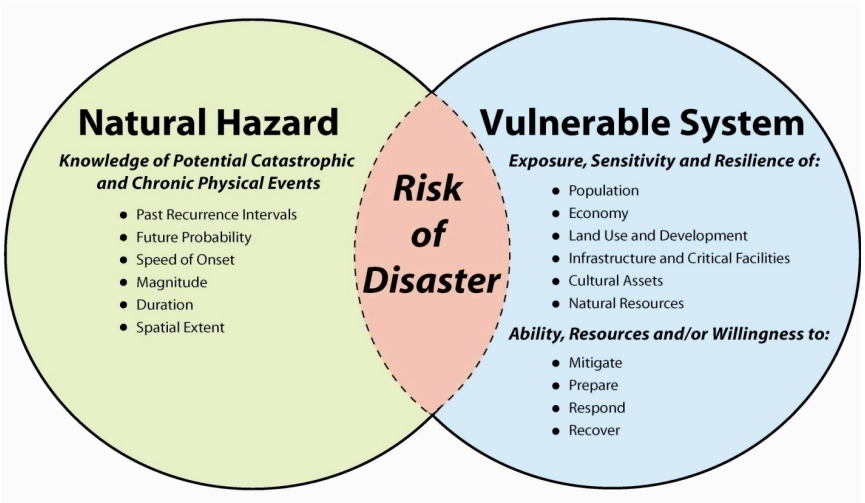
Introduction and Summary

Risk assessments provide information about the geographic areas where the hazards may occur, the value of existing land and property in those areas, and an analysis of the potential risk to life, property, and the environment that may result from natural hazard events. This section identifies and profiles the location, extent, previous occurrences, and future probability of natural hazards that can impact Garfield County, as highlighted in Exhibit 3.1 below.

Methods and Process

A risk assessment consists of three phases: hazard identification, vulnerability assessment, and risk analysis, as illustrated in the following graphic.

Exhibit 3.1: Risk Assessment summary



Source: USGS - University of Oregon Community Service Center, 2006

The first phase of developing a comprehensive Risk Assessment, hazard identification, involves the identification of the geographic extent of a hazard, its intensity, and its probability of occurrence. This level of assessment typically involves producing a map. The outputs from this phase can also be used for land use planning, urban growth management, and regulation; public awareness; and defining areas for further study.

In the summer of 2009, Garfield County contracted with ECONorthwest to begin the process of developing this Risk Assessment. The first step of hazard identification was accomplished in a two-day workshop with County department representative.

Through these workshop discussions, ECO gathered information about the hazards that impact the County, and the vulnerable infrastructure and populations that are likely to be impacted by hazard events. Based on the results of the workshop, the hazards most likely to affect the County are: Fire, Flood (especially flash flood), Hazardous materials spills, and Landslide / rock fall.

Other hazards, which have lower frequency or lower severity, but still might affect the County, include: Snow storms / severe weather, Infectious disease (including agricultural and livestock outbreaks) / pandemic, Terrorism / eco-terrorism / school safety and security, and Airport safety and security. This Risk Assessment focuses on natural hazards and so will not discuss the human induced hazards that were included in this initial ranking process. However, increasing the resiliency of the County in the face of natural hazards will contribute to the ability of the County to recover from other kinds of disruptions. A memo summarizing the results of the workshops are included as an Appendix to this NHMP.

The second phase, vulnerability assessment, combines the information from the hazard identification with an inventory of the existing (or planned) property and population exposed to a hazard, and attempts to predict how different types of property and population groups will be affected by the hazard. This step can also assist in

justifying changes to building codes or development regulations, identifying properties or structures appropriate for acquisition or relocation, policies concerning critical and public facilities, taxation strategies for mitigating risk, and informational programs for members of the public who are at risk.

This vulnerability assessment was conducted in the summer of 2009 using a survey form. completed during the aforementioned workshop. Participants were given worksheets organized by potentially vulnerable systems (e.g.: population, economy, land use and development, infrastructure and critical facilities, etc) that asked specific questions about how that system might be impacted by natural hazards. An example of the worksheet is Figure 3.2 below. A more detailed description of the workshop is included in full in Appendix X: Plan Development Process.

Exhibit 3.2: Issue Identification Worksheet

Infrastructure & Critical Facilities

Instructions: Identify specific response and recovery issues your community could face in the event of a disaster in the left hand column below. For each issue, use the columns on the right hand side to check the potential period of time each issue could affect the community. Check all that apply.

Issues	Community Impacts Felt (Check all that Apply)		
	0- 72 hours - Response	72 hours – 1 month – Response/Recovery	1 month – on-going – Recovery
Framing Questions: • What infrastructure and critical facilities are impacted? • What critical facilities will be operational post-disaster? • Will critical facilities be accessible post-disaster? Will certain access roads and bridges be damaged? Will there be significant debris on access roads and bridges? • What critical facilities and infrastructure need to be operational first?			

The third phase, risk analysis, involves estimating the damage, injuries, and costs likely to be incurred in a geographic area over a period of time. Risk has two measurable components: (1) the magnitude of the harm that may result, defined through the vulnerability assessment, and (2) the likelihood or probability of the harm occurring. An example of a product that can assist communities in completing the risk analysis phase is HAZUS, a risk assessment software program for analyzing potential losses from floods, hurricane winds and earthquakes. In HAZUS-MH current scientific and engineering knowledge is coupled with the latest geographic information systems (GIS) technology to produce estimates of hazard- related damage before, or after a disaster occurs.

In the fall of 2009, Garfield County Emergency Management and ECONorthwest again conducted a survey of department representatives. This time, participants completed a Risk Assessment Matrix like the one pictured below in Exhibit 3.3. The Risk Assessment Matrix asked questions about the relative impact on community systems of various hazards. The result of the compiled responses was a relative ranking of hazards by their severity of impact on the County, its residents, and the economic and physical resilience of the community systems.

It should be noted that, when describing hazard events, it is not always easy to separate causality from occurrence. Severe natural hazard events can alter the environment and trigger other, secondary hazards. For example, winter rain storms often cause flooding and within hours or days over-saturated ground at steep grades can sink or slide.

In one final step of analysis, ECONorthwest cross referenced the percent of County characteristics and assets that are at risk from hazards with the relative importance to the County of those characteristics and assets. It should be noted here that the ranking and ordering of hazards and community assets is primarily a qualitative exercise in comparing relative risk of particular places or assets to natural hazards. No direct accounting was made for dollar values of capital investments, revenue or tax generation, replacement costs, or intangible value of County characteristics. As Garfield County moves forward to building a more resilient community, this Risk Assessment will provide a base of knowledge about what areas of the community face higher risk, and from what kinds of threats The Multihazard Mitigation Council has determined that every $1 spent on mitigation saves $4 in recovery and rebuilding costs[1]. For the purposes of taking action to mitigation impact from hazards, this risk assessment will help to prioritize those areas that need immediate attention.

Exhibit 3.3: Risk Assessment Matrix

Hazard/Threat: Risk Matrix WORKSHEET

Probability – likelihood disruptive hazard will occur: 1= none/doubtful, 2= possible, 3= probable, 4= inevitable
Human Impact – deaths, injuries, serious illnesses, or work absences: 1= none, 2= low, 3= moderate, 4= high
Resources Impact –property, facilities, infrastructure, environment: 1 = undamaged, 2 = minor damage, 3 = moderate damage, 4 = extensive damage
County Impact – Damage to operations /or reputation: 1= none/ minor, 2= limited, 3= moderate, 4= extensive
Impact Severity = Average of Human Impact + Facilities Impact + County Impact
Relative Risk – Probability x Impact Severity: 1 = lowest 16 = highest risk

0

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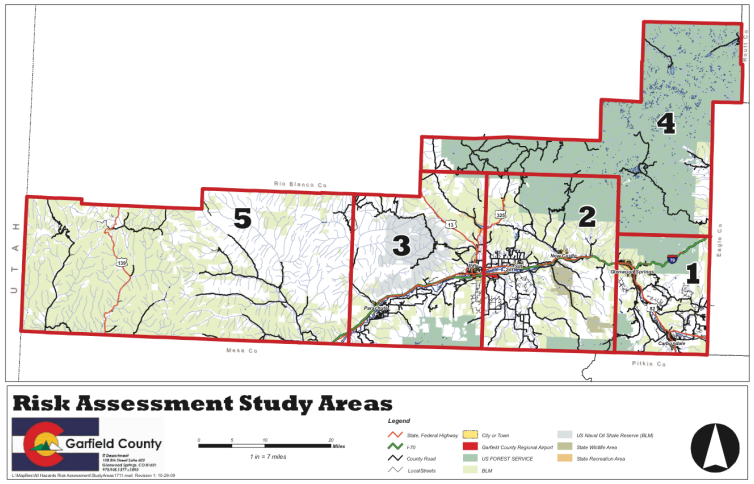
Hazards/Threats	Probability	Injury/Illness and Death	Work absences	Property/ Facilities	Infrastructure / Utilities	Environment	Livability	Economy	Reputation	HUMAN	RESOURCES	IMPACT
Natural										4 High	16 High	
Earthquake										0	0	
Tsunami	na	na	na	na	na	na	na	na	na	na	na	
Landslide, mudslide, subsidence										0	0	
Flood, flash flood, tidal surge										0	0	
Fire – forest, wild, urban, urban interface										0	0	
Snow, ice										0	0	
Windstorm, tornado										0	0	
Extreme temperatures (heat, cold)										0	0	

Exhibit 3.4: Study Areas of the County Risk Assessment



Study Areas At Risk By Hazard

Exhibit 3.5 highlights the risk experienced by each Study Area within each hazard type. The Area that has highest risk of a particular hazard is marked with red and the next highest risk is marked in bold black. Average overall risk for an Area is listed at the bottom of the table. This table illustrates that, overall, Area 1 has the highest hazard risk both in terms of the percent of assets at risk (38%) and in terms of the value – community value – of those assets as noted in the hazard index number (1.4).

Exhibit 3.5: Study Area Risk

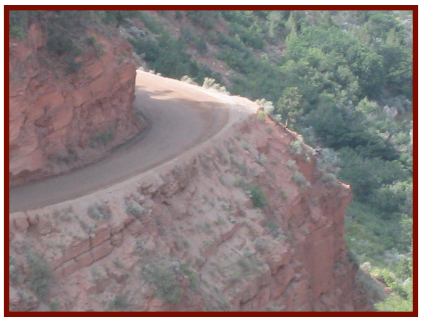
	Area 1		Area 2		Area 3		Area 4		Area 5		
	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index	
Wildfire	**24%**	**0.86**	9%	0.34	13%	0.43	**40%**	**1.42**	**40%**	**1.29**	
Flood	**19%**	**0.81**	16%	0.74	8%	0.35	16%	0.79	**23%**	**1.09**	
Slope	**46%**	**1.63**	24%	0.83	7%	0.21	5%	0.15	**31%**	**1.17**	
Soil	48%	1.71	**65%**	**2.36**	**58%**	**2.08**	.	.	5%	0.18	KEY:
Land-slide	**11%**	**0.37**	9%	0.22	2%	0.06	.	.	**10%**	**0.33**	**Primary**
Debris-flow	**27%**	**1.05**	6%	0.27	.	.	.	.	1%	0.05	**Secondary**
Av.	**29%**	**1.07**	**21%**	**0.79**	18%	0.63	20%	0.79	18%	0.69	

The following is a summary description of the highest risk Areas by hazard type. The detailed tables and discussion that accompany each hazard section in the body of this document provide additional information.

- **Wildfire**: Area 4 and 5 experience the greatest risk of wildfire. In those Areas, the infrastructure most at risk are gas wells, pipelines, and roads.
  - Secondarily, it is the economic components of Area 1 (tourist sites, tram), oil and gas infrastructure, water infrastructure, and the highways are most vulnerable to wildfire.
- **Flood**: Roads (both high traffic asphalt and low traffic gravel) in Area 5 are at a high risk of damage from flood.
  - A flood in Area 1 would impact road and rail infrastructure most significantly as well as carry more direct impact for County residents.

- **Geologic**: Overall, Area 1 has the greatest quantity and types of assets at risk while at the same time those assets are located on hazardously sloped terrain or have soil types that could amplify hazards.
  - ***Slope***: A significant number of assets in Area 1 are located in slope hazard zones. This high risk is felt across all community systems: infrastructure (e.g., communication/information sites, federal/ municipal buildings, water infrastructure, and highways), population sites (e.g., schools and churches), economic assets (e.g., shopping mall and tourism), and development (residential). Primarily, risk in Area 5 is to the federal FAA facility and the road network (both high traffic and low traffic).
  - ***Soil***: In Area 1, the soil type may amplify various hazards and put municipal buildings, water infrastructure, roads and information/ communication facilities, residential development, some industrial and commercial zones at risk of damage and disruption of service. The airport in Area 2 as well as the road network are at risk of soil-aggravated hazards. Additionally, the landfill is at risk. Residential developments including single family, multi family, and a nursing home, have potentially unstable soil.
  - ***Landslide***: Communication facilities and the road network in Area 1 incur specific risk from landslides. In Area 5, it is structures (homes, storage facilities, ,man-camps) as well as the road network that is essential to access those structures that is at risk of damage from landslides.
  - ***Debris Flow***: In Area 1, infrastructure such as the federal and municipal buildings, fire stations and information sites experience greatest risk of debris flows. Additionally, population centers such as churches and schools also experience greater than average risk.

Landslides and rockfall below an access road



Access road carved into a hillside

Highway and railroad in the floodplain

Highest risk areas above a threshold hazard index of 1.00

Exhibit 3.6: Relative Ranking of Risk: Hazard Index +1

	Area 1		Area 2		Area 3		Area 4		Area 5	
	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index	% of asset at risk	Index
Wildfire	24%	0.86	9%	0.34	13%	0.43	**40%**	**1.42**	**40%**	**1.29**
Flood	19%	0.81	16%	0.74	8%	0.35	16%	0.79	**23%**	**1.09**
Slope	**46%**	**1.63**	24%	0.83	7%	0.21	5%	0.15	**31%**	**1.17**
Soil	**48%**	**1.71**	**65%**	**2.36**	**58%**	**2.08**	.	.	5%	0.18
Land-slide	11%	0.37	9%	0.22	2%	0.06	.	.	10%	0.33
Debris-flow	**27%**	**1.05**	6%	0.27	.	.	.	.	1%	0.05

Above a hazard index of 1

As a final method to analyze Garfield County risk, Exhibit 3.6 highlights when the risk index is greater than 1. This emphasizes the greatest risk as it exists anywhere across the County, regardless of the hazard or Study Area.

With this method of data analysis, Areas 1 and 5 are found to be at high risk of multiple hazards.

Area 1 experiences the highest risk from geologic hazards – soil, slope, and debris flow. As discussed above, the risk is spread across all community systems including infrastructure, population assets, economic drivers, and development potential.

Geologic hazards can be triggered in various ways, which can complicate mitigation. There may however, be some overlap in terms of the physical assets at risk in Area 1. Mitigation actions can focus on those specific assets, their location and environment. For example, the steeply sloped slope hills around Glenwood springs are susceptible to landslides at any time during the year. Also, the same hazard zone may be at risk of debris flows after heavy rains.

The assets in Area 5 are threatened by several different hazards – wildfire, flood, and sloped landscapes that can become unstable for any number of reasons. Even though there is very little population in Area 5, it holds the majority of the oil and gas infrastructure. As a central component to the economy of Garfield County, this infrastructure is extremely valuable and mitigation against the impact of a natural hazard can build on the partnerships that already exist between the County and the industries that rely on the resources in Area 5.

Wildfire in Area 5 has the potential to affect the entire county. Air quality is not only important to the health of County residents, but also to the tourism industry. Oil and gas infrastructure may also be directly threatened by wildfires. Wells and pipelines are at a serious risk and any interaction of oil and fire would be a deadly mix.

Area 5 is characterized by step ravines and narrow valleys. In an among that landscape are the wells and pipelines that are the underpinning of the County economy. These assets are at risk of landslide, debris flow, rock falls, and general soil instability due to the steep slopes into which the truck roads and well platforms have been carved. Additionally, because the roads are so delicately woven along the walls of the canyons and ravines, one incident of a road washed out or a slide can cut off entire sections of the Area from road access. Flood in Area 5 would primarily induce landslides and damage the road network, cutting of access to oil and gas sites.

This remainder of this section steps through recent hazard events that have impacted the County, provides an overview of recent scientific data about the hazards and vulnerabilities faced across the County, and describes hazard risk in Garfield County. More extensive descriptions of each hazard is provided in the Appendices.