Part XI
Methods

Hazard Definitions and Analysis Methodologies

MAG collected data and compiled research on nine hazards: dam failure, earthquake, infestation, flooding, landslide, severe weather, drought, and wildfire. Research materials came from a variety of agencies including DES, AGRC, USGS, USACE, UGS, UFFSL, county GIS, city GIS, County Assessors, and County Emergency Managers. Historical data used to define historic disasters was researched through local newspapers, interviewing residents, local knowledge derived through committee meetings, historic state publications, Utah Museum of Natural History, and recent and historic scientific documents and studies.

Vulnerability Methodology

Geographic Information Systems (GIS) were used as the basic analysis tool to complete the hazard analysis for this plan. The goal of the vulnerability study is to estimate the number of structures and infrastructure vulnerable to each hazard and assign a dollar value to this built environment. For most hazards a comparison was made between digital hazard data and the Regional Inventory.

Regional Inventory

In order to determine the possible extent of damage caused by potential events, a regional inventory was developed. This regional inventory is a compilation of residential, commercial, and critical facilities, their locations and their values. In addition, future development was identified and included in the analysis using general plans and demographic projections.

Residential- Parcel, assessor, and building permit data from each of the three counties were analyzed and added to determine current numbers, locations, and values of housing units.

Commercial – As with residential, parcel, assessor, and building permit data from each of the three counties were analyzed and added to determine current numbers, locations, and values.

Critical Facilities* – GIS data, local knowledge and parcel data were used to identify Critical Facilities within the region. Critical Facilities for the purpose of this plan are defined as Schools, Fire, Police, Hospitals, and Emergency Operation Centers.

*It was determined by the planning committee that critical infrastructure facilities such as water sewer and power structures be left out of this plan in order to minimize their vulnerability to outside threats (terrorism). Most of the jurisdictions have been advised by security experts to limit the public exposure of these facilities. However, each jurisdiction has been given the option, if they so choose, to have a separate vulnerability assessment of these structures done. The results would not be made available for public consumption or included in this plan for security reasons. At the publication date of this document, no jurisdiction or entity has requested such an assessment.

All the analysis takes place within the spatial context of a GIS. With the information available in spatial form, it is a simple task to overlay the natural hazards with the regional inventory to extract the desired information. However, some of the hazards identified are not isolated to specific locations within the region or spatial data is unavailable and are therefore discussed at a regional level.

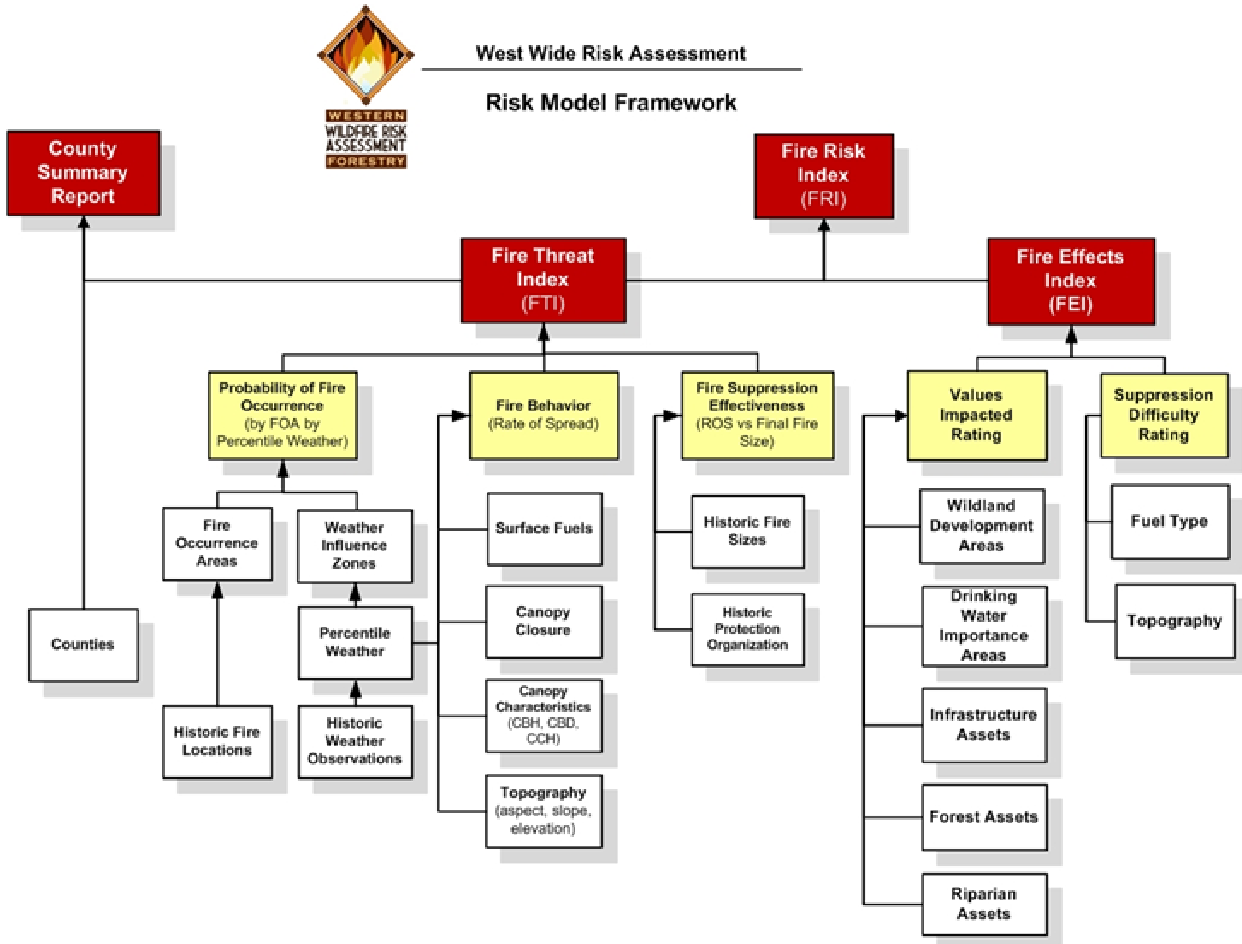
In terms of hazard mapping presentation in this document, simple, letter size maps were created for each city to provide a graphical illustration of location. Larger maps can be plotted out upon request. A web based data manipulation and maps application was also created as a planning tool, to allow interested persons within Utah, Wasatch and Summit Counties in Utah select a certain jurisdiction and view the various hazards on maps as well as the assessment data. The application has been available on the Mountainland Website since the creation of the data.

This information should not take the place of accurate field verified mapping from which ordinances need to be based off of. Owners of critical facilities should, and in most cases do, have detailed pre-hazard mitigation plans for their specific facilities.

Processing Hazard Layers

Fire

The Bureau of Land Management and Forest Service provided locations, both area and point, of historic fires from 1918-2014. The Fire Threat Index was created by an in-depth assessment by the Council of Western State Foresters and the Western Forestry Leadership Coalition. It is derived from the Fire Threat Index (likelihood of an acre burning) and the Fire Effects Index (potential losses). The online map shows the fine Fire Risk Index, combining both Fire Effects (potential losses) and Fire Threat (likelihood of an acre burning). When determining the buildings at risk, however, only the Fire Threat Index was used in order to focus on the assets the city is responsible for and not those of the Forest Service, BLM, gas company, etc.



The categories for the Fire Indices are relative to the risk and effects in each county. Being an index, the final numbers do not represent a concrete value but are rather used to categorize the land into percentages of risk, as seen in the table following.

Fire Index Breakdown

	Category	% Range	Cat. %	
	1	0 – 32.9%	32.9%	Lowest 70%
	2	33.0 - 63.5%	30.5%	
	3	63.5% - 70.0%	6.5%	
	4	70.0 - 77.5%	7.5%	Highest 30% used to determine at risk buildings
	5	77.5 - 85.5%	8.0%	
	6	85.5 - 92.5%	7.0%	

	7	92.5 - 96.5%	4. 0%	
	8	96.5 - 98.5%	2. 0%	
	9	98.5 - 100.0%	1. 5%	

The findings of any calculation using the Fire Risk Index at a home-by-home scale are not to be used in creating a plan for that individual home. The Fire Indices have a 30-meter resolution best suited for local plans, not household ones.

These are the steps we took to manipulate the data to our needs.
Using the Fire Threat Index and Fire Risk Index
1) Import Utah-specific symbology from WWA, and apply it to classified values.
2) Using the Reclassify Raster tool, change the index values to values 1-9
3) Use the Raster to Polygon tool in order to overlay the data on the regional inventory to produce loss estimates
4) For better map display, use a low-pass filter to eliminate salt-and-pepper

Flood

Because many of FEMA'a Flood Insurance Rate Maps (FIRMs) maps have not been updated for decades, we opted to combine the FIRMs with 100 yr. and 500 yr. floodplain maps produced by a FEMA software program called HAZUS. HAZUS uses the latest elevation data (for example, LiDAR for the Wasatch Front) to create flood depth grids for 100 year and 500 year floods. We joined FEMA A-level (100 year) floods to polygon of HAZUS 100-yr flood depth grid, then did the same with shaded-X level (500 year) flood and HAZUS 500-yr flood depth grid. To provide more clarity in mapping we exported 100 year and 500 year layers with dissolved boundaries (for display only, not analysis).

Multiple cities were concerned about the sudden increase in floodplain area determined by HAZUS. When such concerns were stated the methodology was explained and maps delineating NFIP versus HAZUS floodplains were provided. In some cases, HAZUS estimates were closely aligned with actual flooding experienced by a city.

Dams

The U.S. Army Corps of Engineers provided dam information for all Federal dams in Summit, Utah and Wasatch counties. Utah Division of Water Rights includes a Dam Inventory consisting of dam points, hazard level, first downstream town, and notes from the latest inspections. Utah Division of Water Rights also has shapefiles of some dam inundation extents. Both were used wherever possible. Jordanelle and Deer Creek dam failure extents come from a 1994 study by the Bureau of Reclamation. There exist 2012 maps showing extent and depth, but these are carefully kept by the Bureau of

Reclamation for safety purposes. Emergency Managers are able to view and plan with these maps, but Mountainland is not permitted to reproduce them for the public.

The primary purpose of the inundation maps is for warning and evacuation in the event of a dam failure or a large reservoir release. Values chosen to approximate physical characteristics such as dam failure breach parameters, channel roughness coefficients, etc., are based on assumptions and are used to produce best estimates of the downstream inundation. Thus, actual inundation, were it to occur, could be greater or less than that indicated on the inundation maps.

Deer Creek/Jordanelle Dam Study

For this study, the results of the one dimensional National Weather Service (NWS) DAMBRK model performed by the Denver Office was used to obtain the dam break flows from both Jordanelle Dam to Deer Creek Dam and from Deer Creek Dam to the mouth of Provo Canyon. However, the terrain beyond the mouth of Provo canyon is an alluvial fan, which unlike the narrow confined canyon, is a broad, flat plain. A two dimensional model is more appropriate for this type of terrain. It provides a more accurate depiction of the topography and allows for the water to spread and follow multiple drainage paths. The modeling tools used for the Orem/Provo areas utilized the Danish Hydraulic Institute's MIKE 21 two-dimensional hydrodynamic flow model. MIKE 21 is a 2-D finite difference model that simulates unsteady 2-D flows in (vertically homogeneous) fluids using the Saint Venant equations. ARCINFO GIS software is used as both a pre and post processor for the MIKE 21 model. Data used for the Deer Creek Dam models came from 7.5 minute, 10-meter resolution, digital elevation models (DEM) prepared by Land Info Inc., of Aurora, Colorado. The 10-meter data was then resampled at 30-meter cell size for use in the MIKE 21 models. The 10-meter elevation data appeared to be satisfactory for this study however for a more detailed study of the metropolitan area a better resolution of elevation data is recommended.

Landslides

All counties include a simple landslide-susceptibility map consisting of all slopes 30% and over. Additional datasets from the Utah Geological Survey show areas of past landslides, debris flow, and alluvial-fan deposition in the Holocene epoch (everything since Earth's last "ice age"). As with other hazard methodologies, the simple and effective spatial methodology was to overlay these data sets with the regional inventory within GIS to produce loss estimates.

Building Analysis Methodology

Each county provided parcel data with building and tax information. Parcels were determined to be either Residential, Commercial, Industrial, Educational, Public, Religious, or Null (parcels without buildings). Next, a manual sampling comparing satellite data was performed to find areas of misclassification. Not every parcel was checked because going through tens of thousands of parcels was not feasible for this project.

After checking for accuracy, the parcel polygons were converted to points. I then looked at the parcel points (heretofore called building points) with the hazard layers and moved building points on the edges of any hazard to the buildings which they represented while editing any points I found to be in error (ie: an agricultural building misclassified as residential). At this point I was confident that most buildings points were classified correctly and located with their respective hazard areas.

1) **Identifying Buildings at Risk**

To determine the number of buildings at risk, I selected all buildings within a city's boundary then intersected those with each hazard. I ran a report for each city's hazard with the improvement value of the parcel, aka the building value without the land, and the acreage, meaning the acreage of the parcel on which the at-risk building sets. Some hazards were straightforward, but others required a categorical intersection with the building points.

Hazard Profile Methodology

Each hazard profile relied on the following criteria to create meaningful comparisons between hazards.

Standards from FEMA IS 235: Emergency Planning Course

Potential magnitude (Percentage of the community that can be affected):

Catastrophic: More than 50%

Critical: 25 to 50%

Limited: 10 to 25%

Negligible: Less than 10%

Frequency of Occurrence

Highly likely: Near 100% probability in next year

Likely: Between 10 and 100% probability in next year, or at least one chance in next 10 years.

Possible: Between 1 and 10% probability in next year, or at least one chance in next 100 years.

Unlikely: Less than 1% probability in next 100 years

Standards we modified to fit our region

Severity (our definition) **per incident**

Catastrophic: Many lives, a great deal of property

Critical: Multiple lives lost, but mostly property loss.

Limited: Some property loss, less than 3 lives lost.

Negligible: Some property, no life lost.

Summary of Hazard Mitigation Action Plan for Saratoga Springs

Hazard Listed in the Same Order as the MAG Plan	Proposed Mitigation Actions (Y/N)	Description of Potential Mitigation Construction Project Actions	Timeline (10 year time line used.)	Estimated Costs (to City)*	Potential Funding Sources**	Mitigation Possible by New Zoning or Building Code Actions (Y/N)	Mitigation Possible by Public, Business, and Community Awareness Outreach
Debris Flow	Y	Construction of Loose Canyon Debris Flow Mitigation Measures	2017 to 2019	$800,000	PDM,HMGP FMA, DNR	Y	N
		Study of Other Potential Debris Flow Hazards	2019 to 2020	$100,000		Y	N
		Other Debris Flow Mitigation Construction Projects	2021 to 2026	$1,000,000		Y	N
Wildfire	Y	Implement Fuel Reduction in Cooperation with Other Agencies	2018 to 2026	$100,000	PDM,HMGP DNR	Y	N
		Construct Fire Breaks in Cooperation with Other Agencies	2018 to 2026	$300,000		Y	N
		Continued Public Awareness Training	2017 to 2026	To be determined		Y	Y
Severe Weather	Y	Acquisition on Installation of Emergency Generators	2018 to2020	$400,000	PDM,HMGP	Y	N
Flood	Y	Continued Zoning Restrictions	2017 to 2026	n/a	n/a	Y	Y
		Berm Construction at Lift Stations	2018 to 2026	$500,000	PDM,HMGP	N	N
Explosion Induced by Natural Hazard	Y	Enhanced Zoning Restrictions	2017 to 2026	n/a	n/a	Y	Y
Earthquake Ground Shaking-Nonstructural	Y	Design and Construction of Seismic Retrofit Measures for Existing Facilities	2018 to 2020	$100,000	PDM, HMGP	N	N
Earthquake Induced Damage- Structural	N	Enhanced Requirements for New Critical Facilities	2018 to 2026	To be determined	To be determined	Y	N

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Earthquake Induced Liquefaction	Y	Enhanced Requirements for New Critical Facilities	2018 to 2026	To be determined	To be determined	Y	N
		Retrofit Design and Construction of Vulnerable Below Grade Utilities	2022 to 2026	$1,500,000	PDM, HMGP	Y	N
Earthquake Induced Lateral Spreading or PGD	TBD	Retrofit Design and Construction of Vulnerable Below Grade Utilities	2018 to 2026	To be determined	To be determined	Y	N
Natural Hazard Induced Hazardous Material Spill	Y	Enhanced Requirements for New Critical Facilities	2018 to 2026	To be determined	To be determined	Y	Y
Drought	Y	Cooperation with Other Entities to Construct Canal Lining or Piping Projects	2018 to 2026	To be determined	WS	Y	Y
		Continue Ongoing Conservation Efforts	2017 to 2016	In current budgets	WS	Y	Y
Dam Failure	N	Dams Themselves Not Within City's Jurisdiction.	n/a	n/a	n/a	N	Y
Earthquake Induced Seiche	N	Not a High Risk. Limited Response Time Would Exist if a Seiche Occurs.	n/a	n/a	n/a	N	Y

* Estimated costs may be revised as final engineering is completed. The City of Saratoga Springs is considering projects shown. Final decisions on project implementation are subject to year by year fiscal planning done by the City.

** PDM= FEMA Pre-disaster Mitigation Grants

HMGP = Hazard Mitigation Grant Program

WaterSMART= (WS used as shorthand) Bureau of Reclamation Water Savings Grants

DNR = Utah Division of Natural Resources

FMA= FEMA Flood Mitigation Assistance Grants