ranged from high-rise risk assessment, to an accreditation process, to improved insurance ratings. Four researchers who conducted risk and hazard assessments used NFA matrix tools to successfully identify and prioritize critical hazards in their communities (Bowman, 2006; Jankowski, 2006; Moberg, 2006; Mallory, 2007). Two other researchers with the same focus used RHAVE software to accomplish their assessments. Dishner (2002) suggests that fire crews drive through their response areas on a quarterly basis to look for changes in occupancies, renovations to buildings, and new hazards. Marti (2003) found RHAVE easier to use than other methods considered, and found 92% of fire departments surveyed who used RHAVE would recommend its use to others. Four additional researchers who conducted assessments reported use of a combination of tools. Wallace (2003) used a rating scale system and unspecified commercial software for data analysis. He recommended that an objective, quantitative system should be used. Egut (2007) used historical data and a survey of community members, and reported similar results obtained with both methods. Sunderman (2007) used a survey of businesses and the NFA matrix process. She used the city business license process to distribute the surveys, and recommended research towards future RHAVE use. Krueger (2008) used historical data, rating scales, and matrix methods. He did not use VISION software, described as the most quantitative available, due to substantial resource requirements. Krueger found the use

of qualitative matrix analysis simple yet effective, concluding it is better to have a useful qualitative assessment than none at all, and recommended to plan for use of VISION. Six ARPs were located wherein researchers examined various assessment tools available for the conduct of risk and hazard evaluation; four of those recommended RHAVE (Smith, 2002; Kobarda, 2002; Phillips,2003; Carter, 2003). Kobarda also developed a worksheet for gathering the needed data. Carter surmised that of the many good tools available, there is no one tool that best meets all needs, and many are available for little or no cost- including RHAVE. Two researchers recommended use of a combination of methods (Zimmerman, 2005; Blackley, 2008). Zimmerman suggested use of historical data, NFA matrices, and RHAVE; while a survey by Blackley revealed NFA risk matrixes, RHAVE and VISION as methods used commonly for target hazard site assessments. In two ARPs which looked specifically at the RHAVE application researchers found that RHAVE was the tool of choice for structure fire risk assessment (DeIorio, 2003); and that data import from other data bases was possible, more efficient, and desirable for large amounts of records (Phillips, 2004). In two ARPs with different focus, Davis (2005) researched a fire department accreditation process and found RHAVE to useful, although technical support was no longer available due to federal funding cuts. He considered other useful software programs, but cost prohibited their use. Flynn (2005) focused on ways to improve a city's insurance rating and made a recommendation of pre-fire planning all target hazards. One other relevant finding was the frequency suggested for update of risk and hazard data. Two researchers suggested five year intervals (Dishner, 2002; Marti, 2003); while two others suggested annual updates (Wallace 2003; Krueger, 2008).

To summarize the research findings from these ARPs: There seems to be as many methods for risk and hazard analysis as there are reasons for doing it. The predominant methods

mentioned were RHAVE software, and NFA matrices; with more recently developed VISION software mentioned only in the two most recent ARPs from 2008. Ease of use and cost were two factors often mentioned in the selection of methods used, and was a significant factor for this ARP.

Standard of cover documents were found on-line for six fire departments nationwide. Parker Fire Protection District (2002) and Corte Madera Fire Department (2005) used RHAVE and historical data in their risk assessment. Kitchener Fire Department (2004) used RHAVE and historical data combined with rating scales. Winter Park Fire Rescue (2005) initiated RHAVE use in 2004, but found it did not adequately assess all known risks. They used a hybrid process that combined RHAVE with a military rating scale process, and GIS mapping. The resulting overall risk category distribution was said to mimic that of RHAVE. Sioux Falls Fire Rescue (2006) and Tracy Fire Department (2007) used RHAVE and a risk matrix to evaluate community risk. Sioux Falls also reported they have since then converted to the VISION software, and developed data collection worksheets for commercial building surveys and preplanning target hazards.

Standard of cover documents were found on-line for two Pacific Northwest fire departments. Woodinville Fire and Life Safety District (2005) used historic data, planning zones, and defined risk levels. It was reported they would begin using RHAVE to improve their risk assessment process. Portland Fire & Rescue (2008) used a hybrid process for risk assessment which combined an objective RHAVE analysis with a subjective survey method of pre-defined hazard categories. In the process they found that a substantial amount of the information needed about specific locations was not being collected in the field, and they made many assumptions during RHAVE data entry because of the limited information they had available. Subsequently

Portland planned to establish a process for collecting additional data needed for future RHAVE use. The results of their RHAVE study revealed that 34% of their buildings required fire flows greater than they could provide, and only 10% of those had sprinklers. The majority of Portland's high-risk occupancies were located in the downtown core. Many high-rise buildings generated high risk scores. They reported having this information allowed their fire-risk planning efforts to become part of a sound decision-making process.

The results of the literature search had a significant impact in the procedures used to answer all four research questions. For question one, the wide variety of risk and hazard evaluation tools mentioned in the literature was helpful to determine what tools might be used locally by other fire departments for identification and prioritization of target hazards. For question two, the research of others gave a clear indication of what objective evaluation tool to use for evaluation of current MFD target hazards. For question three, the literature was helpful in defining criteria for comparison of current MFD target hazard priorities with those obtained by a more objective evaluation method. For question four, the collective experience of other EFOs shared through their ARPs, along with information gleaned from other sources, helped to frame an ultimate recommendation for this ARP regarding the best tools to use for target hazard identification and evaluation at MFD.

## Procedures

Original research was conducted for this ARP using the evaluative research method, which necessarily involved a systematic process of collecting and analyzing data in order to make decisions and draw conclusions. The purpose of this research was to assess our current process for identification and evaluation of target hazards in MFD. The objectives of this research were to: identify other viable methods of target hazard identification and evaluation,

then to compare our current list of high risk occupancies to that obtained through a more objective evaluation of the same occupancies, and finally to recommend changes, if indicated for improvement, to our process for identification and prioritization of target hazards.

To accomplish those objectives, four research questions were composed, with procedures tailored to answer each question. Those procedures included: literature review, structured interviews involving a group of comparable departments, a software-based target hazard assessment process, and final evaluation of the current MFD target hazard program relative to the research results. The procedures followed to complete this ARP flowed in the same order as the research questions were posed.

Question 1: What methods are fire departments comparable to MFD using for identification and prioritization of target hazards? To answer this question structured interviews were used, defined as "an interview in which questions to be asked… are all predetermined, and where maximum consistency across interviews is needed. Structured interviews are used in cases where information is to be obtained from…members of a comparison group" (FEMA, 1994a, p. 5-4). Fire departments comparable to MFD were used to identify the variety of target hazard evaluation tools used at those departments.

This process started with the literature search. The wide variety of risk and hazard evaluation tools mentioned in the literature was helpful to determine what tools are used by other fire departments for identification and prioritization of target hazards. The search for literature was initiated online through the NFA Learning Resource Center (LRC) in Emmitsburg, Maryland. The LRC was accessed through its website at: http://www.lrc.fema.gov/index.html. By utilizing their on-line card catalog to search for relevant literature using keywords various

journal articles and applied research papers were retrieved. Keyword used in searches included: Hazard analysis, hazard identification, risk evaluation, risk management, and target hazards.

Additional literature was obtained using other resources. Online searches using Google.com helped locate information from fire department web sites, and other non-fire services web sites. Some information was obtained directly online, while some was requested from other sources. The local Everett Community College library was helpful in obtaining material from distant libraries through an inter-library loan process. NFPA standards were available from the MFD Fire Prevention library.

The literature reviewed for this ARP revealed many different types of tools that can be useful, and appropriate to the fire service, for identification and prioritization of target hazards. A list was compiled of the tools used, without regard for objectivity or subjectivity, for risk and hazard evaluation methods as mentioned in the literature reviewed. For evaluation purposes the relative rank of each tool was determined based on the number of times each was mentioned in the literature.

To facilitate structured interviews an interview form was developed around the standardized question: What evaluation tools does your department use for identification and/or prioritization of target hazards? The compiled list of tools accompanied the question. The question was intentionally closed-ended with yes and no answers, which provided uniform results and simplified the data analysis. Two open-ended questions were included to allow interviewees to expand on their use of other software or tools not included in the list. The completed interview form is shown in Appendix A. Identification of fire departments comparable to MFD had been completed during a previous ARP (VanBeek, 2007). These same comparable departments, shown in Table 3, were selected for use in this ARP. These

departments were found to be the most recent list available that had been validated against objective criteria.

Table 3. *Comparable Departments*

| Department Name | Location |
|---|---|
| Lynnwood Fire Department | Lynnwood, WA |
| Edmonds Fire Department | Edmonds, WA |
| Mount Vernon Fire Department | Mount Vernon, WA |
| Bothell Fire and E.M.S. | Bothell, WA |
| King County Fire District No. 2 | Burien, WA |
| King County FD No. 43 | Maple Valley, WA |
| Bremerton Fire Department | Bremerton, WA |
| Pierce County FD No. 2 | Lakewood, WA |
| Thurston County FD No. 3 | Lacey, WA |
| Olympia Fire Department | Olympia, WA |

In conducting the structured interviews, a fire code official representing each of the comparable departments was contacted by phone and by email. Initial contact by phone was used to explain the research purpose; and to explain the need to ask questions and gather information related to their target hazard program. These initial contacts were followed up by emails to the fire code officials with the set of structured interview questions sent as an attached document. Completed interview forms were returned by email. Individual interviews were then conducted over the phone with the fire code officials to clarify any ambiguities in questions and answers, to

allow for limited discussion and explanation to take place, to fill in any missing answers from individual returns, and to thank them for their assistance with this ARP.

Confidentiality of interviewees was maintained in the tabulating and reporting of the raw data collected. A computer spreadsheet was developed and used to tabulate the data. To objectively evaluate this data, yes answers were counted and used to determine a relative rank for each tool from the set.

Question 2: What prioritized results are obtained through objective assessment of MFD target hazards? To answer this question, an objective evaluation method was applied to our target hazards, and resulted in a prioritized list of these hazards based on the risk scores obtained.

The specific target hazards used for this ARP were obtained from the MFD SOC. This document was found to contain a risk assessment section, where hazard locations were listed by station area, and by high, medium, and low risk categories Appendix B shows a copy of this SOC section. A limitation of this research was the lack of a current MFD list of target hazards. It was assumed the list of hazard locations in the SOC was the closest thing in MFD to an official and current list of target hazards. Other possibilities considered were all 178 locations detailed in the MFD *Site Plan Book*, and a list of all 386 occupancies assigned to fire prevention personnel for fire inspections instead of assigned to operations crews. The occupancies identified in the SOC risk assessment best met the definition of target hazard contained in the EAFSOEM course manual: significant hazards; those that can strain fire department response capability (USFA, 2007a).

The CFAI software tool RHAVE was selected for use based on the results of literature reviewed and cost involved. The literature gave the strongest indication that RHAVE was the objective evaluation tool to use for evaluation of current MFD target hazards, as it was the

objective tool cited most often in the literature reviewed. VISION was also considered but rejected due to a prohibitive cost. RHAVE was available at no cost.

The RHAVE software and users manual was Retrieved from the website: http://www.radware-solutions.com/radrhave_registration.htm. RHAVE was installed on a MFD laptop computer with assistance from MFD Technology and Support Services. Instructions given in the downloaded RHAVE version 1.5.2 installation and users manual were followed to complete initial setup of the software with required MFD information.

All 122 occupancies in MFD that were identified in the SOC risk assessment in high, medium, and low risk categories were entered into the RHAVE program. Adequate information was gleaned from existing pre-incident plans and inspection records to fulfill RHAVE data entry requirements, without a need for site visits. Information was entered for six different vulnerability factors defined in the program: Premise, building, life safety, risk, water demand, and value. The software automatically built a database from the information entered. The RHAVE program calculated scores reflective of the risk vulnerability for each occupancy, called the Occupancy Vulnerability Assessment Profile (OVAP) score. It also placed the occupancy into one of four OVAP categories based on the OVAP score. The categories defined by the program were: Maximum for scores of 60 or greater, significant for scores ranging from 40 through 59, moderate for scores ranging from 15 through 39, and low for scores less than 15. The multiple data sorting and reporting options provided by the RHAVE software, along with creative use of several data fields, were used to generate adequate reports needed to show the desired results. Within the OVAP, the data field for address number was used instead for a number indicating the first due station and risk category. For example: 61H was entered for a high risk occupancy in station 61's area, 63M for a medium risk occupancy in station 63's area,

and 65L for a low risk occupancy in station 65's area. This modified use of the address field helped to facilitate later comparison of risk categories. The street name and type data fields were used for occupancy name and MFD site plan number respectively because MFD site plans are organized by that information instead of address.

Question 3: How do MFD target hazard priorities compare with those obtained by an objective assessment method? To answer this question, Results of the RHAVE evaluation were compared to those of our current list of target hazards. Spreadsheets were used for the comparisons. Side-by-side tables were made for each station area, showing the current MFD risk categories, and OVAP scores and categories, for each of the target hazards. Differences were noted for the target hazards as to what risk category each was placed in by the two different risk assessment methods.

Differences between terms used for comparable risk categories of the two assessment methods were not deemed significant. Both methods contained a low risk category. The medium category of the SOC method was deemed equivalent to the moderate category of the RHAVE assessment. The high category of the SOC method was deemed equivalent to a combination of both significant and maximum categories of RHAVE.

For evaluation purposes, the target hazards were reprioritized according to the RHAVE OVAP score results. All differences noted between categories were deemed significant. For example: A target hazard rated medium by the SOC risk assessment and low by the RHAVE assessment was considered a significant difference. A hazard rated as a high risk by the SOC and significant by RHAVE would not be, since it was grouped within equivalent risk categories by the two assessment methods. Results were evaluated by totaling the number of significant

differences within each station first due response area, and for the group of 122 target hazards as a whole, and expressed mathematically as a percent difference.

Question 4: What methods of target hazard identification and prioritization should be recommended for future MFD use? To answer this question, results from the objective evaluation of MFD target hazards, from structured interviews with comparable departments, and from the literature reviewed all had to be considered. An evaluation criterion for final recommendation was established that three methods should be recommended. Criteria were established separately for the final consideration of subjective and objective risk assessment methods. For the results of objective evaluation of MFD target hazards, an evaluation criteria was established that an objective method should move forward for final recommendation if there was more than ten-percent significant differences found in the comparison of results; based on differences found between the subjective MFD list of target hazard risk categories and the objective RHAVE OVAP score based categories. For subjective methods, criteria was established that the top three evaluation tools most often mentioned in literature reviewed, and from comparable departments, would all be carried forward for final consideration. To determine a final recommendation, the methods were all ranked in order according to the product of their relative rankings in the interview results and the literature review results.

This research was limited by the time allowed for research. This ARP was completed during the six-month period from October 2008 through March 2009. Additional time would have allowed collection of data from a larger group of fire departments, to conduct a broader based survey of tools used, perhaps state-wide. User groups for particular software tools might have been identified, or initiated, to aid in the evaluation process.

## Results

The results of this research were needed to assess the target hazard evaluation method that was used in MFD, to identify other methods successfully used in the fire service, and for the final recommendation made regarding future methods to use. The results of this ARP included: (a) a variety of methods found successfully used in the fire service, (b) target hazard priorities for MFD based on RHAVE software use, and (c) suggested methods for future MFD use. The research results were reported in the same order as the four research questions were presented.

For question 1 the desired result was a list of methods that fire departments comparable to MFD have used for identification and prioritization of target hazards. Table 4 shows the results from comparable departments.

Table 4. *Results of Structured Interviews with Comparable Departments*

| Evaluation tools used: | **Bothell** | **Bremerton** | **Burien** | **Edmonds** | **Lacey** | **Lakewood** | **Lynnwood** | **Maple Valley** | **Mt. Vernon** | **Olympia** | **Yes count** | **Relative rank** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Officer judgment | yes | | yes | yes | yes | yes | yes | yes | yes | | 8 | 1 |
| Survey group | no | | no | no | no | no | yes | no | yes | | 2 | 5 |
| Site self-survey | no | | no | no | no | no | yes | yes | no | | 2 | 5 |
| Site plan | yes | | yes | no | yes | no | yes | yes | yes | | 6 | 2 |
| Pre-incident planning | yes | | no | yes | no | yes | yes | yes | yes | | 6 | 2 |
| Inspection checklist | yes | | no | no | no | no | yes | yes | yes | | 4 | 3 |
| Pre-defined hazards (Building code type) (FEMA hazard list) | yes | | no | no | no | no | no | yes | yes | | 3 | 4 |
| Data worksheet | no | | no | no | no | no | yes | yes | yes | | 3 | 4 |
| Standard of coverage | no | | no | no | no | no | no | yes | yes | | 2 | 5 |
| FD based RMS | no | | no | no | no | no | yes | yes | yes | | 3 | 4 |
| GIS mapping | no | | no | yes | no | no | no | yes | no | | 2 | 5 |
| Custom spreadsheet | yes | | no | yes | no | no | no | no | yes | | 3 | 4 |
| Other software used: | Fire House, Fire Zone for drawing, also Excel and Word | | | | | | | | | | | |
| Other tools used: | Interaction between prevention, operations, and training<br>Engine company inspections | | | | | | | | | | | |

The results shown in Table 4 provided three methods for identification and prioritization of target hazards that were most used by comparable departments. Officer judgment (a form of expert opinion) was used by all. Site plan and pre-incident planning use was reported by 75% of the fire officers interviewed. Every department interviewed used at least 2 different tools, and as many as 10, with an average of 6 used. The criteria established for this set of tools was that the top three would be carried forward for further consideration in the final recommendation.

Unexpected findings included: Two departments use of 10 tools, no use of objective methods, and difficulty getting interviews completed. Two interviews were not completed. Multiple contacts were required with all but two departments.

For question 2 the desired outcome was prioritized results for MFD target hazards obtained through objective evaluation. The CFAI RHAVE software was selected for use based on findings from the literature reviewed. Figure 1 shows a screen shot of RHAVE OVAP score statistics after MFD target hazard data was entered.

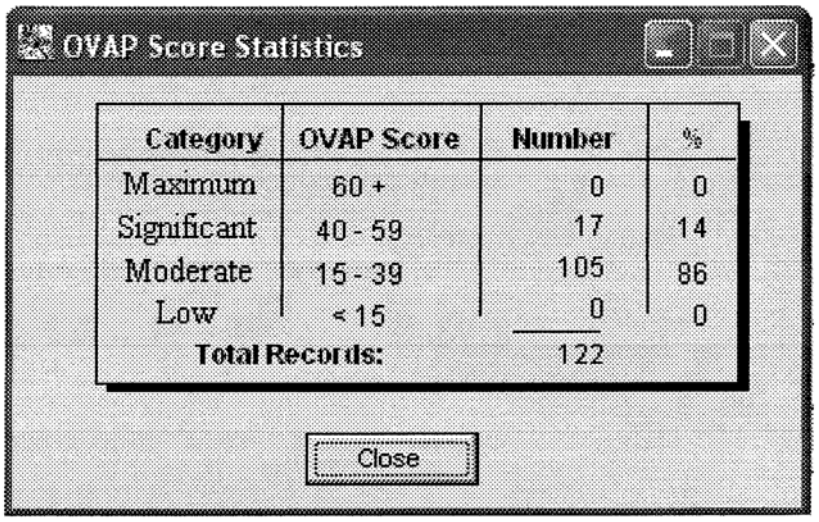


Figure 1. Occupancy vulnerability assessment profile (OVAP) score statistics reported with RHAVE software for all 122 Marysville Fire District target hazards.

Figure 1 shows the RHAVE summary of all OVAP category counts and the percentage of occupancies grouped into each category through the RHAVE analysis. Of the 122 target hazards that were entered into the data base, 86% were grouped into the moderate risk category, 14% as significant, and none were determined to be low risk hazard or maximum risk hazard. It was an unexpected finding to have all occupancies grouped into only two of the RHAVE OVAP categories, a few low and maximum risk hazards were expected.

The report produced by RHAVE for all MFD target hazards, sorted by their OVAP scores, was shown in Appendix C. The OVAP scores ranged from a low of 24.40 to a high of 52.13. The RHAVE report shows that adequate fire flow is not available for 9 of the top 10 significant risk hazards. Some unanticipated manipulating of the RHAVE data fields was needed to produce the most useable report as shown in the appendix. For purposes of this ARP, several data fields were used for purposes other than intended by RHAVE, as data field titles were found to be not user configurable. Several irregularities in MFD documents were uncovered in the process of entering occupancy data into the RHAVE data base: (a) The MFD SOC target hazard lists contained a few duplicates, with locations listed in more than one station area; (b) Arlington airport, which is not located in MFD, was included; (c) as the list is 5 years old, a few occupancies were gone, vacant, or had different occupants; (d) similar hazards rated higher or lower in different station areas; (e) a higher portion of downtown station 61 locations had site plans than did outlaying station 65 locations; and (f) several sites that were rated high hazard in the MFD SOC had no site plan.

For question 3 the desired result was a comparison of the MFD SOC target hazard priorities to those obtained by an objective risk assessment method, with a measure of the degree of difference between the two. Results of the RHAVE assessment were compared to those of the SOC risk assessment.

Table 5 shows summarized statistics regarding the distribution of target hazards within the risk categories of both assessment methods for the 122 MFD target hazards as a group.

Table 5. *Comparison of Risk Category Results*

| MFD SOC assessment | | | RHAVE OVAP assessment | | |
|---|---|---|---|---|---|
| Risk Category | Number of Hazards | Percent | Risk Category | Number of Hazards | Percent |
| | | | Maximum | 0 | 0% |
| High | 48 | 39% | Significant | 17 | 14% |
| Medium | 43 | 35% | Moderate | 105 | 86% |
| Low | 31 | 25% | Low | 0 | 0% |
| Total | 122 | 100% | Total | 122 | 100% |

Comparison of the numbers in Table 5 showed differences in the risk evaluation results between comparable SOC and RHAVE risk categories. The greatest difference was found in the medium and moderate categories, which differed by 51 percentage points. The high and significant categories, along with both of the low categories, differed by 25 percentage points.

A summary of the detailed comparisons made between risk assessment results for the individual target hazards within each MFD station area is shown in Table 6.

Table 6. *Comparison of Risk Assessment Method Differences by Station Area*

| Station Area | Target Hazards | Category Disagreements | Percent Difference |
|---|---|---|---|
| 61 | 42 | 30 | 71% |
| 62 | 32 | 20 | 63% |
| 63 | 30 | 18 | 60% |
| 65 | 18 | 14 | 78% |
| Total | 122 | 82 | 67% |

In the detailed comparisons it was found that many target hazards were placed in two different risk categories by the two different assessment methods. Table 6 showed the unexpected finding that the results of the two risk assessment methods were more different than alike, with a total difference of 67% throughout all MFD areas. The degree of difference was

found to be consistent throughout the four different MFD station areas, ranging from a low of 60% in the station 63 area to a high of 78% in the station 65 area. Appendix D shows the detailed comparisons made of the risk assessment results for all 122 target hazard locations, sorted by station areas and risk categories.

For question 4 the desired result was three methods recommended for future target hazard identification and prioritization in MFD. At least one hazard assessment method was to be objective if the differences that resulted from earlier comparison with the subjective SOC method exceeded 10%. Results from the objective evaluation of MFD target hazards, from structured interviews with comparable departments, and from the literature reviewed all had to be considered.

Results of objective evaluation of MFD target hazards shown in Table 6 showed a 67% difference in results of risk categories when comparing RHAVE use to the MFD SOC results for target hazards. This exceeded the 10% difference evaluation criterion that was established; therefore an objective method of target hazard evaluation, the RHAVE software application, was included in the final recommendation.

Based on the interview results shown in Table 4, these three evaluation tools used most often by comparable departments were moved forward for final consideration: use of officer judgment, use of site plans, and use of pre-incident planning.

Results of the literature search were also used to determine what evaluation tools to include in the final recommendation. Forty different fire service related sources were found and reviewed to identify a range of risk assessment options. Table 7 shows the compiled list of tools mentioned in the literature reviewed, and the number of references made to each of the tools.

Table 7. *Hazard Evaluation Tools Mentioned in Literature Reviewed*

| Evaluation tools mentioned: | Number of mentions | Relative rank |
|---|---|---|
| Officer judgment | 1 | 8 |
| Survey group | 2 | 7 |
| Site self-survey | 1 | 8 |
| Site plan | 1 | 8 |
| Pre-incident plan | 3 | 6 |
| Inspection checklist | 1 | 8 |
| Pre-defined hazards<br>(Building code type)<br>(FEMA hazard list) | 3 | 6 |
| Rating/ranking scales | 5 | 4 |
| Risk rating matrix | 15 | 2 |
| Data worksheet | 3 | 6 |
| Standard of coverage | 8 | 3 |
| FD based RMS | 1 | 8 |
| GIS mapping | 2 | 7 |
| RHAVE software | 23 | 1 |
| VISION software | 4 | 5 |
| HAZARD software | 1 | 8 |
| Custom spreadsheet | 1 | 8 |
| Total | 75 | |

The results shown in Table 7 provided the three methods of risk and hazard evaluation that were most often mentioned in the literature. The RHAVE software was the number one mentioned tool, followed by use of risk rating matrixes and standard of coverage assessment procedures. The criteria established for this set of tools was that the top three would be carried forward for further consideration in the final recommendation.

Table 8 shows the tools moved forward for final consideration with their rankings from the interview and literature review results. A weighted rank was calculated to determine the final rank order of the tools.

Table 8. *Recommended Methods from Evaluation, Interviews, and Literature*

| Recommended methods | Interview rank x | Literature rank = | Weighted rank | Final rank |
|---|---|---|---|---|
| RHAVE software | 6 | 1 | 6 | 1 |
| Officer judgment | 1 | 8 | 8 | 2 |
| Pre-incident planning | 2 | 6 | 12 | 3 |
| Risk rating matrixes | 6 | 2 | 12 | 3 |
| Standard of coverage | 5 | 3 | 15 | 4 |
| Site plan | 2 | 8 | 16 | 5 |

Table 8 shows the top three target hazard assessment methods included the number one ranked RHAVE software. It was the only objective risk assessment tool among the finalists. The top subjective method found was use of officer judgment which ranked number 2, followed by a tie for third place with pre-incident planning and use of risk rating matrixes.

Of the top four ranked methods, two ranked high by other fire departments and low by literature reviewed, while the other two ranked oppositely. The number 1 ranked RHAVE software, an objective tool, was not used at all by any comparable fire departments. That finding was somewhat unexpected. Through the analysis of literature reviewed RHAVE was the most often mention risk assessment process. RHAVE was used to evaluate and prioritize MFD target hazards. The results of the objective assessment of those hazards yielded risk categories for the hazards that were different from the MFD SOC categories to an unexpected degree. It was found through the detailed RHAVE report shown in Appendix C that 7 of the top 10 significant risk hazards as rated by RHAVE were not considered high risk in the SOC, but were medium risk instead. Number 2 ranked officer judgment, a subjective tool, was the highest rated tool by

comparable fire departments, but was rated low by the literature review analysis. Number 3 ranked pre-incident planning and risk rating matrixes both involve subjective use of qualitative and quantitative data. Both also ranked high in one analysis and low in the other, but in opposite analysis. These top four ranked assessment methods were recommended for use.

In summary, the results of this ARP did allow for an objective assessment of MFD target hazards, analysis of a variety of assessment tools used by others in the fire service, and final recommendation of at least four methods of target hazard risk assessment for future MFD use.

## Discussion

The results of this ARP were more than adequate for the purpose of improving our target hazard assessment process in MFD, and in providing answers to the research questions. The results agree well with the findings of others, that there is more than one way to evaluate hazards. The results do show that looking at target hazards in a new way, with new tools and better information, does shed light on the degree of risk these hazards pose. The implication for MFD is that improvement is possible, and needed, to reduce risk from target hazards. The discussion of results follows the same order as the four research questions.

For question 1, the results from comparable fire departments, and the prerequisite literature search, suggested a wide variety of tools used for target hazard identification and evaluation. The finding that other departments used an average of 6 and as many as 10 different tools was supported by the literature. Seven researchers reported or recommended use of a combination of tools. Wallace (2003) used a rating scale system and unspecified commercial software. Egut (2007) used historical data and a survey of community members. Krueger (2008) used historical data, rating scales, and matrix methods. Sunderman (2007) used a survey of businesses and a matrix process, and recommended future RHAVE use. Two additional

researchers recommended use of a combination of methods (Zimmerman, 2005; Blackley, 2008). Carter (2003) concluded there were many good tools available, and no one tool that best meets all needs.

Contrary to the literature, the eight comparable departments interviewed made no use of objective assessment tools. This may be due to the relatively recent advent of tools like RHAVE, or general resistance to change in the fire service. Ideas for improvement at MFD should included short term and long term measures. Continued and expanded use of RHAVE can happen now, as can implementation of a pre-incident planning procedure. Future use of VISION and GIS will take additional work, but seem reasonable courses of action.

For question 2, the results from RHAVE assessment of MFD target hazards gave informative results that helped reveal more about the nature of these hazards. Finding the majority of target hazards in the moderate risk category agreed with the one ARP found that reported RHAVE results. Marti (2003) assessed 110 occupancies and found: 3% low, 68% moderate, 29% significant, and 0% maximum hazards. I concur with Marti's opinion that RHAVE was easy to use. The finding that inadequate fire flow was a major factor in high risk ratings supported the finding by Portland Fire & Rescue (2008) that 34% of their buildings required fire flows greater than they could provide. They also found many high-rise buildings generated high risk scores. The one and only high-rise in MFD did as well.

Advantages foreseen for MFD in the use of RHAVE, or other objective tools, are that a standardized risk assessment tool will be used, data can be linked to the city GIS, and measurable data is gained for useful future comparisons. For example, if improvements are made to the city water supply, then lower risk can be measured. Or conversely, if water system demand increases adversely affect fire flow, the increased risk can be measured. RHAVE could potentially be used

in the pre-construction plan review stage to evaluate risk of a proposed building. A disadvantage for RHAVE specifically is a lack of customer support and upgrades, making it already somewhat obsolete. I agree however with Davis (2005), who found RHAVE still useful regardless of the technical support issue.

For question 3, use of subjective and objective hazard assessment methods were compared. Use of a strictly subjective method, as it was found had been the case at MFD, was supported by four researchers who reported successful use of matrix tools alone (Bowman, 2006; Jankowski, 2006; Moberg, 2006; Mallory, 2007). The conclusion that RHAVE software was the tool of choice for comparison was supported by three researchers who reported use of RHAVE exclusively (DeIorio, 2003; Dishner, 2002; Marti, 2003). The results from RHAVE assessment of MFD target hazards, regarding the risk category assigned to any particular hazard, were found to be quite different from past MFD results using subjective methods. This finding seems to disagree with that of Winter Park Fire Rescue (2005), who found the resulting overall risk category distribution of a hybrid process used mimicked that of RHAVE. I expected findings to be somewhat dissimilar. What would be the point of multiple methods that all yield the same findings?

Having two methods yield results that are up to 78% dissimilar, when assessing the same set of hazards, seems unacceptable. On the other hand, all disagreements in risk category were only one level apart. None were so grossly dissimilar as to yield a high and low rating for the same occupancy. The discrepancies may be explained by a number of possibilities: (a) The rating categories do not precisely align or have slightly different basis, or (b) the effect of different sets of variables or factors considered in the two methods, or (c) problems with data used by both

methods such as water supply changes over the five years between the two assessments. A well designed application of the two methods simultaneously could control these factors.

For question 4, the results from synthesis of a final rank order for the top six risk assessment methods produced what appears to be a very good recommendation for tools to use. There are certain advantages to MFD in the future use of a mix of both subjective and objective tools. This thought is strongly supported by the findings of two researchers who both recommended use of a similar combination of methods (Zimmerman, 2005; Blackley, 2008). Benefits will include: reduced risk to our community and firefighters, hazards more fully recognized and addressed, and enhanced pre-incident planning. This assertion is supported by the finding of Flynn (2005) who concluded pre-fire planning all target hazards improved a community's insurance rating- a measure of risk. Each tool for hazard assessment has its own strengths and weaknesses. Some are better for some hazards than others. It only makes sense to have the best tools for each job in the tool box so that firefighters will be best prepared to tackle the dangers their job.

One last item uncovered in the research worthy of discussion is the transition from RHAVE software to its successor VISION or to another yet to be produced software platform. Although I found no use of such software with comparable fire departments, I believe it makes sense to plan and prepare for this now; especially if RHAVE will continue to be used for the short term.

A fair amount was found in the literature search about VISION, but not much about a possible alternative under development. Regarding these two latest software developments, Krueger (2008) described VISION as the most quantitative available, but chose against its use due to substantial resource requirements. He did however, recommended planning for the use of

VISION. Sioux Falls Fire Rescue (2006) reported they had used RHAVE, but converted to VISION. Blackley (2008) reported VISION used commonly for target hazard site assessments. Although Averill et. al. (2008) reported the intent to develop new software for risk assessment from the ground up; they also reported a plan to work with VISION producers to update a new version of that software. This begs the questions: Will we end up with two similar and competing products; or a more costly feature loaded VISION and a no-frills no- or low-cost alternative? Will transfer of data be possible? What can we do now to prepare?

## Recommendations

There seems to be as many tools for target hazard risk assessments as there are reasons for doing them. What kinds of tools can we plan to use now, so that we can get good at doing them? Many recommendations follow from this ARP, with each one able to build and improve upon the current foundation. Some changes will be quick and easy, with others taking more time and effort, but all based soundly in this research. These changes will all help to complete the goal of this research: To lower risk in our community through an effective program targeting high risk hazards.

Short term changes to recommend include measure addressing data gathering, standards of coverage, and implementation planning. For the time being, our use of RHAVE should be continued and expanded. A process should be established for collecting additional data needed for RHAVE. Data collection worksheets should be developed. Measures to expand the data base should include crew surveys during inspections of commercial buildings and preplanning of target hazards. Businesses self-survey forms should be developed for data gathering that can be linked to our business licensing process.

The more immediate benefits to MFD of these additional data gathering measures include having our target hazard risk management efforts become part of a sound decision-making process. Additionally, doing these things now helps get us ready for VISION, or any other future tool that emerges. The longer we wait, the more difficult it becomes to stay ahead of the risk game. An immediate implementation team should be formed with members representing operations, prevention, training, administration divisions of MFD. This team will do the initial work of planning specific strategies to move these measures forward.

Long term changes to recommend include measures addressing standardization of assessment methods, standards of coverage, technology upgrades, and continual re-evaluation. Without a state or national standard prescribed for risk assessment methods, MFD needs to develop a local standard, with policies and procedures tailored to local needs. A process that makes sense and can be understood by citizens and community leaders is what matters the most. Local stakeholders should be invited into the process, and formal adoption by MFD fire board of directors' resolution should be sought. This process will benefit MFD by being open to community members and leaders, helping them to see the problems facing the fire department.

Recommendation is made for a renewed attempt to produce a standards of coverage document for MFD. Once completed this should be made available to the public on the MFD web site. An advantage here is of educating the community on risks, hazards, and service level expectations; which can ultimately help to facilitate community risk reduction efforts. An additional benefit could include facilitation of future MFD accreditation efforts.

Recommendation is made to partner with the city's community development department to explore data file import and export capabilities between GIS and RHAVE. This is desirable for efficiently collecting large amounts building and property data into the RHAVE data base,

and for exporting hazard information to GIS for advanced risk mapping. A GIS location-based analysis will provide MFD with a new tool for with an enhanced ability to identify trends and areas of high risk in our community. An additional technology recommendation is budgetary planning for an upgrade to VISION, or another new software tool for target hazard risk assessment. Although some cost is involved, the improved software platform and support is needed.

Recommendation is made to re-evaluate RHAVE occupancy data (or other risk software data base) on a three year cycle, to coincide with our code adoption and fire inspection cycles. Evaluation measures are needed to see if any improvement is realized over time. We will need to see if changes made do bring down the level of risk in our community, with benefits of a safer community, and possible justification for lower risk ratings by insurers.

For researchers who wish to do further studies in this field the following specific and general research recommendations are offered: (a) Similar use of a final rank order synthesis procedure to evaluate risk assessment tools; (b) a better constructed interview process, or possible survey of a much larger number of participants; (c) simultaneous application of different assessment methods to better control variables leading to discrepancies; (d) potential use of RHAVE during plan review of proposed buildings; and (e) adaptation of potentially useful non-fire service risk and vulnerability assessment techniques to fire service use.

While all decisions made in MFD should reflect our mission to increase public safety from fire, the elimination of all risk is not possible. In the search for new ways to address increasing risk in the Marysville community, there are many possible solutions. The first step needs to be a thorough assessment of the causes- the hazards. To do this we must be better able to identify and evaluate the risk of multiple hazards.

Specific recommendation for improvements have been put forward, that if implemented will put MFD in a much better position to make decisions about the many ways to manage risk, and to reduce hazards and make better use of our limited resources. We can more fully address the special target hazards in our community. We can gather needed data for risk assessment more efficiently. We can use the best tools available to make daily decisions. We can have pre-incident plans that are needed to make critical decisions. We can be assured that the best decisions are being made with regard to fire safety in our community.

Our whole community, not just MFD, has to seek new and creative ways to address today's risks. We are challenged to be the agents for change in our community. We must lead our community into a safer tomorrow. Our MFD leaders will make better decisions when armed with all the right information, and the all the right tools for the job. These decisions are made daily. These decisions affect the safety of all our lives. Let's make the right decisions- so everyone goes home safely!

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# Appendix A

## Structured Interview Form

Question: What evaluation tools does your department use for identification and/or prioritization of target hazards?

Fire Department: Your Name and Title:

| Evaluation tools used: | Please indicate Yes or No answers below: | |
|---|---|---|
| Officer judgment | Yes | No |
| Survey group | Yes | No |
| Site self-survey | Yes | No |
| Site plan | Yes | No |
| Pre-incident plan | Yes | No |
| Inspection checklist | Yes | No |
| Pre-defined hazards (such as building code type or FEMA hazard list) | Yes | No |
| Rating/ranking scales | Yes | No |
| Risk rating matrix | Yes | No |
| Data worksheet | Yes | No |
| Standard of coverage | Yes | No |
| FD based RMS | Yes | No |
| GIS mapping | Yes | No |
| RHAVE software | Yes | No |
| VISION software | Yes | No |
| HAZARD software | Yes | No |
| Custom spreadsheet | Yes | No |

Please explain additional answers below:

Other software used:

Any other tools used:

Appendix B

Risk Assessment Section of MFD Standards of Coverage Draft Document

## Risk Categories: Specific

### Risk Category Assessment Data Collection

Our Risk Category Assessment has been completed on a Station-by-Station basis in order to provide a more detailed analysis of where the majority of the hazards are located from each category.

### Station 61 First Due Response Area

**High Risk Areas:** *Occupancies with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors.*

Marysville Care Center
Madeline Villa Care Center
Welco Lumber
Winterhill Apartments
Grandview Village
Sunnyside Elementary
Allen Creek Elementary
Liberty Elementary
Marysville Middle School
Marysville Junior High School
10th Street School
Cedarcrest School
Kellogg Marsh Elementary
Quill Ceda Elementary
Old Tulalip Casino
Crown Pacific Lumber
Grace Academy
Marysville Plating (88th and State)
Ebey Arms Apartments

**Medium Risk Areas:** *Occupancies with less severe tactical hazards, medium hazard occupancies, medium incident frequencies, or other pertinent factors.*

Cedar Landing Apartments
Quil Ceda Tannery
Co-Op Supply
Sewage Treatment Plant
E&E Lumber
Tulalip Inn
Best Western Inn
Holiday Inn Express
Westover Apartments (1350 Cedar)
Residential Care Facilities (Multiple)
Marysville Mall
The Willows Apartments
Valley Commons Apartments
Assembly of God Church
Willow Run Apartments
Liberty Square Apartments
Wishing Well Apartments

**Low Risk Areas:** *Occupancies with few tactical hazards, low hazard occupancies, low incident frequency or other pertinent factor.*

Marysville Apartments
Pilchuck Apartments
Glennwood Mobile
Les Schwab tires
Wildwood Estates/Woodgate Apartments
Cedar Landing Apartments

## Station 62 First Due Response Area

**High Risk Areas:** *Occupancies with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors.*

Cascade Elementary
Marshall Elementary
Shoultes Elementary
Marysville Pilchuck High
Windsor Pointe
Residential Care Centers (6 Known)
Merrill Gardens
Tulalip Casino
Fred Meyer
Walmart
Home Depot

**Medium Risk Areas:** *Occupancies with less severe tactical hazards, medium hazard occupancies, medium incident frequencies, or other pertinent factors.*

Hunter Place Apartments
Albertson's
Regal Cinemas
Shoultes Gospel Church
LDS Church
7th Day Adventist Church
Haggen's Grocery
Alfy's Strip Mall
Wagner's Jeweler's Strip Mall
116th Strip Mall
United Rental

**Low Risk Areas:** *Occupancies with few tactical hazards, low hazard occupancies, low incident frequency or other pertinent factor.*

Wishing Well Apartments
Cascadian Apartments
Quil Ceda Tanning
Salvation Army Thrift Store
Clear Image Photo
Charlie's Auto
Big "O" Tire
128th and 51 Ave Apartments
115th and 51 Ave Apartments
Whispering Firs Apartments

## Station 63 First Due Response Area

**High Risk Areas:** *Occupancies with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors.*

Stilliguamish Senior Center Apts.
Finishing Touch II
Pacific Grinding Wheel
Lakewood High School
Lakewood Middle School
Thomas Foundry
Stillaguamish Thrift Shop
Hawthorn Suites
Carroll Creek Apartments
Cumulus Park
Northwest Composites
Cougar Creek Elementary
English Crossing
Arlington Airport
Aerocell North west
Smokey Point RV Park

**Medium Risk Areas:** *Occupancies with less severe tactical hazards, medium hazard occupancies, medium incident frequencies, or other pertinent factors.*

Naval Support Complex
Pacific Coast Feather Co.
Smokey Point Motor Inn
Lowe's
Food Pavilion
Safeway
Suburban Propane
Fuel Distribution Center 136th St.
Rite Aid

**Low Risk Areas:** *Occupancies with few tactical hazards, low hazard occupancies, low incident frequency or other pertinent factor.*

Eagle Point Mobile Home Park
Shurgard Storage
Anchor Storage
DSHS (172nd St)
Gold's Gym Complex

## Station 65 First Due Response Area

**High Risk Areas:** *Occupancies with tactical hazards, high hazard occupancies, high incident frequencies, geographical restrictions, or other pertinent factors.*

Camp Killoqua - *Access and building location/construction.*
Port Susan Camping Club - *Qty. and size, water supply, Access, some building construction.*

**Medium Risk Areas:** *Occupancies with less severe tactical hazards, medium hazard occupancies, medium incident frequencies, or other pertinent factors.*

7 Lakes Baptist Church
Peninsula Road
Wenberg State Park
4800 to 5200 of 174th and 175th Place
7 Lakes Tavern
North Country Chapel

**Low Risk Areas:** *Occupancies with few tactical hazards, low hazard occupancies, low incident frequency or other pertinent factor.*

Lake Ki Mobile
Camp Ki
7 Lakes Mobile
Lake Goodwin Mobile
Mountain View Assembly of God Church
Edward Springs Reservoir
Cedar Grove RV Park
7 Lakes Video
Lake Goodwin Resort
Verizon Switch Facility

# Appendix C

## Data Reported by RHAVE for All MFD Target Hazards Sorted by OVAP Score

**Risk, Hazard and Value Evaluation**
**Occupancy Vulnerability Assessment Report**
**Marysville Fire District**

| | ADDRESS | | OVAP CATEGORY | OVAP SCORE | OCCUPANCY TYPE | PLANNING ZONE | FIRST DUE | REQUIRED FIRE FLOW | FIRE FLOW AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|
| 61H | Quil Ceda ES | 19X | 3 | 24.40 | E | 61 | 61 | 1500 | Yes |
| 61H | 10th St School (new | 19L | 3 | 24.80 | E | 61 | 61 | 1125 | Yes |
| 61L | Cedar Landing | 20R | 3 | 25.42 | R-2 | 61 | 61 | 2750 | Yes |
| 61H | Crown Pacific (CD | 18D | 3 | 25.42 | B | 61 | 61 | 1000 | Yes |
| 61M | E&E Lumber | 20A | 3 | 26.28 | M | 61 | 61 | 1500 | Yes |
| 63L | Anchor Storage | 23C | 3 | 26.40 | S-2 | 63 | 63 | 1000 | Yes |
| 62M | 116th St strip malls | 22- | 3 | 26.40 | A-2 | 62 | 62 | 1125 | Yes |
| 61L | Glennwood Mobile | 19O | 3 | 26.55 | R-3 | 61 | 61 | 1000 | Yes |
| 61M | Sewage Treatment | 18- | 3 | 26.60 | H-4 | 61 | 61 | 750 | Yes |
| 62M | United Rental | 20- | 3 | 27.26 | M | 62 | 62 | 1750 | Yes |
| 63M | Rite Aid, Smokey Point | 26- | 3 | 27.50 | M | 63 | 63 | 1250 | Yes |
| 65L | Edward Springs | 25- | 3 | 27.53 | S-2 | 65 | 65 | 500 | No |
| 63M | Smokey Point Motor Inn | 26G | 3 | 27.62 | R-1 | 63 | 63 | 1500 | Yes |
| 61H | Grandview Village | 19N | 3 | 27.74 | R-4 | 61 | 61 | 1875 | Yes |
| 65M | Peninsula Road | 25- | 3 | 27.78 | R-3 | 65 | 65 | 1250 | No |
| 65M | 4800-5200 174/175 Pl | 25- | 3 | 27.78 | R-3 | 65 | 65 | 1250 | No |
| 65L | Lake Goodwin MHP | 25- | 3 | 27.78 | R-3 | 65 | 65 | 1000 | No |
| 62M | Haggen Grocery | 20B | 3 | 28.36 | M | 62 | 62 | 1375 | Yes |
| 63H | Finishing Touch II | 24E | 3 | 28.48 | M | 63 | 63 | 875 | Yes |
| 62L | Charlies Autobody | 20 | 3 | 28.60 | B | 62 | 62 | 750 | Yes |
| 63M | Food Pavilion (vacant) | 25- | 3 | 28.60 | M | 63 | 63 | 1500 | Yes |
| 63L | Eagle Point MHP (gone) | 24A | 3 | 28.67 | R-3 | 63 | 63 | 1250 | Yes |
| 61M | Cedar Landing | 20R | 3 | 28.72 | R-2 | 61 | 61 | 1875 | Yes |
| 62M | Hunter Place | 22I | 3 | 28.72 | R-2 | 62 | 62 | 1875 | Yes |
| 61H | Allen Creek ES | 19M | 3 | 29.18 | E | 61 | 61 | 1500 | Yes |
| 63H | Cougar Creek ES | 25G | 3 | 29.18 | E | 63 | 63 | 1375 | Yes |
| 63H | English Crossing ES | 25F | 3 | 29.18 | E | 63 | 63 | 1375 | Yes |
| 65L | Lake Ki MHP | 25- | 3 | 29.22 | R-3 | 65 | 65 | 1000 | No |
| 65L | 7 Lakes MHP | 26J | 3 | 29.22 | R-3 | 65 | 65 | 1000 | No |
| 65L | Cedar Grove RV Park | 25N | 3 | 29.22 | S-2 | 65 | 65 | 1000 | No |
| 61H | Kellogg Marsh ES | 20K | 3 | 29.33 | E | 61 | 61 | 2750 | Yes |
| 65L | Verizon Switch Facility | 25- | 3 | 29.55 | S-2 | 65 | 65 | 500 | Yes |
| 62M | Wagners strip mall | 21N | 3 | 29.58 | A-2 | 62 | 62 | 2625 | Yes |
| 61H | Cedarcrest MS | 20M | 3 | 29.60 | E | 61 | 61 | 3250 | Yes |
| 63H | Thomas Foundry | 23- | 3 | 29.70 | F | 63 | 63 | 2500 | Yes |
| 62M | Albertsons at 116th | 22G | 3 | 29.70 | M | 62 | 62 | 1625 | Yes |
| 61L | Marysville Apartments | 18C | 3 | 29.82 | R-2 | 61 | 61 | 750 | Yes |
| 62L | Whispering Firs Apt | 23- | 3 | 29.82 | R-2 | 62 | 62 | 1250 | No |
| 65L | Lake Goodwin Resort | 25- | 3 | 30.07 | S-2 | 65 | 65 | 500 | No |
| 61L | Pilchuck Apartments | 19I | 3 | 30.31 | R-2 | 61 | 61 | 2000 | Yes |
| 63H | Smokey Point RV Park | 25- | 3 | 30.43 | S-2 | 63 | 63 | 750 | Yes |
| 61M | Residential care facility | 19- | 3 | 30.68 | R-4 | 61 | 61 | 1250 | Yes |

## Risk, Hazard and Value Evaluation
## Occupancy Vulnerability Assessment Report
### Marysville Fire District

| ADDRESS | | | OVAP CATEGORY | OVAP SCORE | OCCUPANCY TYPE | PLANNING ZONE | FIRST DUE | REQUIRED FIRE FLOW | FIRE FLOW AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|
| 63L | Golds Gym | 26G | 3 | 30.80 | A-2 | 63 | 63 | 1500 | Yes |
| 65L | 7 Lakes Video | 25- | 3 | 30.80 | M | 65 | 65 | 1000 | No |
| 62H | Residential care facility | 21- | 3 | 30.92 | R-4 | 62 | 62 | 1250 | No |
| 63M | American Distributing | 23- | 3 | 31.04 | S-1 | 63 | 63 | 1500 | Yes |
| 62M | 7th Day Adventist | 21- | 3 | 31.20 | A-2 | 62 | 62 | 2750 | Yes |
| 62L | Clear Image Photo | 20- | 3 | 31.78 | B | 62 | 62 | 1750 | Yes |
| 62L | Big O Tire Store | 21- | 3 | 31.78 | B | 62 | 62 | 1750 | Yes |
| 63H | Pacific Grinding Wheel | 23A | 3 | 31.90 | F | 63 | 63 | 1875 | Yes |
| 62M | Shoultes Gospel | 22H | 3 | 31.90 | A-2 | 62 | 62 | 2250 | No |
| 63M | Pacific Coast Feather | 24G | 3 | 31.90 | F | 63 | 63 | 1875 | Yes |
| 61M | Westover Apartments | 20C | 3 | 32.02 | R-2 | 61 | 61 | 2250 | Yes |
| 61M | Valley Commons | 19K | 3 | 32.02 | R-2 | 61 | 61 | 1750 | Yes |
| 62L | Cascadian Apartments | 21- | 3 | 32.02 | R-2 | 62 | 62 | 2250 | Yes |
| 62L | Apartments at 11500 51 | 22- | 3 | 32.02 | R-2 | 62 | 62 | 2250 | No |
| 62H | Walmart | 20T | 3 | 32.40 | M | 62 | 62 | 2750 | Yes |
| 65H | Port Susan Camping | 24- | 3 | 32.63 | S-2 | 65 | 65 | 1000 | No |
| 62L | Quil Ceda Tannery | 20- | 3 | 32.88 | M | 62 | 62 | 2000 | No |
| 62H | Merrill Gardens | 21E | 3 | 32.93 | I | 62 | 62 | 2250 | Yes |
| 62H | Marshall ES | 22B | 3 | 32.93 | E | 62 | 62 | 2500 | Yes |
| 63H | Stillaguamish Thrift | 26- | 3 | 33.00 | M | 63 | 63 | 2000 | Yes |
| 63L | DSHS Office building | 25Q | 3 | 33.00 | B | 63 | 63 | 1625 | Yes |
| 63M | Lowes | 25H | 3 | 33.00 | M | 63 | 63 | 2000 | Yes |
| 61M | Liberty Square | 20D | 3 | 33.12 | R-2 | 61 | 61 | 3000 | Yes |
| 61M | Wishing Well | 20J | 3 | 33.12 | R-2 | 61 | 61 | 2500 | Yes |
| 62L | Wishing Well | 20J | 3 | 33.12 | R-2 | 62 | 62 | 2500 | Yes |
| 61H | Sunnyside ES | 17B | 3 | 33.20 | E | 61 | 61 | 1250 | No |
| 61M | Co-Op Supply | 20Z | 3 | 33.60 | M | 61 | 61 | 1375 | Yes |
| 63H | Carroll Creek | 26- | 3 | 33.61 | R-2 | 63 | 63 | 3750 | Yes |
| 62L | Apartments at 12800 51 | 23- | 3 | 33.73 | R-2 | 62 | 62 | 2250 | No |
| 61L | Les Schwab Tire Store | 20- | 3 | 34.10 | M | 61 | 61 | 2250 | Yes |
| 61H | Madeline Villa Care | 19P | 3 | 34.13 | I | 61 | 61 | 750 | Yes |
| 62M | Regal Cinemas | 21D | 3 | 34.27 | A-1 | 62 | 62 | 2625 | Yes |
| 61M | Holiday Inn Express | 20Y | 3 | 34.40 | R-1 | 61 | 61 | 2625 | Yes |
| 61M | Willow Run Apartments | 20B | 3 | 34.71 | R-2 | 61 | 61 | 2250 | Yes |
| 63M | Safeway, Smokey Point | 25Q | 3 | 34.80 | M | 63 | 63 | 3875 | Yes |
| 62H | Fred Meyer | 21- | 3 | 34.80 | M | 62 | 62 | 2750 | Yes |
| 63L | Shurgard Storage | 26H | 3 | 35.20 | S-2 | 63 | 63 | 1750 | No |
| 62H | Cascade ES | 21A | 3 | 35.33 | E | 62 | 62 | 2750 | Yes |
| 63M | Suburban Propane | 23- | 3 | 35.44 | S-1 | 63 | 63 | 2000 | No |
| 65M | North Country Chapel | 25- | 3 | 35.60 | A-2 | 65 | 65 | 2250 | No |
| 63H | Lakewood MS | 25E | 3 | 35.97 | E | 63 | 63 | 2000 | Yes |
| 63M | Naval Support Complex | 24D | 3 | 36.00 | M | 63 | 63 | 2875 | Yes |

## Risk, Hazard and Value Evaluation
## Occupancy Vulnerability Assessment Report
### Marysville Fire District

| | ADDRESS | | OVAP CATEGORY | OVAP SCORE | OCCUPANCY TYPE | PLANNING ZONE | FIRST DUE | REQUIRED FIRE FLOW | FIRE FLOW AVAILABLE |
|---|---|---|---|---|---|---|---|---|---|
| 61H | Grace Academy | 20N | 3 | 36.00 | E | 61 | 61 | 2750 | No |
| 62H | Home Depot | 21P | 3 | 36.00 | M | 62 | 62 | 3125 | Yes |
| 65M | Wenberg State Park | 25- | 3 | 36.40 | S-2 | 65 | 65 | 750 | No |
| 62H | Shoultes ES | 23B | 3 | 36.53 | E | 62 | 62 | 2500 | Yes |
| 63H | Northwest Composites | 23D | 3 | 36.67 | F | 63 | 63 | 2000 | Yes |
| 63H | Aerocell Northwest | 23D | 3 | 37.20 | H-2 | 63 | 63 | 1500 | Yes |
| 62L | Salvation Army Store | 21- | 3 | 37.20 | M | 62 | 62 | 2000 | Yes |
| 61M | The Willows | 19R | 3 | 37.64 | R-2 | 61 | 61 | 2000 | No |
| 61L | Wildwood/Woodgate | 19Q | 3 | 37.64 | R-2 | 61 | 61 | 1750 | No |
| 61H | Winterhill Apartments | 19T | 3 | 37.77 | R-2 | 61 | 61 | 2750 | Yes |
| 61H | Quil Ceda Creek Casino | 19U | 3 | 38.13 | A-1 | 61 | 61 | 2750 | No |
| 65L | Camp Ki | 25- | 3 | 38.13 | S-2 | 65 | 65 | 1500 | No |
| 62H | Windsor Square | 21B | 3 | 38.27 | R-4 | 62 | 62 | 3000 | Yes |
| 61H | Liberty ES | 19- | 3 | 38.28 | E | 61 | 61 | 2500 | Yes |
| 63H | Cumulus Park | 25- | 3 | 38.40 | B | 63 | 63 | 2250 | Yes |
| 65H | Camp Killoqua | 24- | 3 | 38.53 | A-2 | 65 | 65 | 2000 | No |
| 65L | Mountain View AOG | 25- | 3 | 38.80 | A-2 | 65 | 65 | 2000 | No |
| 61H | Marysville MS | 19B | 3 | 39.00 | E | 61 | 61 | 4500 | Yes |
| 62M | Alfy's strip mall | 21- | 3 | 39.33 | A-2 | 62 | 62 | 2750 | Yes |
| 63H | Arlington Airport | 26- | 3 | 39.60 | S-2 | 63 | 63 | 3750 | No |
| 61M | Marysville Mall | 18E | 3 | 39.60 | M | 61 | 61 | 1625 | Yes |
| 63H | Lakewood HS | 25C | 3 | 40.13 | E | 63 | 63 | 1750 | Yes |
| 63H | Lakewood High School | 25C | 2 | 40.13 | E | 63 | 63 | 1750 | Yes |
| 61H | Welco Lumber | 18A | 2 | 40.30 | F | 61 | 61 | 1375 | Yes |
| 61H | Totem MS (former | 19C | 2 | 40.30 | E | 61 | 61 | 5000 | Yes |
| 63H | Hawthorn Suites | 25- | 2 | 40.67 | R-1 | 63 | 63 | 2250 | Yes |
| 61H | Marysville Plating | 20- | 2 | 40.70 | H-4 | 61 | 61 | 1250 | Yes |
| 61H | Marysville Care Center | 19H | 2 | 40.80 | I | 61 | 61 | 2250 | Yes |
| 62H | Marysville Pilchuck HS | 22E | 2 | 41.53 | E | 62 | 62 | 2500 | Yes |
| 63H | Stilly Senior Center Apts | 26B | 2 | 42.67 | R-2 | 63 | 63 | 4750 | No |
| 61H | Ebey Arms Apartments | 19D | 2 | 42.80 | R-2 | 61 | 61 | 5500 | No |
| 61M | Tulalip Best Western | 19- | 2 | 44.93 | R-1 | 61 | 61 | 2750 | No |
| 62M | LDS Church | 21F | 2 | 46.80 | A-2 | 62 | 62 | 5250 | No |
| 61M | Quil Ceda Tannery | 20- | 2 | 47.30 | H-4 | 61 | 61 | 3750 | No |
| 62H | Tulalip Casino/Hotel | 21J | 2 | 48.39 | A-1 | 62 | 62 | 2875 | Yes |
| 65M | 7 Lakes Baptist Church | 25- | 2 | 48.40 | A-2 | 65 | 65 | 2000 | No |
| 61M | Assembly of God | 19 | 2 | 50.13 | A-2 | 61 | 61 | 5500 | No |
| 65M | 7 Lakes Tavern | 25- | 2 | 51.60 | A-2 | 65 | 65 | 2000 | No |
| 61M | Tulalip Inn | 19A | 2 | 52.13 | R-1 | 61 | 61 | 5500 | No |

# Appendix D

## Tables Used for Comparison of Risk Assessment Results

Eight tables, two for each of the four MFD station areas, were used for comparison of risk assessment results for all 122 target hazards. Tables D1 and D2 show station 61 area results.

Table D1. Station 61 Target Hazards Sorted by SOC Risk Category

| Target hazard | SOC risk category | RHAVE OVAP | OVAP score |
|---|---|---|---|
| Ebey Arms Apartments | High | 2-Significant | 42.80 |
| Marysville Care Center | High | 2-Significant | 40.80 |
| Marysville Plating | High | 2-Significant | 40.70 |
| Totem Middle School | High | 2-Significant | 40.30 |
| Welco Lumber Company | High | 2-Significant | 40.30 |
| Marysville Middle School | High | 3-Moderate | 39.00 |
| Liberty Elementary School | High | 3-Moderate | 38.28 |
| Quil Ceda Creek Casino | High | 3-Moderate | 38.13 |
| Winterhill Apartments | High | 3-Moderate | 37.77 |
| Grace Academy | High | 3-Moderate | 36.00 |
| Madeleine Villa Care Center | High | 3-Moderate | 34.13 |
| Sunnyside Elementary School | High | 3-Moderate | 33.20 |
| Cedarcrest Middle School | High | 3-Moderate | 29.60 |
| Kellogg Marsh Elementary School | High | 3-Moderate | 29.33 |
| Allen Creek Elementary School | High | 3-Moderate | 29.18 |
| Grandview Village Retirement Center | High | 3-Moderate | 27.74 |
| CD Building Dept. annex | High | 3-Moderate | 25.42 |
| 10th Street School | High | 3-Moderate | 24.80 |
| Quil Ceda Elementary School | High | 3-Moderate | 24.40 |
| Tulalip Inn | Medium | 2-Significant | 52.13 |
| Marysville Assembly of God Church | Medium | 2-Significant | 50.13 |
| Quil Ceda Tannery | Medium | 2-Significant | 47.30 |
| Tulalip Best Western Inn | Medium | 2-Significant | 44.93 |
| Marysville Towne Centre Mall | Medium | 3-Moderate | 39.60 |
| The Willows Apartments | Medium | 3-Moderate | 37.64 |
| Willow Run Apartments | Medium | 3-Moderate | 34.71 |
| Holiday Inn Express | Medium | 3-Moderate | 34.40 |
| Cenex Co-Op Supply | Medium | 3-Moderate | 33.60 |
| Liberty Square Apartments | Medium | 3-Moderate | 33.12 |
| Wishing Well Apartments | Medium | 3-Moderate | 33.12 |
| Valley Commons Apartments | Medium | 3-Moderate | 32.02 |
| Westover Apartments | Medium | 3-Moderate | 32.02 |
| Residential care facilities | Medium | 3-Moderate | 30.68 |
| Cedar Landing Apartments - 3 story | Medium | 3-Moderate | 28.72 |
| Waste Water Treatment Plant | Medium | 3-Moderate | 26.60 |
| E&E Lumber and Hardware Store | Medium | 3-Moderate | 26.28 |
| Woodgate Apartments | Low | 3-Moderate | 37.64 |
| Les Schwab Tire Store | Low | 3-Moderate | 34.10 |
| Pilchuck Apartments | Low | 3-Moderate | 30.31 |
| Marysville Apartments | Low | 3-Moderate | 29.82 |
| Glennwood Mobile Home Park | Low | 3-Moderate | 26.55 |
| Cedar Landing Apartments - 2 story | Low | 3-Moderate | 25.42 |

Table D2. *Station 61 Target Hazards Sorted by RHAVE OVAP Score and Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Tulalip Inn | Medium | 2-Significant | 52.13 |
| Marysville Assembly of God Church | Medium | 2-Significant | 50.13 |
| Quil Ceda Tannery | Medium | 2-Significant | 47.30 |
| Tulalip Best Western Inn | Medium | 2-Significant | 44.93 |
| Ebey Arms Apartments | High | 2-Significant | 42.80 |
| Marysville Care Center | High | 2-Significant | 40.80 |
| Marysville Plating | High | 2-Significant | 40.70 |
| Totem Middle School | High | 2-Significant | 40.30 |
| Welco Lumber Company | High | 2-Significant | 40.30 |
| Marysville Towne Centre Mall | Medium | 3-Moderate | 39.60 |
| Marysville Middle School | High | 3-Moderate | 39.00 |
| Liberty Elementary School | High | 3-Moderate | 38.28 |
| Quil Ceda Creek Casino | High | 3-Moderate | 38.13 |
| Winterhill Apartments | High | 3-Moderate | 37.77 |
| The Willows Apartments | Medium | 3-Moderate | 37.64 |
| Woodgate Apartments | Low | 3-Moderate | 37.64 |
| Grace Academy | High | 3-Moderate | 36.00 |
| Willow Run Apartments | Medium | 3-Moderate | 34.71 |
| Holiday Inn Express | Medium | 3-Moderate | 34.40 |
| Madeleine Villa Care Center | High | 3-Moderate | 34.13 |
| Les Schwab Tire Store | Low | 3-Moderate | 34.10 |
| Cenex Co-Op Supply | Medium | 3-Moderate | 33.60 |
| Sunnyside Elementary School | High | 3-Moderate | 33.20 |
| Liberty Square Apartments | Medium | 3-Moderate | 33.12 |
| Wishing Well Apartments | Medium | 3-Moderate | 33.12 |
| Valley Commons Apartments | Medium | 3-Moderate | 32.02 |
| Westover Apartments | Medium | 3-Moderate | 32.02 |
| Residential care facilities | Medium | 3-Moderate | 30.68 |
| Pilchuck Apartments | Low | 3-Moderate | 30.31 |
| Marysville Apartments | Low | 3-Moderate | 29.82 |
| Cedarcrest Middle School | High | 3-Moderate | 29.60 |
| Kellogg Marsh Elementary School | High | 3-Moderate | 29.33 |
| Allen Creek Elementary School | High | 3-Moderate | 29.18 |
| Cedar Landing Apartments - 3 story | Medium | 3-Moderate | 28.72 |
| Grandview Village Retirement Center | High | 3-Moderate | 27.74 |
| Waste Water Treatment Plant | Medium | 3-Moderate | 26.60 |
| Glennwood Mobile Home Park | Low | 3-Moderate | 26.55 |
| E&E Lumber and Hardware Store | Medium | 3-Moderate | 26.28 |
| CD Building Dept. annex | High | 3-Moderate | 25.42 |
| Cedar Landing Apartments - 2 story | Low | 3-Moderate | 25.42 |
| 10th Street School | High | 3-Moderate | 24.80 |
| Quil Ceda Elementary School | High | 3-Moderate | 24.40 |

Tables D1 and D2 were each used to show the 42 target hazards in the station 61 response area. Disagreement between the risk categories was found in 30 of the 42 hazards, a 71% difference. Tables D3 and D4 show station 62 area results.

Table D3. *Station 62 Target Hazards Sorted by SOC Risk Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Tulalip Casino and Hotel | High | 2-Significant | 48.39 |
| Marysville Pilchuck High School | High | 2-Significant | 41.53 |
| Windsor Square Apartments | High | 3-Moderate | 38.27 |
| Shoultes Elementary School | High | 3-Moderate | 36.53 |
| Home Depot Store | High | 3-Moderate | 36.00 |
| Cascade Elementary School | High | 3-Moderate | 35.33 |
| Fred Meyer Store | High | 3-Moderate | 34.80 |
| Marshall Elementary School | High | 3-Moderate | 32.93 |
| Merrill Gardens (former Windsor Pointe) | High | 3-Moderate | 32.93 |
| WalMart Store | High | 3-Moderate | 32.40 |
| Residential care facilities | High | 3-Moderate | 30.92 |
| LDS Church | Medium | 2-Significant | 46.80 |
| Alfy's Strip Mall | Medium | 3-Moderate | 39.33 |
| Regal Cinema | Medium | 3-Moderate | 34.27 |
| Shoultes Gospel Church | Medium | 3-Moderate | 31.90 |
| 7th Day Adventist Church | Medium | 3-Moderate | 31.20 |
| Albertson's Store | Medium | 3-Moderate | 29.70 |
| Wagner's Strip Mall | Medium | 3-Moderate | 29.58 |
| Hunter Place Apartments | Medium | 3-Moderate | 28.72 |
| Haggens Grocery Store | Medium | 3-Moderate | 28.36 |
| United Rentals | Medium | 3-Moderate | 27.26 |
| 116th Street Strip Mall | Medium | 3-Moderate | 26.40 |
| Salvation Army Thrift Store | Low | 3-Moderate | 37.20 |
| 12800 51 Av NE Apartments | Low | 3-Moderate | 33.73 |
| Wishing Well Apartments | Low | 3-Moderate | 33.12 |
| Quil Ceda Tannery Store | Low | 3-Moderate | 32.88 |
| 11500 51 Av NE Apartments | Low | 3-Moderate | 32.02 |
| Cascadian Apartments | Low | 3-Moderate | 32.02 |
| Big O Tire Store | Low | 3-Moderate | 31.78 |
| Clear Image Photo | Low | 3-Moderate | 31.78 |
| Whispering Firs Apartments | Low | 3-Moderate | 29.82 |
| Charlie's Autobody | Low | 3-Moderate | 28.60 |

Table D4. *Station 62 Target Hazards Sorted by RHAVE OVAP Score and Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Tulalip Casino and Hotel | High | 2-Significant | 48.39 |
| LDS Church | Medium | 2-Significant | 46.80 |
| Marysville Pilchuck High School | High | 2-Significant | 41.53 |
| Alfy's Strip Mall | Medium | 3-Moderate | 39.33 |
| Windsor Square Apartments | High | 3-Moderate | 38.27 |
| Salvation Army Thrift Store | Low | 3-Moderate | 37.20 |
| Shoultes Elementary School | High | 3-Moderate | 36.53 |
| Home Depot Store | High | 3-Moderate | 36.00 |
| Cascade Elementary School | High | 3-Moderate | 35.33 |
| Fred Meyer Store | High | 3-Moderate | 34.80 |
| Regal Cinema | Medium | 3-Moderate | 34.27 |
| 12800 51 Av NE Apartments | Low | 3-Moderate | 33.73 |
| Wishing Well Apartments | Low | 3-Moderate | 33.12 |
| Marshall Elementary School | High | 3-Moderate | 32.93 |
| Merrill Gardens (former Windsor Pointe) | High | 3-Moderate | 32.93 |
| Quil Ceda Tannery Store | Low | 3-Moderate | 32.88 |
| WalMart Store | High | 3-Moderate | 32.40 |
| 11500 51 Av NE Apartments | Low | 3-Moderate | 32.02 |
| Cascadian Apartments | Low | 3-Moderate | 32.02 |
| Shoultes Gospel Church | Medium | 3-Moderate | 31.90 |
| Big O Tire Store | Low | 3-Moderate | 31.78 |
| Clear Image Photo | Low | 3-Moderate | 31.78 |
| 7th Day Adventist Church | Medium | 3-Moderate | 31.20 |
| Residential care facilities | High | 3-Moderate | 30.92 |
| Whispering Firs Apartments | Low | 3-Moderate | 29.82 |
| Albertson's Store | Medium | 3-Moderate | 29.70 |
| Wagner's Strip Mall | Medium | 3-Moderate | 29.58 |
| Hunter Place Apartments | Medium | 3-Moderate | 28.72 |
| Charlie's Autobody | Low | 3-Moderate | 28.60 |
| Haggens Grocery Store | Medium | 3-Moderate | 28.36 |
| United Rentals | Medium | 3-Moderate | 27.26 |
| 116th Street Strip Mall | Medium | 3-Moderate | 26.40 |

Tables D3 and D4 were each used to show the 32 target hazards in the station 62 response area. Disagreement between the risk categories was found in 20 of the 32 hazards, a 63% difference. Tables D5 and D6 show station 63 area results.

Table D5. *Station 63 Target Hazards Sorted by SOC Risk Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Stillaguamish Senior Center Apartments | High | 2-Significant | 42.67 |
| Hawthorn Suites Inn | High | 2-Significant | 40.67 |
| Lakewood High School | High | 2-Significant | 40.13 |
| Arlington Airport (not in MFD) | High | 3-Moderate | 39.60 |
| Cumulus Park Business Center | High | 3-Moderate | 38.40 |
| Aerocell Northwest | High | 3-Moderate | 37.20 |
| Northwest Composites | High | 3-Moderate | 36.67 |
| Lakewood Middle School | High | 3-Moderate | 35.97 |
| Carroll Creek Apartments | High | 3-Moderate | 33.61 |
| Stillaguamish Thrift Shop | High | 3-Moderate | 33.00 |
| Pacific Grinding Wheel | High | 3-Moderate | 31.90 |
| Smokey Point RV Park | High | 3-Moderate | 30.43 |
| Thomas Foundry | High | 3-Moderate | 29.70 |
| Cougar Creek Elementary School | High | 3-Moderate | 29.18 |
| English Crossing Elementary School | High | 3-Moderate | 29.18 |
| Finishing Touch II Flooring Store | High | 3-Moderate | 28.48 |
| Naval Support Complex | Medium | 3-Moderate | 36.00 |
| Suburban Propane | Medium | 3-Moderate | 35.44 |
| Safeway Store | Medium | 3-Moderate | 34.80 |
| Lowe's Home Center | Medium | 3-Moderate | 33.00 |
| Pacific Coast Feather Company | Medium | 3-Moderate | 31.90 |
| American Distributing | Medium | 3-Moderate | 31.04 |
| Food Pavilion | Medium | 3-Moderate | 28.60 |
| Smokey Point Motor Inn | Medium | 3-Moderate | 27.62 |
| Rite Aid Store | Medium | 3-Moderate | 27.50 |
| Shurgard Storage | Low | 3-Moderate | 35.20 |
| DSHS Office | Low | 3-Moderate | 33.00 |
| Gold's Gym Complex | Low | 3-Moderate | 30.80 |
| McKendree Park (former Eagle Point) | Low | 3-Moderate | 28.67 |
| Anchor Storage | Low | 3-Moderate | 26.40 |

Table D6. *Station 63 Target Hazards Sorted by RHAVE OVAP Score and Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Stillaguamish Senior Center Apartments | High | 2-Significant | 42.67 |
| Hawthorn Suites Inn | High | 2-Significant | 40.67 |
| Lakewood High School | High | 2-Significant | 40.13 |
| Arlington Airport (not in MFD) | High | 3-Moderate | 39.60 |
| Cumulus Park Business Center | High | 3-Moderate | 38.40 |
| Aerocell Northwest | High | 3-Moderate | 37.20 |
| Northwest Composites | High | 3-Moderate | 36.67 |
| Naval Support Complex | Medium | 3-Moderate | 36.00 |
| Lakewood Middle School | High | 3-Moderate | 35.97 |
| Suburban Propane | Medium | 3-Moderate | 35.44 |
| Shurgard Storage | Low | 3-Moderate | 35.20 |
| Safeway Store | Medium | 3-Moderate | 34.80 |
| Carroll Creek Apartments | High | 3-Moderate | 33.61 |
| Stillaguamish Thrift Shop | High | 3-Moderate | 33.00 |
| Lowe's Home Center | Medium | 3-Moderate | 33.00 |
| DSHS Office | Low | 3-Moderate | 33.00 |
| Pacific Grinding Wheel | High | 3-Moderate | 31.90 |
| Pacific Coast Feather Company | Medium | 3-Moderate | 31.90 |
| American Distributing | Medium | 3-Moderate | 31.04 |
| Gold's Gym Complex | Low | 3-Moderate | 30.80 |
| Smokey Point RV Park | High | 3-Moderate | 30.43 |
| Thomas Foundry | High | 3-Moderate | 29.70 |
| Cougar Creek Elementary School | High | 3-Moderate | 29.18 |
| English Crossing Elementary School | High | 3-Moderate | 29.18 |
| McKendree Park (former Eagle Point) | Low | 3-Moderate | 28.67 |
| Food Pavilion | Medium | 3-Moderate | 28.60 |
| Finishing Touch II Flooring Store | High | 3-Moderate | 28.48 |
| Smokey Point Motor Inn | Medium | 3-Moderate | 27.62 |
| Rite Aid Store | Medium | 3-Moderate | 27.50 |
| Anchor Storage | Low | 3-Moderate | 26.40 |

Tables D5 and D6 were each used to show the 30 target hazards in the station 63 response area. Disagreement between the risk categories was found in 18 of the 30 hazards, a 60% difference.

Tables D7 and D8 show station 65 area results.

Table D7. *Station 65 Target Hazards Sorted by SOC Risk Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| Camp Killoqua | High | 3-Moderate | 38.53 |
| Port Susan Camping Club | High | 3-Moderate | 32.63 |
| 7 Lakes Tavern | Medium | 2-Significant | 51.60 |
| 7 Lakes Baptist Church | Medium | 2-Significant | 48.40 |
| Wenberg State Park | Medium | 3-Moderate | 36.40 |
| North Country Chapel | Medium | 3-Moderate | 35.60 |
| 4800-5200 174Pl NW and 175 Pl NW | Medium | 3-Moderate | 27.78 |
| Peninsula Road | Medium | 3-Moderate | 27.78 |
| Mountain View Assembly of God Church | Low | 3-Moderate | 38.80 |
| Camp Ki | Low | 3-Moderate | 38.13 |
| 7 Lakes Video Store | Low | 3-Moderate | 30.80 |
| Lake Goodwin Resort | Low | 3-Moderate | 30.07 |
| Verizon Switch Facility | Low | 3-Moderate | 29.55 |
| 7 Lakes Mobile Home Park | Low | 3-Moderate | 29.22 |
| Cedar Grove RV Park | Low | 3-Moderate | 29.22 |
| Lake Ki Mobile Home Park | Low | 3-Moderate | 29.22 |
| Lake Goodwin Mobile Home Park | Low | 3-Moderate | 27.78 |
| Edward Springs Reservoir | Low | 3-Moderate | 27.53 |

Table D8. *Station 65 Target Hazards Sorted by RHAVE OVAP Score and Category*

| Target Hazard | SOC Risk Category | RHAVE OVAP Category | OVAP Score |
|---|---|---|---|
| 7 Lakes Tavern | Medium | 2-Significant | 51.60 |
| 7 Lakes Baptist Church | Medium | 2-Significant | 48.40 |
| Mountain View Assembly of God Church | Low | 3-Moderate | 38.80 |
| Camp Killoqua | High | 3-Moderate | 38.53 |
| Camp Ki | Low | 3-Moderate | 38.13 |
| Wenberg State Park | Medium | 3-Moderate | 36.40 |
| North Country Chapel | Medium | 3-Moderate | 35.60 |
| Port Susan Camping Club | High | 3-Moderate | 32.63 |
| 7 Lakes Video Store | Low | 3-Moderate | 30.80 |
| Lake Goodwin Resort | Low | 3-Moderate | 30.07 |
| Verizon Switch Facility | Low | 3-Moderate | 29.55 |
| 7 Lakes Mobile Home Park | Low | 3-Moderate | 29.22 |
| Cedar Grove RV Park | Low | 3-Moderate | 29.22 |
| Lake Ki Mobile Home Park | Low | 3-Moderate | 29.22 |
| 4800-5200 174Pl NW and 175 Pl NW | Medium | 3-Moderate | 27.78 |
| Peninsula Road | Medium | 3-Moderate | 27.78 |
| Lake Goodwin Mobile Home Park | Low | 3-Moderate | 27.78 |
| Edward Springs Reservoir | Low | 3-Moderate | 27.53 |

Tables D7 and D8 were each used to show the 18 target hazards in the station 65 response area. Disagreement between the risk categories was found in 14 of the 18 hazards, a 78% difference. The overall difference between results of assessment methods was 67%.