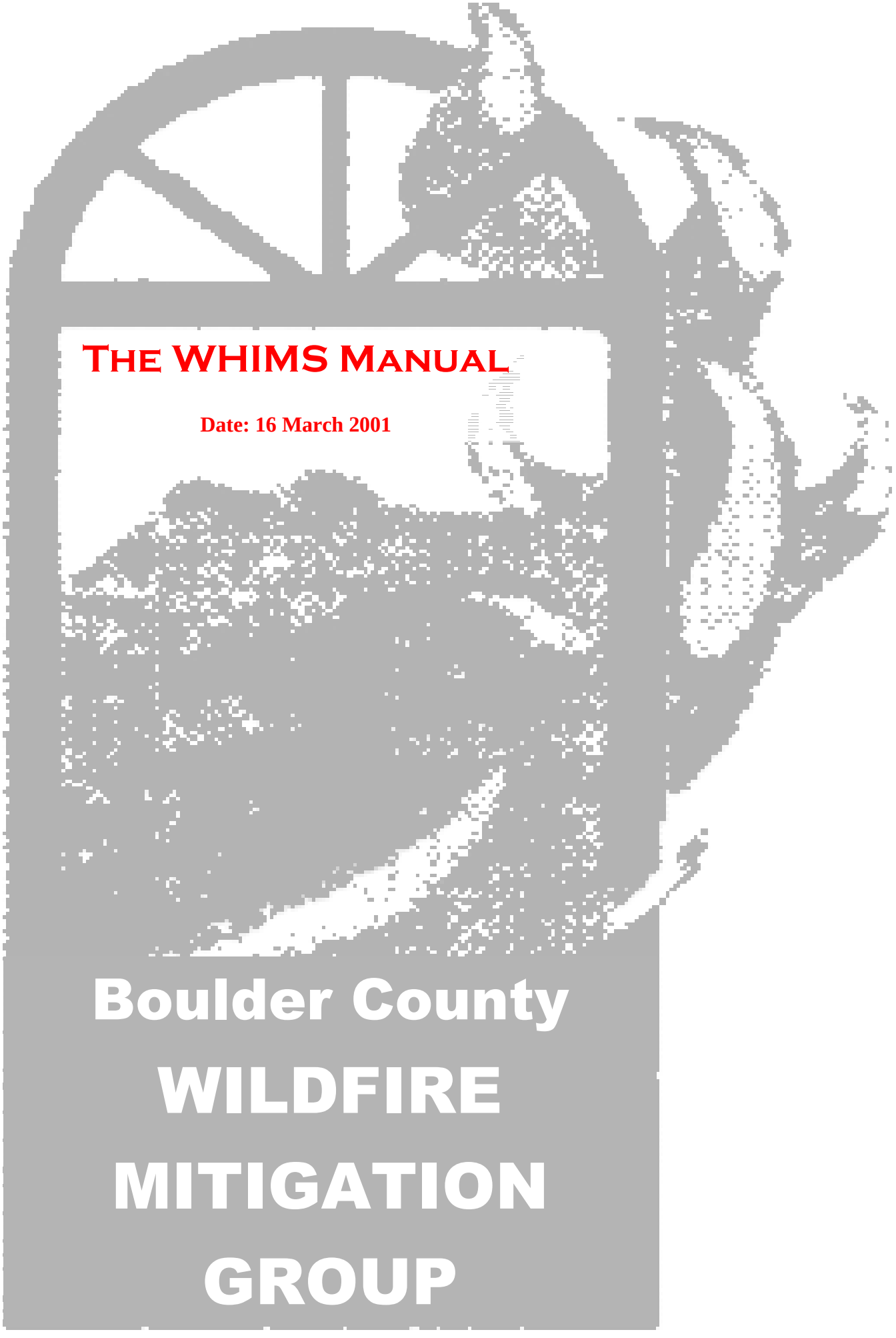

The WHIMS Manual

Date: 16 March 2001

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EXECUTIVE SUMMARY

The possibility of a wildfire is an ever-present danger in the Colorado Front Range. One hundred years of fire suppression and grazing have left the forests with vegetation densities 10 to 100 times their historic levels. This combined with increased residential development and high recreation demands in the mountains has pushed the potential for catastrophic wildfire to crisis levels.

Within the past two decades, Boulder County has experienced its share of large and small wildfires. In Garfield County, 14 fire fighters lost their lives while trying to control a wildfire that threatened homes near Glenwood Springs. In 1996 in Jefferson County, the Buffalo Creek Fire charred over 10,000 acres and two people were killed in post fire-related flooding.

The situation in Boulder County reached a crisis point in 1989, when the Black Tiger Fire burned 44 homes and blackened over 2,000 acres of forested land in the western part of the county just five miles from the city of Boulder. In 1990, under a mandate from the Federal Emergency Management Agency (FEMA), the agencies and individuals involved in the Black Tiger Fire produced a report *(National Fire Protection Association, year unknown)* that became the wildfire portion of the Colorado Natural Hazards Mitigation Plan. At the directive of the Board of County Commissioners, that group evolved into the Boulder County Wildfire Mitigation Group (BCWMG), chaired by staff in the County Land Use Department and consisting of members from the County Land Use and Sheriff Departments, the County's Fire Protection Districts, the Colorado State Forest Service, the City of Boulder Fire Department, the USDA Forest Service, National Park Service, and private citizens. The group's mission was to discuss and coordinate actions that could help minimize loss of life and property from future wildfires.

In 1992, the BCWMG realized the potential for a geographic information system (GIS) to assist in its mission. A technical team from the group began designing and developing what is now referred to as the Wildfire Hazard Identification and Mitigation System or, WHIMS, for short. By 1994, the City of Boulder implemented its own version of the system, called FIRMIT (for Fire Mitigation).

With involvement of public and private agencies and individuals from the community, WHIMS combines hazard assessment, forest management, land use planning, building safety, wildfire behavior, and fire suppression expertise with geographic data management and analysis technologies. When fully implemented, WHIMS strives to identify wildfire hazards, educate homeowners, assist land managers, and assess risks. In addition, it aims to assist in pre-attack planning, emergency response planning, land use planning, and disaster assessment.

The goal is to communicate information effectively and to follow up with action programs, using GIS as the medium. WHIMS puts information into the GIS, compiles and displays it, and gets the information out to be used by the agencies represented in the BCWMG. To accomplish this, community and interagency partnerships are a necessity.

WHIMS is designed with 4 components - data collection and management, data analysis, information dissemination, and implementation of recommendations, and system maintenance. Lot boundaries and ownership information are extracted from the County Assessor's parcel ownership database. Topographic information is extracted from USGS digital elevation model data (DEM). Fuel type data was specifically mapped for the project, and site-specific hazard data are collected on-site using a hazard-rating questionnaire for each parcel. The questionnaire, developed with wildfire hazard experts, is filled out on-site by volunteer fire fighters involving personal contact with homeowners whenever possible. This allows the resident to ask questions and discuss the hazards and possible mitigation actions. In addition to educating homeowners during the site visit, the fire fighter becomes more familiar with his/her district. This direct contact, participation, and education opportunity is a key benefit of WHIMS.

The wildfire hazard is assessed using a hazard-rating model based upon wildfire behavior models and the expertise of wildfire behavior specialists. An overall hazard rating and individual factor ratings, i.e., topography and fuels, construction, landscaping, defensible space, accessibility, water, and fire protection are produced. In addition, the mitigation potential through improved site maintenance or structure remodeling can easily be determined. Hazard and factor rating maps are provided to the fire protection districts for pre-attack and resource placement and planning. The information is available in the Land Use Department for site design and land use planning. Periodic data updates are needed to keep the system current.

The WHIMS Manual documents the organizational, technical and operational aspects of the WHIMS project. The manual is intended to aid communication between WHIMS project personnel, to insure smooth operation of the project despite personnel changes, and to share WHIMS with other communities and interested parties.

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City of Boulder Planning Department

Claire M. Hay
The Wildfire Interface Group

Chris White
The Anchor Point Group

FOREWORD

Purpose of the WHIMS Manual

WHIMS stands for the **W**ildfire **H**azard **I**dentification and **M**itigation **S**ystem. The primary goal of the WHIMS project is to educate homeowners about the hazards from wildfire in the Urban Wildland Interface (UWI) and to encourage homeowners to voluntarily mitigate those hazards. The purpose of the WHIMS Project Manual is to document the organizational, technical and operational aspects of the WHIMS project. The manual is intended to serve as a document to facilitate communication among WHIMS project personnel and to insure the continued smooth operation of the project despite any personnel changes. This manual provides a standardized reference of project components and protocols. In addition, the manual is intended to provide a convenient mechanism by which to respond to requests for project information from other state, county and federal agencies. This document will hopefully serve as an adequate description of the WHIMS project so that other interested agencies and organizations can initiate their own programs.

Besides describing the organizational, technical and operational aspects the WHIMS, the manual incorporates a brief description of the problem of living in the UWI, and describes and illustrates important concepts concerning the building and maintenance of fire resistive structures in the UWI.

It is expected that as the WHIMS project continues to develop, so will this manual continue to develop, be refined, and expand.

Organization of the Manual

Preceding the first chapter, the WHIMS Manual starts with an introduction to the overall context and scope of the WHIMS Project. In that section, a brief description and definition of the urban wildland interface (UWI) is presented along with a very brief overview of the wildfire hazard in the UWI. The concept of an interface zone between a wildland vegetation environment and residential or commercial development areas in which a hazard exists is central to the entire scope of the WHIMS project. The description of the interface zone and the associated wildfire hazard is pertinent to every subsequent chapter in the WHIMS Manual. Also included in the introduction is a brief description of the origins of the Boulder County Wildfire Mitigation Group (BCWMG) and the WHIMS technical working group that was setup under the BCWMG. Chapter 2: THE NEED FOR WHIMS continues with a description and brief history of the wildfire hazard in the Boulder County UWI. Beginning with Chapter 3: WHIMS OVERVIEW, the WHIMS project is described in a sequence of chapters starting with an overview of the project. Chapter 3 describes the goals and objectives of the project, the philosophy and underlying concepts that guide and continue to guide the development of the project, and key elements of the project.

Those readers interested only in a general description of the scope of the WHIMS project, its goals, objectives, and community involvement activities, the following section list will provide an overview of the project without getting into the technical details of the project - PREFACE, Chapter 1: INTRODUCTION, Chapter 2: THE NEED FOR WHIMS, and Chapter 3: WHIMS OVERVIEW.

Following the overview, a more detailed description of the operational components is presented. See - Chapter 4: GETTING STARTED - initial steps required to implement the project, Chapter 5 through Chapter 8: operational components of the WHIMS project, specifically, data collection and management, data analysis and interpretation, using the data in land use planning and management decisions, and finally, maintaining the system and database to insure that the data are reasonably current. Chapter 9: CASE STUDY - description of the City of Boulder's FIRMIT project, Chapter 10: WHAT'S NEXT? - needed improvements and desired expansions in the project.

More detailed technical information on certain aspects of the WHIMS project is presented in the appendices - Appendix A - field manual for the WHIMS questionnaire. The set of questions on the WHIMS questionnaire is presented and each question is described with instructions for selecting the most appropriate response for each question; Appendix B - standardized fire fuel model descriptions found within Boulder County. These fire fuel models are used in the BEHAVE (Rothermel, 1983) fire behavior model. The description and models presented in Chapter 0Appendix B have been tailored to the specific vegetation situations found in Boulder County; Chapter 0Appendix D: SAMPLE COVER LETTER TO HOMEOWNERS presents a sample of the cover letter that is sent to all homeowners within a district prior to the start of the WHIMS questionnaire data collection effort; Appendix E describes building design and material elements and landscape maintenance elements that can be modified to reduce the hazard to a structure due to a wildland fire, and Appendix J: - list of additional resource contacts.

Completeness of the Manual

Some sections of this manual are incomplete. This is often due to the fact that for a particular aspect of the project, e.g., Chapter 8: MAINTAINING WHIMS, procedures, policies, and protocols have as yet not been established. WHIMS is still a work in progress. Those sections, however, appear in the manual in outline

form so that the issues related to that topic can be identified and listed. Other sections are incomplete because personnel associated with those aspects of the project have left before they could document that part of the project. Again those sections appear in the manual in outline form so that the issues related to that topic can be identified and listed for future attention.

Distribution of the WHIMS Manual

The WHIMS Manual will be available to all of the fire protection districts within Boulder County. Homeowners within the districts, either individually or as a group, can most easily review or examine the WHIMS Manual through interaction with their local fire protection district officials. Additionally, the WHIMS Manual is available to the Chiefs' Working Group of the BCWMG.

In general, broader dissemination of the WHIMS information will be facilitated through the various national, state, and local agency and organization representatives to the BCWMG and the WHIMS technical working group.

Suggested Use of the Manual by Other Agencies

Use By State Agencies

This manual can be of value as a guide for state agencies inside and outside of Colorado that may want to develop projects addressing the following issues:

1) Wildfire hazard identification (assessment)
2) Planning and coordination with local agencies and departments
3) Homeowner wildfire hazard information and education/awareness
4) General wildfire hazard information gathering and research
5) Project planning and implementation

Use By Other/Outside Agencies

Agencies outside of Boulder County will hopefully find this manual helpful for a broad spectrum of uses. Possible utilization ranges from use of the manual as a source of general information about a wildfire hazard assessment project to specific information about implementation of a wildfire hazard assessment project. It is important to emphasize that the specific hazard assessment analysis used in the WHIMS project in Boulder County *is not* meant to be construed as ideal for all areas, situations, or conditions. It is meant to be used as a tool by wildland fire managers, planners, land use departments, and subdivisions that want to begin a wildfire hazard education and evaluation program in order to encourage or direct mitigation planning and implementation.

Acknowledgments

The achievements of the WHIMS program are due to the efforts and good will of many people from all aspects of the Boulder County community. Not the least of thanks needs to be extended to the Boulder County Commissioners for the financial support that they have provided the program over the years as well as their continuing good will and encouragements in keeping the program alive and active. The support both financial and technical provided by various people from the Colorado State Forest Service has often been the lifeblood of the project. We can only say Thank You Colorado State Forest Service – we wouldn't be where we are with out you and your people specifically, Jim Hubbard – State Forester for the State of Colorado, Steve Hartsell - former District Forester for Boulder County, Craig Jones - former District Forester for Boulder County, and Rich Gray - former Forester for the Boulder County District. Equally grateful thanks need to be extended to the USDA Forest Service, specifically to Mike Foley of the Arapahoe-Roosevelt National Forest Office in Fort Collins. The USDA Forest Service provided much needed funds to get the program up and going.

The support and assistance of the various fire protection district chiefs and former chiefs cannot be too strongly acknowledged. Without the support of the fire protection district chiefs, many of them volunteers, WHIMS would not have succeeded. Many other 'volunteer' persons from the community have also been instrumental in the success of WHIMS. It must be noted that at least 50% of all effort and support for WHIMS has been from 'volunteer' persons in the community. The list includes the volunteer fire fighters from the fire protection districts who gave up their free weekend time to collect the WHIMS data for their districts, people from private organizations and companies that provided their time and support to the program. Volunteer interns and staff of the Boulder County Land Use Department and the GIS Division who helped prepare and encode data for the project. Most importantly thanks to the people who provided the much needed technical support and guidance – the WHIMS Technical Working Group (WTWG). A partial list of the WTWG includes the following participants from:

the Boulder County Land Use Department: Marie-Annette (Nan) Johnson, Former WHIMS Project Coordinator and currently withCity of Boulder Planning, Gary Goodell, Former Chief Building Official for Boulder County, Ken

Ziebarth, GIS Division Supervisor, Jim Korte, GIS Division, Chris White, Former Boulder County Wildfire Mitigation Coordinator and currently with Cherryvale Fire Protection District and The Anchor Point Group;

the Boulder County/ Sheriff's Department: Larry Stern, Boulder County Deputy Sheriff, Gary Fager, Boulder County Deputy Sheriff, Dave Booten, Boulder County Deputy Sheriff;

the City of Boulder: Greg Toll, FIRMIT Project Manager, City of Boulder Fire Department, Marc Mullenix, City of Boulder Wildland Fire Coordinator, City of Boulder Fire Department;

the State of Colorado: Craig Jones, Colorado State Forest Service, Steve Hartsell, Colorado State Forest Service, Rich Gray, currently with the Texas State Forest Service;

the USDA Forest Service: Mike Foley, Arapahoe-Roosevelt NF, Fort Collins, CO, Paul Mintier, Arapahoe-Roosevelt NF, Boulder, CO, Dave Buchanan, Arapahoe-Roosevelt NF, Boulder, CO;

the Boulder County Fire Protection Districts: Peter D. Slack, Former Chief, Pine Brook Hills FPD; The Wildfire Interface Group, Bob DeHaas, Director, Pine Brook Hills Water District and, Former Chief, Pine Brook Hills FPD, Mike Tombolato, Chief, Cherryvale FPD, Margaret Hansen, Former Chief, Four Mile FPD, Dave Nyquist, Chief, Left Hand Canyon FPD, Vivian Long, Former Training Chief, High County FPD, Eric Ramberg, Former Chief, Boulder Heights FPD, Tom Atkins, Former Chief, Boulder Heights FPD, Clark Woodward, Four Mile FPD, John Hilson, Gold Hill FP D; and

Private Industry: Claire M. Hay, The Wildfire Interface Group, and Bob Almotovar, BB Software.

And lastly thanks to the people who took the time to review the manuscript for this manual: Margaret Hansen, Marie-Annette (Nan) Johnson, Craig Jones, Deborah A. Martin, Chief Mike Tombolato, Chris White, Chief Don Whittemore, Boulder Mountain Fire Authority, and Scott Woods, State Wildfire Mitigation Coordinator, Colorado State Forest Service.

Dedication

From the inception of WHIMS, Ms. Nan Johnson, the former WHIMS Coordinator for Boulder County, Colorado, worked tirelessly and with a dedication that far outdistanced her assigned duties with the Boulder County Land Use Department. Due to her enthusiasm and commitment to the WHIMS goal of mitigating wildfire hazards within the county through the education of homeowners and others, she has help to build a wildfire hazard identification and mitigation system of which Boulder County and the State of Colorado can be proud. In recognition of her dedication and contributions to the success of the WHIMS project, this manual is dedicated.

Claire M. Hay
WHIMS Manual Coordinator

Table of Contents

Table of Figures

Table of Figures

Contributors to the Manual

Foreword by Claire M. Hay, Craig Jones, and Nan Johnson

Chapter 1: THE WHIMS MANUAL by Claire M. Hay, and Craig Jones

Chapter 2: THE NEED FOR WHIMS by Craig Jones, Claire M. Hay, and Nan Johnson

Chapter 3: WHIMS OVERVIEW by Nan Johnson, and Claire M. Hay

Chapter4: GETTING STARTED by Nan Johnson

Chapter 5: COLLECTING AND MANAGING THE DATA by Claire M. Hay, Rich Gray, Craig Jones, Nan Johnson, and Jim Korte

Chapter 6: INTERPRETING THE DATA by Claire M. Hay

Chapter 7: USING THE WHIMS INFORMATION by Craig Jones, Claire M. Hay, and Nan Johnson

Chapter 8: MAINTAINING WHIMS by Claire M. Hay

Chapter 9: CASE STUDY by Greg Toll

Chapter 10: WHAT'S NEXT? By Claire M. Hay

Appendix A: WHIMS QUESTIONNAIRE FIELD GUIDE by Claire M. Hay with illustrations by Peter D. Slack

Appendix B: FUEL MODELS FOR COLORADO - A GUIDE FOR THE HOMEOWNER by Rich Gray

Appendix C: FOREST FIRE BEHAVIOR IN FOUR MILE CANYON by Margaret Hansen

Appendix D: SAMPLE COVER LETTER TO HOMEOWNERS by The Boulder County Land Use Department

Appendix E: LICENSE AND EXCHANGE AGREEMENT FOR GEOGRAPHIC DATA by The Boulder County land Use Department

Appendix F: ELEMENTS OF MITIGATION by Peter D. Slack and Claire M. Hay

Appendix G: FIRMIT FOLLOW_UP SURVEY RESULTS by Greg Toll

Appendix H: FIRE SUPPRESSION IN BOULDER COUNTY by Craig Jones

Appendix I: PROGRAM WHINFOE: USER'S GUIDE (Version 4.00) by Claire M. Hay

Abbreviations and Terms Used in the Manual

ARC/INFO	Registered product name for Environmental System Research Institute's GIS
ARCVIEW	Registered product name for Environmental System Research Institute's geographic data viewer
BCFFA	Boulder County Fire Fighters Association
BCLUD	Boulder County Land Use Department
BCWMG	Boulder County Wildfire Mitigation Group
Brush	an area where the majority of vegetation is comprised of dense shrubs.
Chimney	A topographic term used to describe a steep gully or drainage that will funnel wind and fire rapidly up slope. In effect, like a chimney.
Closed Canopy	A situation in which tree crowns are intertwined with one another, creating closed cover over the forest floor.
Crowns	A term used to describe the top portion of trees, which includes limbs, branches and needles.
Crown Fire	A situation in which a fire burns through the upper portions or "crowns" of trees. This is a high intensity rapidly spreading fire.
CSFS	Colorado State Forest Service
ESRI	Environmental Systems Research Institute
Fire Brands	also referred to as burning embers, these are small airborne pieces of burning vegetation, which can ignite new fires.
Fire Carrier	Refers to the fuel that is actually burning and allowing the fire to spread.
Fire Intensity	describes the intensity level at which a fire is burning. Relates directly to the rate of fire spread, flame length of the fire, and the overall energy released by burning.
FIRMIT	Fire Mitigation Project for the City of Boulder, Colorado
Forest	A condition in which the majority of an area is covered by trees.
FPD	Fire Protection District
Fuels	any material that will burn and contribute to the spread of a wildfire. This includes trees, shrubs, grasses, wooden fences, trash and homes.
GIS	Geographic Information System
GPS	Global Positioning System
GRID	Environmental System Research Institute's (ESRI) raster (cell based) spatial analysis module for the ARC/INFO GIS.
Hazard	Chemical, biological, or physical source of risk; characteristics of a system that represent the potential for an event that would have adverse effects. (adapted from Kolluru, et al., 1996)
Interface	An area in which wildland fuels and human structures occur in close proximity to each other.
Interface Wildfire	A wildfire that occurs in the Interface.
Ladder Fuels	Any material that will allow a fire to spread from the ground to the crowns of trees. This includes understory shrubs, and trees, low hanging branches and dead limbs, and wooden fences and trash.
Litter	this is any dead vegetative material that has fallen to the forest floor, including grasses, leaves, needles, twigs and branches.
MAS	Mountain Addressing System
Open Grown	A condition in which trees are few in number and widely spaced.
PBH	Pine Brook Hills
Risk	A measure of the likelihood and magnitude of adverse effects. (Hazard does not mean risk per se.) (Kolluru, et al., 1996)
Spotting	A situation in which smaller fires are started in front of the existing fire. This is caused when fire brands fall and ignite fuels. This activity leads to the rapid expansion of the wildfire.
TIN	Triangular Irregular Network; an additional analysis module for ESRI's ARC/INFO GIS product that analyzes digital elevation surface data.
Torching	A situation where individual tree crowns burn, but the fire does not advance from tree to tree.
Understory	A term used to describe the lower level of vegetation growing under the canopy of taller vegetation. Examples are grasses and shrubs growing under trees.

URWIN	Urban-Wildland Interface
USDA	United States Department of Agriculture
USFS	United States Forest Service
USGS	United States Geological Survey
WHIMS	A Wildfire Hazard Identification and Mitigation System for Boulder County, Colorado
WHINFOE	The wildfire hazard-rating model used by WHIMS
Wildfire	A fire that is an unintentional ignition by human action or is a natural ignition that is unplanned and burning in a wildland environment.
UWI	Urban Wildland Interface

Chapter 1 : INTRODUCTION[1]

Throughout the west, an increasing number of people are moving away from urban centers into the more rural or wildland fringes. The ability to drive in difficult terrain with four wheel sport utility vehicles and the availability of technology which provides faxes, modems, and cell phones has accommodated a growing trend of people working at home away from city centers. Often times these new residences are pushing the size limits of what once used to be small cabins. In Boulder County, it is not uncommon to see new structures (including expansions) ranging between 3,000 - 12,000 square feet being constructed in flammable wildland vegetation.

This intermixing of structures with wildland vegetation creates a significant fire management problem. In the one case, wildland fuels are partially dependent upon or adapted to fire as part of their environment. In the other case, residential and other structures are not compatible with a fire environment. This mixture of two different types of fuel with different tolerances for the presence of fire is the crux of the wildfire management problem in the urban wildland interface.

The Urban Wildland Interface

The urban wildland interface (UWI) is a term used to refer to a geographic area in which flammable wildland fuels are in close proximity to urban and/or suburban structures. Various terms are used to describe this geographic area depending upon the users' focus or professional arena. Some of the more common terms are the urban wildland interface (UWI), the wildland urban interface (WUI), the urban/wildland interface (URWIN), and the I-Zone (Slaughter, 1996). Natural resource managers and planners tend to emphasize the 'wildland' focus more than urban land managers or planners. With regard to wildfire in the UWI, the term 'urban' may be used to refer to low density development of a few residential structures on large acreage lots, 35 acres (14 hectares) or larger; or the term may refer to high density development that is typically considered to be 'urban', but that is heavily interlaced with wildland vegetation (Slaughter, 1996). In the term 'urban wildland interface', the word 'urban' refers as much to the background, expectations, and perspectives of the newly relocated residents as it does to the actual structures and developments.

According to Slaughter (1996), three types of interface were defined by Charles W. Philpot of the USDA Forest Service. The three interface types are the classic interface, the mixed interface, and the occluded interface. The classic interface occurs where urban or relatively high density, subdivision development is immediately adjacent to wildland vegetation on the edge of the urbanized developed area. The mixed interface, also called the intermix, occurs where less dense development is scattered throughout a wildland environment. The occluded interface occurs where a patch of wildland vegetation has become surrounded by urban or subdivision, high-density development (Slaughter, 1996).

Wildfire Hazard in the Interface

The urban wildland interface problem is a growing issue in many of the arid and semi-arid western states. The legendary seasonal wildfires in Southern California quickly come to mind. However, all of the western states have also experienced significant loss of life and structures due to wildfires. The two main factors contributing to an increased wildfire hazard in the UWI are: 1) increased population density in areas that were formerly wildland, and 2) increased fuel loads due to approximately 100 years of altered fire frequency patterns.

Expansion of residential and other types of development into surrounding rural and wildland areas has led to increased risk due to wildfire for those developments. Couple this increased development pattern with more than 70 years of active wildland fire suppression and the hazard is higher than would have been the case had frequent fires not been suppressed. Active, effective, fire suppression has led to the buildup of substantial fuel loads which has lead to higher fire intensity when a wildfire does occur. When this higher fire intensity takes place in areas where structures are now located, wildfire management becomes even more difficult. The USDA Forest Service (Averill, 1996) completed a study on the wildfire risk in the Colorado Front Range. One result of the study is a map of the Probability of Catastrophic Disturbance Events (known as the 'Red Zone' map). According to the USDA Forest Service study, the Front Range communities from Fort Collins to Colorado Springs are in the medium to high probability of catastrophic disturbance class.

The concern addressed by the WHIMS project is a fire that threatens residential or other structures where the fire hazard is primarily due to the existence of wildland vegetation near a structure or set of structures. While there is some concern about a structure fire spreading to the wildland environment, the frequency of such an event is quite low. The main concern is a wildland fire spreading to structures.

[1] Portions of this section have been extracted from Hay, 1998.

Figure 1: Boulder County, Colorado Location Map

Boulder County and the WHIMS Project

Located just 40 miles northwest of Denver, Colorado on the eastern side of the Rocky Mountains Front Range, Boulder County is home to the WHIMS project (see Figure 1). Covering approximately 750 square miles, the county lands range from the semi-arid eastern grasslands and plains through the montane forests of the foothills to the alpine tundras along the Continental Divide. Steep rugged canyons, strong Chinook and Bora winds, and semi-arid conditions describe the physical conditions of the county's mountainous area. Beyond that, steep winding roads access rural developments that are predominately residential with septic tank sewer systems and ground water wells. Local city and county open space lands along with the National Park Service, US Forest Service, and Bureau of Land Management lands comprise over half of the western 450 square miles of the county. These public lands intermix with private landholdings in the form of old subdivisions and town sites, mining claims, and four incorporated towns. Eighteen local fire protection districts serve the mountainous western half of the county. This half of the county includes high to extreme probability classes on the "Red Zone" map (Averill, 1996).

In 1989, the Black Tiger fire destroyed 44 homes and burned 2086 acres of the highly visible Sugarloaf Peak area. After that and other smaller wildfire events, the Boulder County Wildfire Mitigation Group (BCWMG) was established by the County Commissioners to discuss solutions and coordinate actions to help mitigate the wildfire threat. A technical working group of the BCWMG was set up to design a wildfire hazard identification and mitigation system (WHIMS) which was also to utilize the county's geographic information system (GIS) as part of the system. The WHIMS working group "combined expertise in hazard assessment, wildfire behavior, forest management and fire suppression" (Johnson 1994) to the extent that it has earned creditability and respect from other peer agencies.

The successful outcomes of the WHIMS project, backed by the need for documentation and fostered by the financial support of the Colorado State Forest Service, has led to the publication of this manual.

Chapter 2 : THE NEED FOR WHIMS

"Is There a Problem?"

Fire History in the Rocky Mountain Forest Ecosystem

Fire is one of the most dynamic forces in Rocky Mountain forest ecosystems. In fact, fire has significantly shaped the composition, density and overall characteristics of Colorado's forests. Colorado's forests have evolved within the context of wildfire generated disturbance processes, so that the structure and health of the environment is dependent upon wildfire.

In the northern Front Range and, in particular, Boulder County, there are four primary forest types - Ponderosa pine, Douglas fir, Lodgepole pine and Spruce/fir. While fire plays a role in all forest types, it is in the Ponderosa and Lodgepole pine types that fire's influence is most apparent.

In Ponderosa pine stands, fires traditionally occurred on a fairly frequent basis[2]. These fires were generally of low intensity and created the characteristic open or "park like" structure of these forests. Fires in the Lodgepole pine type, on the other hand, occurred on a less frequent time scale, and were more intense, stand replacement type of events. Due to Lodgepole's thin bark and serotinous (i.e., heat activated) cones, stands reproduce as even or same-aged after such major conflagrations.

Ignition Sources

Historically, wildfires were primarily caused by lightening. Native Americans also intentionally lit fires to improve game habitat and maintain travel corridors. The character and structure of the landscape that Europeans found when they first arrived in Colorado was due to the occurrence of frequent fire caused both by lightening and by Native Americans.

It was the European settlement of the west and the subsequent growth and development of that population that initially added additional ignition sources to the environment. Escaped land-clearing or agricultural burns, campfires, railroad engine sparks, general carelessness and even arson were, and still are, all responsible for increased wildfire ignitions.

Frequency and Intensity

The two factors, frequency (i.e., return interval) and intensity (heat output of a wildland fire), are the primary fire factors that influence forest stand composition, density and character. The two primary stand types - Ponderosa pine type and Lodgepole pine type - found in the Colorado Front Range, are described in more detail below.

Ponderosa Pine

Dr. Tom Veblen of the University of Colorado, Boulder, has used non-destructive sampling techniques of fire-scarred trees to accurately show the fire return frequency in the Ponderosa pine (Pinus ponderosa), grass, shrub ecotype. Using dendrochronology technology (tree ring dating), he has been able to "graph" the frequency of fires in the Boulder County area of the Front Range. Prior to European settlement, it is fairly certain that fires occurred every 25 to 35 years in the Ponderosa pine ecotype. These fires were not extremely intense - stand replacement events, but low intensity, stand maintenance events. The low intensity fires would burn primarily along the ground, consuming the duff and needle/twig layer, or killing shrubs and small trees. Depending on weather conditions, pockets of intense fire would kill individual or small groups of larger trees. Frequent, low intensity fires maintained the Ponderosa stands as a mosaic of open, park-like stands, interspersed with meadows and small pockets of more densely grouped tress. The patchwork mosaic pattern of these low-intensity, fire-maintained landscapes appeared similar to that shown in Figure 2.

[2] Dr. Thomas Veblen, Professor, University of Colorado, Department of Geography, personal communication, 1997.

Figure 2:Typical Ponderosa Pine Stand **Photo by R. Gray**

Lodgepole Pine

In the previous section, it was stated that fire plays a vital role in coniferous forests throughout the west. That concept is most evident in the Lodgepole pine forest type. Lodgepole pine (Pinus contorta) is in fact considered a 'fire pine' – one of several such pines found in North America. By definition, fire pines are those that are totally dependent on fire for regeneration.

Lodgepole pine as a species has adapted a unique feature in order to reproduce itself after catastrophic fire events. While stand replacement fires occur much less frequently than in the Ponderosa pine type, such events as a rule 'reduce' entire stands. Depending on conditions during the fire (drought, wind, etc.) and the site location, such wildfires can rage over hundreds or thousands of acres. This is primarily due to the dense nature of the Lodgepole pine forest type, its flammability, and the very thin bark characteristic of the species.

To ensure regeneration, Lodgepole has adapted *serotinous* or closed cones. These types of cones as a general rule do not open until high temperatures are reached – as during a wildfire. As the cones open, seeds are dropped onto the freshly exposed mineral soil ensuring a new stand of trees.

Figure 3: Typical Lodgepole Pine Stand **Photo by R. Gray**

Because of this phenomenon, Lodgepole pine forests are frequently even-aged (same aged) stands of trees since the trees generally germinate at the same time following the wildfire event. After a stand replacement event, regeneration occurs relatively quickly – usually within four to eight years. The number of stems per acre can reach 10,000 or more. Over time the stands thin themselves until stocking densities level off. Such stands remain very uniform and quite dense. With such high densities the Lodgepole pines shade out the understory vegetation leaving the forest floor fairly void of other plant life. The sparse understory creates the very characteristic 'clean' appearance of Lodgepole pine forests as shown in Figure 3.

Wildfire Hazards in the Urban Wildland Interface (UWI)

The two main factors contributing to an increased wildfire hazard are:

1) heavy fuel loads as a side effect of increased grazing since European settlement in the mid-19th century and approximately 70-80 years of effective fire suppression, and
2) increased population density in areas that were formerly undeveloped.

100 Years of Fire Exclusion

When European settlers moved into the Front Range Region of Colorado, they started grazing the land with their cattle. The increased grazing of grasses at the lower elevations led to a decrease in the continuity of the grass and forbs type fuels. When fires started either naturally or by man, the fires did not carry as far into the wooded environments as they had in the past before increased grazing. Woody fuels began to accumulate in the forests.

By the 1920's, active, vigorous exclusion of fire from western forests became the policy of the federal and state land management organizations (Pyne, Andrews, and Laven, 1996). Seventy plus years of effective, vigorous fire suppression has further shifted the historical pattern of wildfire occurrence from frequent, low intensity events to a pattern characterized by less frequent low intensity events and more frequent, moderate to severe events. Basically, due to fire suppression policies, forest fuels have accumulated to the point that when a wildfire does occur, there is a higher likelihood that the event will be a more intense event with higher heat output. With the occurrence of more intense fire events, fire protection personnel are at higher risk and services are sorely taxed, both technically and financially, in attempts to suppress wildfire.

A Changing Population in the Wildland-Urban Interface

During the first half of the 1990's, Boulder County like many of the Front Range communities experienced a rapid influx of new residents. These residents came from many parts of the country including California. Many new

residents had large gains from the sale of their primary residences in California and they needed to reinvest those gains in primary residence property in order to postpone capital gains taxes. Since land in Colorado is relatively less expensive than in California, more funds were available for the construction of very large homes. The average size of dwellings increased significantly. Where once there was the desire to build cabins or summer getaways averaging between 600 to 2000 square feet, the structure sizes increased in the 1990s to somewhere between 2000 and 12,000 square feet with a few homes reaching 25,000 square feet. Besides large lots, the remaining development lies on old town sites, 5-acre mining claim tracts that often were further subdivided or aggregated with other claims. In the mining belt districts, hundreds of claims overlap each other resulting in a crisscrossed ownership pattern.

Several subdivisions exist which were approved prior to mid-1978 when the Boulder County Comprehensive Plan was adopted. The plan halted any further subdivisions from being approved in an attempt to restrict development requiring urban services to areas within city limits and to maintain the unincorporated lands as rural. Only four incorporated towns exist in the mountains of the county: Nederland, Jamestown, Ward, and Lyons all of which are severely constricted in the expansion of their city limits by their physical site conditions and surrounding land ownership. About 60% of the land in the mountains is held in public ownership, predominantly by the USDA Forest Service. The Rocky Mountain National Park, USDI Bureau of Land Management, State of Colorado, the City of Boulder, the City of Longmont, and Boulder County comprise the remaining public ownership.

In the 1990's, the population in Boulder County increased from 230,000 to almost 250,000 and a significant part of this population now resides in the mountainous half of the county. The planning community's response to the increased development in the mountains was the development of a site plan review process through regulations added to the Boulder County Land Use Code in 1993. Land use patterns in the mountains were and continue to be influenced by the 35-acre minimum building lot requirement. This results in a dispersed rural land use pattern characterized by large lots served by sometimes long, steep, winding roads and often with structures located in highly visible sites with great scenic views but in dangerous topographic locations from a wildfire hazard perspective, e.g., ridge tops, steep slopes, or above a chimney. For a variety of reasons, the turnover of residents in the mountains is quite high which contributes to an increasing number of mountain residents that are unfamiliar with the forest setting and the hazards associated with it.

Expansion of residential and commercial development into surrounding rural and wildland areas has led to increased risk due to wildfire for these developments. Not only do residential and commercial developments increase the population living in the interface, but also the number of transitory visitors interested in recreation in the interface has increased the number of potential fire starts and people at risk from wildfires.

The Interior Columbia Basin Ecosystem Management Project has looked at the changing nature of the interface population (Mejer, 2000). New interface residents often have social and cultural values that are based upon urban expectations and fanciful ideas of living with and in nature. The new interface residents are not in the habit of anticipating nor accepting the risks associated with a more hazard, risk prone, rural environment (Cortner, Swinford, and Williams, 1990). Fire protection services are not at the level that would be available within the more urban environment. Response time and volunteer fire fighter training is often not what would be found within an urban, paid fire department (Moore, 1981). In the mountainous areas of Boulder County, local fire protection district chiefs and wildfire managers report attitudes and values among the new residents that are similar to those reported in the Interior Columbia Basin Study[3]. Not only do the attitudes and values of many new residents ill prepare them to recognize and accept the risks of living 'close to nature', but their lack of ecological understanding of the natural environment, makes them pre-disposed to reject ecologically sound, viable solutions to the wildfire problem.

[3] personal communications: 1996, 1997, Mike Tombolato, Chief Cherryvale Fire Protection District, Boulder, CO, and, 1996, Peter D. Slack, Former Pine Brook Hills Fire Protection District, Boulder, CO.

Chapter 3 : WHIMS OVERVIEW

"Mitigating Wildfire Hazards through WHIMS"

WHIMS Defined

Project Goals and Objectives

The primary goal of the WHIMS project is to minimize the loss of life and property from wildfires by encouraging wildfire mitigation for homes and structures in the urban-wildland interface (UWI). Achieving that goal requires significant education of the general public particularly of homeowners about the hazards from wildfire in the UWI. A related goal of the project is to provide local fire protection districts with the wildfire hazard information for their district so that the district can be directly involved with the homeowners' mitigation efforts. The acronym WHIMS stands for the **W**ildfire **H**azard **I**dentification and **M**itigation **S**ystem. As the sequencing of words in the name correctly indicates, we must first identify the wildfire hazard before we can mitigate that hazard. So identification which involves description and measurement of the wildfire hazard is a significant component of the WHIMS.

WHIMS stands for

W	**Wildfire**
H	**Hazard**
I	**Identification &**
M	**Mitigation**
S	**System**

The term 'system' is an important word within the project name. 'System' can be defined as a group of interacting components that form a unified whole. Thus to understand the unified whole of the WHIMS project, we need to look at the different components that make up that whole. Some components of the WHIMS project are focused on the hazard identification aspects of the project. Such tasks involve major data collection, data processing and data analysis activities. These activities while not more important than the mitigation related activities, consume the lion-share of the time, money, and personnel resources of the project. However, it needs to be noted that the system is complete only when the mitigation measures are *implemented* - a critical point in the definition of WHIMS. This means that changes must be notably occurring 'on the ground' as programs are instigated based upon the information provided through the WHIMS program.

General Concepts

WHIMS combines community involvement along with expertise from several natural resource and emergency hazard management disciplines combined with GIS and computer technology. WHIMS brings together those with knowledge in wildfire behavior, forest management, hazard and risk assessment, emergency response and disaster planning, fire suppression, building safety, architectural and landscape design, and land use planning. The geographic information system (GIS) provides the tool to manage and analyze the enormous amount of information and put it into an effective visual format that can be readily and easily used. Community involvement comes from the local fire protection districts, community and homeowner associations, and the individual homeowners or residents living in the interface.

WHIMS combines:

- **Wildfire Behavior & Hazard Assessment Expertise**
- **GIS & Computer Technology**
- **Local Fire Protection Districts**
- **& Homeowners**

WHIMS is designed for:

- **Wildfire Hazard Identification**
- **Risk Assessment**
- **Homeowner Education & Motivation**
- **Land Use Planning**
- **Pre-Attack Plans**
- **Emergency Preparedness & Response**
- **Disaster Assessment**

The WHIMS data and the information extracted from that data is intended for use in land management and land use planning activities especially when policies, regulations, and guidelines for dealing with the use of the land are under consideration. WHIMS can provide information to land managers for fuel reduction and ecosystem restoration programs including prescribed burn projects. The system is designed to assist local fire protection districts and emergency responders in preparing pre-attack plans for a wildfire event.

Lastly, when a wildfire or other disaster occurs the system is designed to assist with assessing and analyzing the damage. County staff is prepared to provide emergency officials with information and maps extracted from the GIS, and the staff is also prepared to enter information on property and infrastructure losses needed to generate a variety of reports concerning the effects of the disaster.

It should be noted that the WHIMS developers have explored the possibilities of the WHIMS data being used to help manage fire suppression activities under real time conditions, i.e., as a tactical decision support tool. This would require further exploitation of wildfire behavior models currently in existence, the collection of additional data beyond that now collected, as well as additional funding for system and software development.

Operational Components of WHIMS:

WHIMS involves four operational components: 1) data collection, entry and storage, 2) data analysis and interpretation, 3) information dissemination, and 4) database management and maintenance.

WHIMS involves 4 components:

- **Data Collection, Input and Management**
- **Analysis**
- **Information Dissemination**
- **Database Maintenance**

Simply stated, WHIMS puts information into a GIS, makes sense of it, gets the information out and makes an effort to see that the information is used. An effort is made to ensure that the system stays dynamic with updates or changes when needed. A more expanded description of each of the four main operational components is presented in forthcoming chapters. It should be noted that many of the components overlap in time so that activity on all four components can occur simultaneously. It is important to bring products to the public, the districts, and others as quickly as possible. However, the accuracy and quality of the information must be evaluated and judged acceptable prior to its release.

Data Collection, Input and Management

Collecting the data and accurately entering it into a computer is the greatest time and resource demand on the system. Large volumes of data (i.e., questionnaires, map/data coverages, updates) require efficient management of the data to ensure timeliness and data quality. This component is the critical step in insuring the success of the system. Great care must be given to quality control in the data input tasks. The quality of the outcomes is determined by how well the input component is controlled and monitored.

Data Gathering & Data Entry:

- **Parcel Information**
- **Terrain Data**
- **Vegetation Data**
- **WHIMS Wildfire Hazard Data (Questionnaire)**

Using the County's GIS, both the County Assessors' parcel ownership data (in Arc/Info™) and the County Land Use's building data (in Oracle™) are related to physical environment data (i.e., slope, aspect, fuel/vegetation type). Included, also, are the hazard surveys of the individual parcels and the information provided by the fire chiefs on access and water resources. The hazard survey or questionnaire (WHIMS Questionnaire) is the product of comprehensive discussions with wildfire behavior and management experts. The questionnaire consists of 24 questions (data elements) with an additional 4 data elements (slope, aspect, fuel type, lot size) extracted directly from data stored in the GIS database, namely from USGS (US Geological Survey) digital elevation model (DEM) data, and digitized fuel type data. The fuels information was mapped by the Colorado State Forest Service using aerial photos based upon national fuel model classifications (Anderson, 1982), USGS topographic maps, and extensive field inspection.

To collect the hazard related data, fire fighters survey each property, examining topographic features and fuels, building construction and design, landscaping, access, water availability, and fire protection response capability. This information is returned to the County Land Use Department and entered into the computer and mapped.

Direct contact with the homeowner is sought and participation of the resident in the survey is encouraged. That contact with the homeowners by the fire fighters is what makes WHIMS so unique and so effective. Such contact allows the resident to ask questions, discuss the hazards and possible mitigation actions that can be implemented on the site. An additional benefit to having the fire fighters complete the surveys on site is that the fire fighters meet their constituents and familiarize themselves with their district. This direct contact, participation, and educational experience are the key

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benefits of WHIMS - something that has been absent in past mitigation efforts. Information collection began on a number of fire protection districts within the mountainous areas of the county in 1993. All fire districts within the mountainous area will eventually be surveyed. For more information on this component, refer to Chapter 5 : COLLECTING AND MANAGING THE DATA".

Analysis and Interpretation

After the on-site data is collected and put into a workable format, the data must be analyzed to extract the hazard information, in this case, with the help of the GIS. The beauty of the GIS is that not only does it allow the user to work with large amounts of data, but also allows the user to look at the data within a spatial context. That is, data can be evaluated for the relationships that exist between different locations.

Analysis:

- **Hazard/Risk Assessment**
- **Wildfire Behavior Modeling**

The complied data are used to calculate an overall wildfire hazard rating as well as a rating for each of seven primary factors that relate to the hazard. A model called WHINFOE (Hay, 1998) is used to calculate the hazard and factor ratings. WHINFOE is a hierarchical, mostly experiential, but partly physical-process model, based upon a pre-existing, wildfire behavior model [**BEHAVE**, (Rothermel, 1983)] and the expertise of wildfire behavior experts and managers. By partitioning the data into informational components (primary factors), and calculating a separate rating for each factor, the most significant factors contributing to the overall hazard for a site and the effect of possible mitigation can easily be determined. In addition, as management goals change and expand, the analysis model can easily be reconfigured to support additional information needs. The hazard rating and individual factor information is presented in both tabular and map format. In addition to the overall hazard rating and the primary factor ratings, a hazard rating with mitigation is calculated. The side-by-side display of maps showing the hazard rating without mitigation and the hazard rating with mitigation (or the 'before-and-after') is an effective mechanism for communicating with the homeowner the value of undertaking some simple mitigation actions. The easiest mitigation actions involve simple landscape maintenance around the structure and the creation of an effective 'defensible space' zone. Another communication benefit occurs when residents can see on the map the surrounding ratings of their neighbors or what their ratings are in comparison to their neighbors. For more information on this component, refer to Chapter 6: INTERPRETING THE DATA.

Dissemination and Use of the Information

For the information gained from the analysis to be understood and used, it must be in an effective format both visually and in substance. In addition, the information must be easily converted to different formats for transfer between different computer systems.

Information Dissemination:

- **Homeowners ('The Road Show')**
- **Local Fire Protection Districts & Departments**
- **Planners**
- **Emergency & Disaster Service Groups**
- **Forest & Resource Managers**

One way in which information is returned to the homeowners is through what is known as "the Road Show." Here officials from a variety of local agencies that deal with wildfire issues, go out into the community and talk about the hazards, the analysis results, and what actions homeowners can take to improve their situation. Speakers from a variety of backgrounds allow the public to ask and get answers for a wide range of questions. Other community forums include invitations to attend and present at local community association meetings and local fire district open houses.

Participating local fire protection districts are particularly interested in the map products that are produced for the questionnaire data, and the calculated hazard ratings. In recent years, many of the districts have acquired better computer systems with which to store the WHIMS data and have acquired GIS desktop software packages to help them with their own planning needs. In fact, it was always anticipated that this would occur over time, however, the computer and GIS software upgrades at the district level is occurring sooner than expected.

It is also important to make the information available to planners who are in a position to guide and regulate new development. The information gained through the WHIMS project is not just that from the map products but also includes the mitigation concepts learned as an adjunct of the WHIMS project. Those concepts are valuable in guiding new policy development, regulations, land use and building codes.

Forest and natural resource managers are looking to use the wildfire hazard information to help develop land management plans that may include planning for open space lands, and fuel treatments on selected areas. For more information on this component, refer to Chapter 7: USING THE WHIMS INFORMATION.

Database Management and Maintenance

The system must remain dynamic - meaning the data and information in the system must be maintained and updated periodically. In addition, WHIMS is open to making improvements and expanding capabilities with new technologies, techniques, models, and knowledge as they become available. This requires an active management plan for the system's future and a commitment to maintaining the system. For more information on this component, refer to Chapter 8: MAINTAINING WHIMS.

Database Management & Maintenance:

- **New Information**
- **Updates**

Chapter 4 : GETTING STARTED

Interagency Participation and Commitment

As stated earlier, interagency participation and commitment is vital to the success of WHIMS. The early beginning of the BCWMG shortly after the 1989 'Black Tiger' fire, was a time of turmoil. It wasn't until it was realized that we all shared a common goal that cooperation began. That goal was and still is to minimize the loss of lives, property and resources from wildfire regardless of what political boundaries exist. Knowing that fire does not recognize these boundaries requires the community to participate at all levels, from private to public. A commitment to get things done and to implement hazard reduction projects is based on knowing that it's a question of *when* and *where* the next fire will occur, not '*if a fire will occur'*.

The WHIMS Technical Working Group

The WHIMS Technical Working Group (WTWG) is a subgroup under the BCWMG. The BCWMG set up a technical working group to muster the technical expertise required to establish and develop WHIMS. The WHIMS project was fortunate in having a good cross section of backgrounds and expertise represented within the technical working group that guided its development. The number of working group participants at most of the meetings consisted of 10-25 participants. These participants included forestry experts, fire managers, fire behavior experts, building and safety officials, land use planners, emergency responders, natural resource specialists, local, long time residents, community educators, disaster servicers, computer and GIS 'techies', local fire district chiefs and fire fighters, as well as invaluable interns and even a geologist. For those agencies not traditionally involved with projects of this nature, it was necessary for them to develop an understanding of their role in the project and to come to appreciate the importance of their involvement. Prime examples of such agencies were the land use planning departments where traditionally such projects were managed by the fire departments and/or the forest agencies.

At the outset, not all WHIMS working group participants were convinced of the benefits of the project, but continued to offer their support and input nonetheless. For others, knowing that the project was 'cutting edge' and that we were working in 'unchartered waters' made for some exciting discussions. Without the participation and commitment from the involved agencies, WHIMS would not be in existence today. The WHIMS technical working group never operated under any Memorandum of Understandings (MOUs) or the like. Rather, all the agencies that came to participate in WHIMS were already supporting common goals of the Boulder County Wildfire Mitigation Group.

Community Acceptance, Participation, and Commitment

Fire Protection District Chiefs

Since many of the local district chiefs were involved with the BCWMG, many were aware of and involved in the development of WHIMS. Regular reports given at the monthly Boulder County Fire Fighter's Association (BCFFA) meetings served to keep the non-participating chiefs informed about the project's progress and status.

Local FPD Fire Boards

Before the WHIMS project could be started within a specific fire protection district, it was first necessary to meet with and gain the approval of the local fire protection district's governing board. If the board was not comfortable with the project or was not interested after informational meetings with the WHIMS project coordinator and/or persons in the WHIMS technical working group, then the project did not go forward within that district.

Residents
After project approval by the fire district's governing board, meetings with homeowner groups were arranged to inform the residents about this voluntary data collection program. Should any resident choose not to participate that choice was respected as far as trespass onto their property was concerned. It must be pointed out, however, that where information was obtainable from public roads and right of ways, it was gathered for non-participating properties as well.

Elected Officials, Community Leaders and Organizations
Periodic presentations were made to the Boulder County Commissioners to keep them apprised of the progress and status of the project. This was done to maintain and foster continued support for the program.

Start-Up Needs and Requirements

Leadership
A WHIMS coordinator was appointed to oversee the day-to-day progress of the project. The coordinator position is vital to maintaining and insuring that a significant level of support and funding is available for the project. Additionally, the WHIMS coordinator ensures that progress is monitored and maintained on the project.

Funding
Some small grants from the Boulder County Commissioners, Federal Emergency Management Agency, the Colorado State Forest Service, and the USDA Forest Service were obtained to help with the costs associated with the project.

Hardware and Software
The system currently operates on PCs and workstations running ESRI's ARC/INFO© and GRID© GIS software, ESRI's ArcView© desktop GIS software, and Microsoft Excel© spreadsheet software, with output to an HP1050C plotter.

Chapter 5 : COLLECTING AND MANAGING THE DATA

"What Info Do We Need and How Do We Get It"

Data/Information Needs

The data needed to conduct the WHIMS project can be divided into two basic levels of data and four basic types of data. The two basic levels of data are data that refer to a general neighborhood with a minimum mapping unit area of 1 to 5 acres in size, and data that are site specific at the individual ownership parcel level. The four basic types of data are data about the topography for a neighborhood or site, data about the vegetation for a neighborhood or site, parcel/structure ownership data for a site, and structure construction data for a site. Table 1 summarizes the data required to conduct the WHIMS project by types and levels of information.

Table 1: Type and Level of Data Used for the WHIMS Project

		Types of Data			
		Topography	**Vegetation**	**Ownership**	**Construction**
Levels of Information	**Neighbor-hood**	30 meter DEM for the entire project area	Surface Fuel Type for the entire project area	N/A[4]	N/A
	Site	Local Dangerous Topographic Features	Site Specific Vegetation Arrangement & Maintenance	Owner Name, Address of Site	Specifics of Construction Materials & Elements

Topographic Data

Topographic data for the WHIMS project are required at two levels of spatial specificity – at the neighborhood level and at the site specific level. The neighborhood topographic data are needed to evaluate the general intensity and direction of propagation for a wildfire that may occur within an area. The neighborhood topographic data was obtained from the USGS digital elevation data for each topographic quadrangle that covers the project area. The resolution of that set of data is 30 meters (98.43 feet) meaning that an elevation measurement is recorded every 30 meters (98.43 feet) along sample transects across an area. The sample transects are also located at 30 meter (98.43 feet) intervals across the quadrangle. From the digital elevation data, angle of slope (or just slope) and orientation of slope (aspect) can be extracted using the spatial analysis capabilities of the GIS.

The site-specific topographic data contains information about dangerous local topographic features such as chimneys, saddles, ridge tops, and v-shaped canyons. Such topographic features amplify the intensity of fire behavior or control the likely direction of fire propagation, and thus are important features to factor into the evaluation of wildfire hazard for a site.

Vegetation Data

Vegetation data for the WHIMS project is required at two levels of spatial specificity – at the neighborhood level and at the site-specific level. The neighborhood vegetation data are needed to evaluate the general fire behavior that may occur within an area. The type of fuel available to the fire significantly affects fire behavior. The WHIMS vegetation data at the neighborhood level consists of the standard 13 surface fuel type models that were mapped specifically for the WHIMS project (see ***Fuels Mapping*** on page 5-3). The 13 standard fuel type models are the models that are used with the USDA Forest Service's **BEHAVE** (Rothermel, 1983; Rothermel, 1972; Andrews, 1986; Andrews and Morris, 1986) fire behavior model.

[4] N/A – Not Applicable

The site-specific vegetation data consists of information concerning fuel type density and arrangement within 45 meters (150 feet) of the structure. Those data are collected on site as part of the site visit in conjunction with completing the WHIMS questionnaire for a site.

Ownership Data

Parcel ownership data including the address of the site, the owner's name and mailing address (if different from the site address) is required to link the WHIMS questionnaire data to each specific site and to facilitate the mailing of information packets. Packets are mailed to the homeowner prior to the site visit by the fire fighter. The packets contain a cover letter (see Appendix D) describing the WHIMS project, brochures describing wildfire mitigation efforts that homeowners can implement to reduce the wildfire risk to their homes, and a copy of the WHIMS questionnaire so that the homeowner can see the information being collected about their site. The parcel ownership data and the geographic coordinates that define a parcel are extracted from the county assessor's database.

Construction Data

Subject to permission from the homeowner, structure construction data is collected on-site for each parcel in the project area. Lacking homeowner permission or lacking the homeowner's presence, structure construction data are collected as best can be observed from public access roads or trails that overlook a property. The construction data are collected using the WHIMS questionnaire (see Appendix A).

Data from Existing Databases

Wherever possible, the needed data was acquired from existent data from other federal or county agencies or departments.

Parcel Information

The parcel boundary or cadastral information was available through the county assessor's office and was in the county assessor's database. The parcel information was brought across from the assessor's system into the WHIMS project database. The information brought into the WHIMS GIS database included the geographic location of the parcel boundaries and several attribute fields. The attribute fields contained information on:

1) the assessor's identification code,
2) whether a structure had been built on the parcel,
3) the name and address of the parcel owner,
4) the street address of the parcel if one had been assigned,
5) the structure classification code,
6) the year the structure was built, and
7) the fire protection district servicing the parcel.

Fire District Boundaries

Fire Protection District boundaries were extracted from the assessor's database based upon the assessor's taxing district code for fire protection. The aggregated total set of all parcels within a given fire protection taxing district defined the boundaries for each fire protection district.

Topographic Information

USGS 30 meter (98.425 feet) digital elevation model (DEM) data for each 7.5-minute topographic quadrangle sheet was used for the topographic base of the WHIMS database. The 30-meter (98.425 feet) digital data was reinterpolated to a grid cell size of 15 meters (49.213 feet) for each fire protection district. The topographic slope and slope orientation (aspect) information were extracted from the reinterpolated DEM data using the analysis capabilities of the GIS. In addition to the cell based elevation, slope and aspect data layers, the slope and aspect information were aggregated for each individual parcel. The average slope and the predominant aspect across each parcel were recorded in additional attribute fields added to the spatial database. The parcel aggregated slope and aspect data were used for the parcel because house pad locations were not available in the database. House pad locations are the preferred information to be used in evaluating the topography and background fuels within 76 meters (250 feet) of a structure. However, lacking the house pad location information, the topography and background fuels information was extracted from the data aggregated over the entire parcel. This is particularly problematic for larger lot sizes, say for lots greater than 5 acres in size. In the City of Boulder FIRMIT project (see Chapter 9), house pad locations information is

available for parcels within the city boundaries, thus house pad location information was used in the city's implementation of the WHIMS. There are plans to obtain the house pad location information for the county parcels when resources become available to acquire and digitize that data.

Fuels Mapping

Background

Fuels are an important component contributing to a wildfire hazard. The general fuels within an area determine the nature of the fire behavior expected if a wildfire occurs. An initial fuels type map of the Pine Brook Hills Fire Protection District pilot study area had been completed early in the WHIMS project. However, as the WHIMS effort expanded, it was apparent that we needed to map the fuel types for the entire interface area within the county. Doing this by Fire Protection Districts as initially planned was not efficient. It was agreed by an interagency team to utilize a dedicated crew to conduct both photo interpretation and field verification checks in order to obtain the information required for the fuels layer in the GIS database. The WHIMS Project Coordinator, and the WHIMS technical working group worked with federal, state, county, city and fire protection district personnel to fund, implement and administer the enormous fuels mapping task.

Funding and Administration

Funding and administration of the fuel type mapping project was truly an interagency effort. Funds and personnel support came from a variety of cooperating agencies and organizations. A summary of the personnel, cost and material resources required to accomplish the fuels mapping task is provided in Table 2.

Field Methods and Procedures

Mapped Data

The mountainous areas of the county were inventoried for surface fuel type cover. The standard 13 fuel type models used in the USDA Forest Service's **BEHAVE** fire behavior model were used to classify the vegetation types. The Fire Forester for the CSFS developed a locally relevant description of each of the standard fuel model types (see Appendix B). These descriptions were used to classify the surface fuel types within the mapping project. A minimum mapping unit of 1 to 5 acres was used for the mapping. This means that if an area of less than 1 acre in size contained a different fuel type from its surroundings, then the smaller area was not separately delineated.

Field Strategy

The fuel mapping effort was organized around a systematic inventory of each U.S.G.S. 7.5-minute topographic quadrangle (quad) map. There are 14 quad maps that cover the mountainous areas (296,648 acres) of the county. The sequence in which the quad sheets were mapped was prioritized based upon the FPDs that were currently conducting or soon to conduct their WHIMS assessments. The mapping and inventory crew was under daily CSFS supervision and worked under the direction of the WHIMS coordinator.

Once a quad was selected, a general strategy was planned on how to conduct the fieldwork across the specific landscape of the given quad's area. The strategy was developed based upon the complexity of the fuel types covering an area, the topography of an area, ease of access to sites within the quad area, and land ownership patterns, i.e., public versus private ownership. For the most part, the crew would work up each of the primary drainages on a quad sheet. This generally meant working from east to west in the eastward flowing drainages within Boulder County. The crew would start at the south end of a particular quad and work their way north through successive drainages or watersheds.

If the terrain was steep, the crew would drive or hike to high points to visually survey the area. The crew would then traverse the primary ridges and map the fuel types as they went. Based upon the fuel types interpreted on the aerial photos, or observed visually in the field, the fuel types were delineated onto acetate overlays of the aerial photos of the area. If, due to high crown densities or other factors, the fuel type was difficult to determine 'from a distance', the crew would hike to the general vicinity of the stand being typed in order to accurately determine the fuel type.

Ground verification was performed as much as possible using the general procedure described above. Ground verification was not as critical for areas comprised of grass fuel model types, i.e. standard fuel model types 1,2, and 3. On the other hand, fuel types initially identified as possible timber fuel model types, i.e., standard fuel model types 8, 9, or 10 through aerial photo interpretation, almost always needed to be field verified.

The information mapped in the field was put directly onto acetate overlays of the aerial photos. It was imperative that the polygons delineated on the photos be checked for closure prior to finishing the field mapping in a given field area. Checking the polygons for closure insured that follow-up field visits were minimized during transfer of the photo-delineated information to the 7.5-minute quad sheets. Minimizing site revisits was a critical efficiency and cost containment measure for the project. However, in order to insure the consistency of the mapped fuels information and to maintain a high general level of quality control, there were times when the crew did return to given field areas with the mapping supervisor.

Table 2: Summary of Agency Fiscal and In-Kind Support Contributed for the Fuels Mapping Task

Agency	Dollars	Persons	In Kind Support
USDA Forest Service, Regional Office, and, the Arapahoe-Roosevelt National Forest	$10,000	Technical support by ranger district & Supervisors Office personnel	Use of aerial photos, topographic maps, light table/mapping stations; Technical assistance
Colorado State Forest Service	$10,000	Field Crew Supervisor/Administrator; Field Crew: 2 persons;	CSFS vehicle, gas and maintenance.
Boulder County	$8,000	Financial administration; GIS technical & map production assistance - 1 GIS professional, and 1 intern;	
	$4,500		Production of maps and digitizing of final fuel type maps; Computer usage & map materials
City of Boulder, Mountain Parks Department	$1,500		
Boulder County Fire Fighters Assoc. through the Chief's Working Group	$1,500	Technical and general support by BCFFA and all the local fire protection districts.	
TOTALS	**$35,500**		

Digitizing the Data

The next phase of the mapping project involved transferring the photo-delineated polygons onto mylar overlays of the 7.5-minute quadrangle maps. During this step the polygons of the classified fuel model types were finalized. This work was done at the USDA Forest Service – Boulder District office utilizing their light tables, and aerial photos. This step required careful matching of topographic features between the photos and their representation on the topographic maps. The mylar overlays produced from this step were the data that would be digitized and entered into the spatial database maintained within the GIS.

During the photo to map transfer step of the project, the crew worked closely with the mapping project supervisor to insure the accuracy of the fuel model type identifications. It was often necessary to conduct follow-up field visits to verify fuel model types and/or 'problem solve' for situations that were not easily categorized into the standard models.

Once a given 7.5-minute quad sheet was completed, it was turned over to the GIS staff in the Boulder County Land Use Department. The BCLUD staff performed the final digitizing of the fuel model polygons and the geographical registration of the information to the rest of the WHIMS spatial database.

End Product
The final product was a set of 14 - 7.5-minute quad map sheets showing topography, roads and surface fuel model types. Each type was clearly shown and described in a detailed legend. Representative picture examples of the types are included in Appendix B.

Table 3: Summary of the Resources Required for the Fuels Mapping Task

Item		Costs	FTE's Or Time
Salaries:	Field Crew Supervisor Salary	$5,000	0.2 FTE for 9 months
	Field Crew Salaries	$26,000	2 FTE for 9 months
	GIS & Map Production Persons Salary	$4,000	0.6 FTE for 3 months
Materials Costs:	Computer/Map Materials	$500	
Total:		$35,500	
Cost/Acre:		$0.12/acre	

WHIMS Questionnaire Data Collection

Preparing for the Field

Questionnaire
Residential parcel information is collected in the field at each house site using a questionnaire consisting of 24 data elements. An additional 4 data items are measured using a geographic information system (GIS) and spatial analysis routines applied to USGS digital, topographic, 30 meter (98.4 feet), 7.5-minute, elevation data, the digitized fuel type data, and digital parcel boundary data downloaded from the County assessor's data files.

Packets and Letters to Homeowners
Prior to the start of data collection operations in the field, all of the residents within a district are notified in writing about the data collection effort and the goals of the WHIMS project. Mailing labels for residents within the district are generated using the property owners name and address of record in the Assessor's parcel database. A packet of information is included in the homeowner mailings. The packet contains a cover letter (see Appendix D) describing the WHIMS project and informing the homeowner of the upcoming visit by the volunteer fire fighter. A copy of the WHIMS questionnaire, material describing wildfire mitigation efforts that the homeowner can implement, and a list of resources for further information concerning the WHIMS project are also included in the packet (see Appendix J).

Training the Field Volunteers
Before data collection begins within a district, a training session is held to train the fire fighters on the WHIMS questionnaire. The intent of each question in the questionnaire is described and some of the various situations that might arise for each data item are discussed. There is a field guide to the WHIMS Questionnaire (see Appendix A) to help encourage consistent data collection methods across all of the volunteers gathering the data.

Collecting the Questionnaire Data
Volunteer's usually worked weekends to collect the questionnaire data. This activity occurred over several months. Some districts took over a year to finish with their data collection effort. This was due to the fact that the fire fighters are all volunteers with career jobs during the week and a family life on the weekends. An extended data collection period is problematic when data for some properties within a district is out of sync with other more current property

surveys within the district. WHIMS has yet to solve this problem effectively. Some suggestions have included the use of volunteers other than the fire fighters, or a paid survey crew. If these suggestion were adopted then the benefit of fostering fire fighter's familiarization with their district would be lost, but it may be a necessary trade-off for the districts that can not get their data collected within a reasonable time period.

Database and Mapping System Set-Up

PC-based Spreadsheet Database

A database of the WHIMS questionnaire responses is maintained in a PC-based spreadsheet database. When the questionnaires are first returned from the field, the response data are entered onto the PC-based spreadsheet. This allows personnel without geographic information system (GIS) expertise to process and view the data during this step. When the spreadsheet for a fire protection district is first established, the GIS specialist downloads the parcel address and spatial-link field-identifiers into the spreadsheet. The spatial-link field-identifiers allow the records in the spreadsheet to be linked to a specific geographically referenced parcel within the GIS database. The data entry person then works exclusively with the spreadsheet to enter the returned questionnaire response data. The specific spreadsheet application used by the WHIMS project is Microsoft EXCEL™. However, any standard PC-based spreadsheet application could be used.

Questionnaires with incomplete information are flagged and a listing of those parcels is maintained on separate worksheets. Parcels for which incomplete or no addresses have been recorded are also listed on separate worksheets within a workbook. Incomplete questionnaires are sent back to the districts for revision. Parcels with no addresses are researched in the Assessors on-line database or on microfiche. Some of the newly developed parcels (i.e., have new structures on them) may not yet have been updated in the electronic records from the assessor's office. Those parcels await further identification. When all of the returned and verified questionnaires have been processed into the spreadsheet, the GIS specialist then imports the questionnaire response data into the GIS database from the PC-based spreadsheet.

Table 4: Possibility of Error Matrix for Returned/not-Returned Surveys (Questionnaires)

	Structure Present	**No Structure Present**
Survey Returned	OK	Possible Incorrect address or a new structure not yet updated in the Assessor's electronic database
No Survey Returned	Non-participating homeowner, possible incorrect address, or site overlooked in the field visits.	OK

Due to resource limitations within the Boulder County Land Use Department, data encoding of the WHIMS data does not always precede as quickly as one would like. In the past, a series of part time administrative support staff or even student interns have been used to help with the data encoding. However, such a system has resulted in long delays between the districts' delivery of completed questionnaires to the County and the return of the electronic and mapped response data back to the districts. In order to help alleviate this situation and to not deprive the districts of their data during processing at the County offices, a new WHIMS questionnaire data processing protocol has been proposed. The proposed new data processing procedure is as follows:

> Each district should appoint a 'WHIMS liaison' to interact directly with the Boulder County Land Use GIS division to help resolve data completeness and correctness issues on their district. Data processing gets bogged down when the County can not answer questions about the data. Often there is the need to have the district answer those questions or revisit a site to clarify the questionnaire data. Two districts have already used this procedure successfully.
>
> Each district, after completing their WHIMS questionnaire, should enter the questionnaire data into a PC-based spreadsheet before sending the data to the Land Use Department for merging into the GIS database. To aid this process, the Land Use Department's GIS Division will provide each district with a spreadsheet template. This template will have a record for each parcel in the district

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with the owner name(s) and address from the Assessor's Parcel database, and the headings for the WHIMS questionnaire data. The district can then enter the questionnaire response data into the spreadsheet. In this way the district will maintain a copy of the original questionnaire data at all times and will be able to access and refer to that data even if the County has not finished producing the WHIMS maps for the district.

Besides the district maintaining a copy of their data at all times, other benefits include increased data quality. District personnel know their district far better than anyone in the County's GIS Division. Thus, the district person can spot and resolve data inconsistencies much more efficiently than the County can.

The district's WHIMS liaison and WHIMS data encoder do not need to be fire fighters. That person can be any district auxiliary person who is computer literate or willing to become so, at least to the extent of learning to navigate and encode data into the spreadsheet. In addition, the district need not necessarily 'own' the computer if the 'volunteer data encoder' has his/her own computer. If needed, a member of the WHIMS Technical Working Group will be available to work with any of the districts to train their 'WHIMS liaison' on the data encoding and data maintenance procedures. A benefit of this proposed change is the possibility that the data will get encoded more quickly than is currently possible with the limited resource available in the County's Land Use Department.

After a district provides a copy of the completed spreadsheet to the County, the GIS division will verify and merge all records into the GIS database. During this process, some additional questions may arise and it is expected that the district's WHIMS liaison will help to resolve these questions with the Land Use Department's GIS Division personnel.

UNIX Workstation Spatial Database

The spatial database is maintained within a GIS installed on the county's workstation computer system. The operating system currently used by the County for its workstations is UNIX, however, Windows NT™ could also have been used for the workstation environment. Several types of data layers are maintained which include: the vegetation (surface fuel type) layer, a hydrology layer with surface water features, a transportation layer which includes public roads in the county, a digital elevation layer from which topographic contours, slope angle and slope orientation (aspect) are generated.

The assessor's database is imported into the WHIMS database as the basis for the parcel data. The parcel database consists of the geographic location of each ownership parcel with associated attribute fields. The attribute fields maintained in the WHIMS database includes the unique WHIMS polygon identification number, a parcel identification number constructed from the public land survey coordinates (township and range designations), the assessor's identification number, the address of the parcel if the parcel has a structure, the owner's name, the owner's mailing address, the township, range, section, and quarter section designations of the parcel's location. If a structure exists on the parcel, the year that the structure was built with the number of bedrooms and bathrooms are also included within the attribute fields for a parcel. The WHIMS questionnaire data and the results of the analysis from the WHINFOE program are imported into the GIS database from the PC-based spreadsheet. Within the GIS database, the questionnaire response data and the hazard rating data are stored in separate 'look-up' tables that can easily be linked to the parcel data layer when the need arises.

It is important to note that it may seem redundant to maintain the questionnaire data in both a PC-based spreadsheet and in the GIS spatial database. However, GIS specialist's time is costly and is limited due to heavy demands from other projects. Maintaining the PC-based spreadsheet version of the questionnaire data allows non-GIS personnel to be utilized for initial questionnaire data entry. In addition, since some districts do not have GIS software capabilities and have only standard PC-applications computing capabilities, the PC-based spreadsheet version of the questionnaire data allows those districts to maintain an electronic copy of the data on their systems.

Recognizing Errors and Discrepancies

Encoded Data Errors

At the time of data entry, automatic error checking for response values that are 'out of range' for a given question can be implemented using the capabilities of the spreadsheet program. This type of error checking will only catch those

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responses that are 'out-of-range' for the set of valid responses to a question. Mis-codes that result in a number that is within the valid range of the response set cannot be automatically detected. Mis-codes due to transcribing of the data can be reduced by using electronic data entry tools such as personal data assistants (PDA), palmtops or laptop computers in the field. By using electronic data entry tools, the data are directly entered into an electronic medium that can be downloaded into the main spreadsheet database. Electronic data entry tools however, have not been available to the field volunteers to date due to insufficient resources to provide this capability.

There are some data items (questions) for which one would expect a high degree of spatial correlation. That is, the response values for neighboring properties should be the same. For example, the Accessibility and Water-Availability questions and the Fire Protection Response Time questions should be the same for many adjacent properties. By plotting the response values for these spatially correlated questions, one can easily detect possible errors for specific parcels based upon inconsistencies in the expected spatial pattern. These inconsistencies if indeed in error, can be the result of mis-coding in the transcribing of the data or they can be due to inconsistent evaluation criteria on the part of the data collector. In order to maintain consistency of evaluation criteria, for the questions that deal with overall neighborhood infrastructure, it is recommended that only one person in the district fill out the responses for these questions. It is suggested that the Fire Chief of the district, or their appointed representative, complete the questions dealing with neighborhood/sub-division infrastructure (see Appendix A for a description of the Fire Chief's section of the questionnaire). After review of the maps of the spatially correlated questions, the District Fire Chief can verify that the suspect responses are correct or change the response values if incorrect. The corrected set of values are returned to the Boulder County Land Use Department for correction in the database prior to the calculation of the wildfire hazard rating.

Chapter 6 : INTERPRETING THE DATA

Defining the Interface Wildfire Hazard

The hazard of concern to the WHIMS project is a dangerous wildfire situation that threatens residential or other structures, where the hazard is primarily due to the existence of wildland vegetation (fuel) near those structures. The main concern in the wildland situation is that a wildfire will spread to structures located close to relatively natural wildland environments. While there is some concern about a structure fire spreading to the wildland environment, the frequency of occurrence of such events is low. The possible spatial arrangements between the wildland environment and structures include a broad range of situations. At one end of the spectrum is the situation where an urban development has an abrupt boundary with a bordering wildland environment. The other end of the spectrum includes the more diffuse location of occasional structures within the wildland environment. The full range of variation between these two extremes can be seen among sub-divisions or other developments with lot sizes varying from one-half (1/2) acre or less to 35 acres or more.

Identifying the Hazard

In order to develop management and mitigation strategies for the wildfire hazard in the interface, we first need to identify the relative magnitude and location of the hazard. The WHIMS project chose to focus on evaluating the hazard at the individual parcel/lot level. This is in contrast to the more regional focus of agencies such as the USDA Forest Service, which has looked at wildfire hazard over broader management units such as ranger districts or other large units within a national forest. By selecting the individual ownership parcel as the minimum unit of evaluation, the WHIMS project can generate information that is of benefit to individual homeowners. Through appropriate aggregation methods, the information is also useful for summarizing the hazard across larger management units such as fire protection districts, and ultimately the entire county.

Purpose and Rationale for the Model

One of the main purposes in collecting the WHIMS data is to provide decision makers, be they county land use planners, fire protection district chiefs, or others, with wildfire hazard information that can be easily communicated to homeowners or others involved in planning, and fire management. In order to foster effective communication with homeowners and to support efficient use of the WHIMS data, a means of combining the field and spatial data into fewer but meaningful information categories was needed. The wildfire hazard rating model, WHINFOE (Hay, 1998), was developed to meet that need.

There are 29 data items collected either in the field or extracted from the GIS spatial database. WHINFOE synthesizes that data into seven informational variables, which directly relate to primary factors contributing to an interface wildfire hazard. The 7 informational variables are ultimately combined into an overall rating of the wildfire hazard. The WHINFOE model is a hierarchical, partly experiential, and partly physical-process model. It is based upon a pre-existing, wildfire behavior model and the expertise of wildfire behavior experts and wildfire managers. The benefit of using such a model is that the 'interpretation' of the field and spatial data are consistent from one site to another and from one district to another and even from one county or larger management unit to another.

Primary Factors in the Interface Wildfire Hazard[5]

There are 7 primary factors that determine the nature and severity of a wildfire hazard to structures in the urban-wildland interface (UWI). These factors are Topographic Location and Fuels (TOPO), Building Construction and Design (CONST), Landscape Maintenance (LANDS), Existence of Defensible Space (DEF_SPACE), Accessibility (ACCESS), Fire Protection Response Time (FIRE_PROT), and Water Availability (WATER). The first three factors, TOPO, CONST, and LANDS determine the base wildfire hazard for a structure. The remaining factors, DEF_SPACE, ACCESS, FIRE_PROT, and WATER, contribute to lessening the Base Hazard by providing a protective zone around a structure (Defensible Space) or by providing suppression resources to fight the fire. The function of defensible space is to reduce the intensity of a wildfire so that the structure can survive the passage of the flame front, or so that fire fighters can more easily and safely protect the structure.

[5] Extracted from Hay, 1998.

Basic Structure of the Model

The 7 primary factors described above are partitioned into one of two categories – the Base Hazard (BASE_HAZ) and the Reduction Credits categories. The BASE_HAZ category relates to the characteristics of the direct hazard. Factors assigned to BASE_HAZ relate 1) to the characteristics of the fuel on or near a site (including the structure itself), i.e., 'the burnable stuff' and 2) to the likelihood that this material will become involved in an approaching wildfire. The TOPO, CONST, and LANDS factors belong to the Base Hazard category.

Factors assigned to the reduction credits category relate to conditions or resources that help lessen the base hazard. The DEF_SPACE, ACCESS, FIRE_PROT, and WATER factors belong to the reduction credits category. The Base Hazard category and the Reduction Credits categories are combined to produce the Overall Wildfire Hazard Rating for a site (see Figure 4). The primary factors that constitute the core of the WHINFOE model are briefly described below.

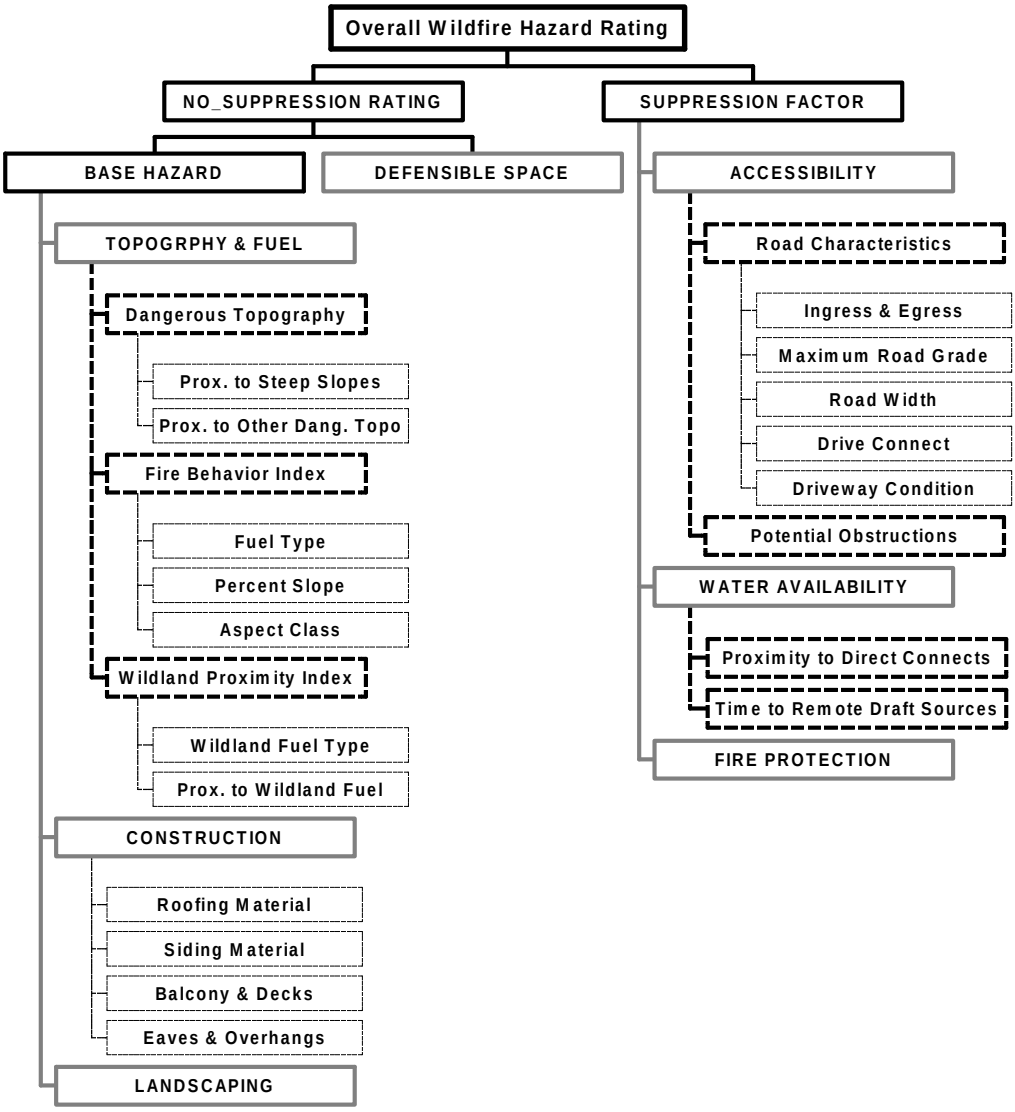

Figure 4: WHINFOE **Model Structure**

Topographic Location and Fuels (TOPO)

The Topographic Location and Fuels factor evaluates the wildfire danger to a structure or vacant-site based upon the physical setting of the site. Important elements of the physical setting can be broken down into two main areas. The first element deals with the topographic characteristics of the site, and the second deals with the general fuel type, that is, the vegetation type in and around the site. The topographic characteristics include 1) the slope of the site, 2) the

orientation (aspect) of the slope, and 3) the location of structures relative to dangerous topographic features. Dangerous topographic features include steep slopes, V-shaped canyons, ridges, saddles, and chimneys that serve to funnel an advancing wildfire to the structure,. The slope and aspect of a site help determine how fast and in which general direction a wildfire will travel across a site. The near proximity of 'dangerous topographic features' to a structure determines the likelihood that a fire in the general neighborhood of the structure will tend to 'funnel' into the immediate area of the structure. Areas that are in close proximity to 'dangerous topographic features' are considered to be in a 'fire accumulation zone'. This is a very hazardous situation for a structure.

The **fuels/vegetation characteristics** that are important include the vegetation type as well as how that vegetation is 'arranged' on the site. The amount, the density, and the structure of the vegetation all need to be evaluated to determine how much fuel is present, and how that fuel will burn if a wildfire approaches. The TOPO factor operates at the neighborhood level or scale. This means that the TOPO factor needs to be evaluated with vegetation information collected at a mapping resolution of approximately one (1) to five (5) acres. The slope and aspect data need to be evaluated with 50 to 100 foot (15 to 30 meters) resolutions. The elements that characterize the TOPO factor are fixed and not subject to mitigation with the possible exception of major, neighborhood-wide fuel modification efforts.

Building Construction and Design (CONST)

The Building Construction and Design factor (CONST) evaluates the wildfire danger to a structure based upon the materials and methods used in the construction of the structure. Specifically, the type of roofing and siding material are evaluated, as well as how balconies, decks, eaves, and overhangs are constructed. In the case of a pre-existing structure, a significant remodeling effort would be required to reduce the level of hazard due to the CONST factor. For new construction, however, building materials and construction methods that contribute to a lower wildfire hazard can be efficiently and effectively incorporated into the initial design of the structure.

Landscaping (LANDS)

The Landscaping factor (LANDS) evaluates the wildfire danger to a structure based upon the nature of the 'fuels' in the immediate vicinity (within 150 feet to 250 feet) of the structure, and the quality of maintenance of areas near or adjacent to the structure. Fuels in the immediately vicinity of a structure include both natural and ornamental vegetation, firewood stored near a structure, leaf and litter material on the roof or in the gutters, and propane tanks. All of these materials can be a source of sustained ignition near a structure or can contribute to the carrying of a wildfire to the structure. The wildfire hazard due to the LANDSCAPING factor can be easily reduced with only a moderate maintenance effort.

Defensible Space (DEF_SPACE)

The Defensible Space factor (DEF SPACE) is partly related to the Landscaping factor. The concept of a defensible space integrates the effect of the fuels' arrangement near a structure on fire behavior. The goal of developing and maintaining an adequate defensible space is to change the fire behavior of an advancing fire, so that the intensity and rate of spread of the fire are reduced. In other words, the purpose of defensible space is to change the characteristics and continuity of burnable material near a structure so that if an advancing fire is propagating through a tree canopy (crown fire) then that fire will drop to the ground when it reaches the defensible space zone. A low intensity fire on the ground can be controlled more easily and pose less of a threat to a structure or fire fighters.

The wildfire hazard can be significantly reduced by the development of an adequate defensible space. Often, only a moderate maintenance effort is required to develop an adequate defensible space. The difference between the LANDSCAPING factor, and the DEF SPACE factor is that the LANDSCAPING factor describes or inventories burnable materials near a structure, i.e., the LANDSCAPING factor focuses on the hazard aspect of the area immediately adjacent to a structure (150'-200'). The DEF SPACE factor, on the other hand, assesses the effectiveness of all of the integrated elements in reducing the intensity and severity of fire behavior within that space. That is, the DEF SPACE factor focuses on the fire behavior mitigating aspects of the area immediately adjacent to a structure.

Accessibility (ACCESS)

The Accessibility factor (ACCESS) evaluates the ease of access to a structure or vacant-site by fire fighters. Elements evaluated include the road characteristics of the public right-of-way such as road width and grade, private driveway condition, and where the drive is connected to the primary road network. Included in the Accessibility evaluation are elements that could cause a slowed response such as downed power lines, or lack of lot identification. The ACCESS factor is related to general characteristics of the neighborhood infrastructure, which are relatively fixed and not easily modified.

Fire Protection Response (FIRE_PROT)

The Fire Protection Response factor (FIRE PROT) evaluates how quickly fire protection resources can arrive at a site. The Fire Protection Response is partly related to the community infrastructure, which is relatively fixed and may require a significant effort to modify.

Water Availability (WATER)

The Water Availability factor (WATER) evaluates the availability of water for protection of a structure or vacant site. Two basic types of water resources can be available to a structure. These are **direct connection (nearby) water resources** and **remote draft water resources.** The direct connection resources such as pressurized hydrants or permanent streams, ponds, or cisterns are located close enough to a structure so that a direct hose line can be supplied to the structure. Typically this distance is 1000'. The remote draft resources lie at a distance from the structure so that a tanker truck must drive to the remote location, fill its tank, and return to the vicinity of the structure. The Water Availability factor, like Accessibility and Fire Protection Response, is related to the characteristics of the neighborhood and the community infrastructure and are relatively fixed and can not be easily modified.

Factor Weights - An Experiential (expert opinion) Model[6]

The weight of all variables in the model was established through an extensive query of numerous fire management persons within agencies of Boulder County, the Colorado State Forest Service, and the USDA Forest Service. Each expert was queried using a multi-criteria querying protocol. Each expert was interviewed regarding his or her knowledge about, and experience with, specific environmental and structural factors relating to wildfire behavior and hazard.

The Weights Query

The weights query for variable importance in the WHINFOE model included 16 fire behavior/management experts selected from the Boulder County Fire Protection Districts, the Boulder County Land Use Department, the City of Boulder Fire Department, the City of Boulder Parks and Open Space Department, the City of Boulder Mountain Parks Department, the Colorado State Forest Service, and the USDA Forest Service. The range of experience of the queried group collectively included more than 200 large, major event wildfires, more than 1500 small, initial attack wildfires, and numerous prescribed fires. The experience within the group spanned more than just Boulder County, Colorado experience. Many of the participants had national, major event wildfire experience from other western and southern states, as well as other locations within Colorado but outside of Boulder County. Based upon the broad national fire behavior/management experience represented by some of the experts queried, the model was designed to be applicable throughout the Western US.

Query Method

Part of the query method employed a technique of pairwise comparisons between specifically related factors. The pairwise comparison method is based upon a technique developed by Saaty (1977), in a process he called the Analytical Hierarchical Process (AHP). This technique has also been used in GIS-based multi-factor rating model applications (Eastman, 1993).

The pairwise comparison method used for the development of the WHINFOE weights is a modification of the procedure reported by Eastman (1993). The WHINFOE model is a hierarchically structured model, thus, variables are 'stratified' according to their membership in a higher-level parent variable. To develop the variable weights, each participant was asked a set of questions that presented all possible pairs of sub-variables of the higher-level, parent variable. Each person was queried individually. The pairwise, multiple comparisons procedure was used only for variables that are weighted sums of their member sub-variables. The participant was first asked to select the most important variable from a specific pair combination. After selecting the more important variable of the pair, the participant was told to assume that the more important variable had a relative weight of 100. The participant was then asked to assign a weight to the less important variable in a range from 0.001 through 99.0. The relative weight of each paired variable was divided by 100 and entered into a pairwise comparison matrix in which the less important variable was the row index to the matrix and the more important variable was the column index to the matrix. The value of the reciprocal-transposed matrix element (i.e., less important variable = column index, more important variable = row index) was assigned the reciprocal value of the relative weight of the less important variable. For example, if a participant indicated that the Topographic variable (**TOPO**) was more important than the Construction variable (**CONST**), and, assigned **CONST** a relative importance weight of 80, assuming that **TOPO** had a relative value of 100,

[6] Extracted from Hay, 1998.

matrix element (**CONST**, **TOPO**) was assign a value of 0.8 and matrix element (**TOPO**, **CONST**), the reciprocal-transposed matching element, was assigned a value of 1/0.8 or 1.25. If both variables in a variable-pair were rated as equal, the two corresponding matrix elements were both assigned values of 1.0. All diagonal elements (i.e., a variable compared to itself) were assigned values of 1.0. Using this method, only the pairs represented by the lower half of the matrix needed to be queried.

The variable weights were calculated for each column in the matrix and the final weights for the specific participant was determined by averaging the weights in each column over all columns. The mean estimate for a given set of sub-variables across all participants was then calculated to produce the final estimate of variable weights. A computer software program written specifically to facilitate and track the weights query process was used to present the query questions to the participants, to record the participants' responses, and to calculate the resultant weights. The participant was presented with their resultant weights for each specific parent variable. The participant was asked whether they agreed with the resultant weights. If the participant did not agree with the weights then the participant was asked to adjust the weights for the given group.

The above-described procedure is only appropriate for establishing the weights of sub-variables whose parent variable is a weighted-sum of the sub-variables. For parent variables that are not calculated using a weighted-sum function, another type of questioning procedure was used to establish the relevant weights. The specific question(s) used to extract the required information about a given parameter value is (are) dependent upon the nature of the variable and the function used to calculate the parent variable value. Some of the more complex questions were asked in several different ways to insure that the participant was clear about the information being requested. A similar question structure with appropriate modification for the specific variable was used to establish other sub-variable weights for non-weighted sum parent variables. The 'weights' for the topographic and fuel-related data elements were not queried since these data elements are used with the **BEHAVE** fire behavior model (Rothermel, 1983; Rothermel, 1972; Andrews, 1986; Andrews and Morris, 1986) which is a physical process, partly empirical model. The parameter values for the TOPO related data are already determined in the **BEHAVE** model.

Understanding the Model Results

The model outputs an overall wildfire hazard rating on a scale from 0 through 10, where 0 represents no hazard and 10 represents maximum hazard. The overall hazard rating includes all of the primary variables of the model, i.e., topography and fuels, construction elements, landscaping, defensible space, accessibility, water availability, and fire protection response. A 'what-if mitigated' overall hazard rating is also calculated taking into account the easily implemented mitigation steps relating to landscape maintenance and the establishment of a defensible space zone around the structure. That 'what-if mitigated' rating indicates the reduction in hazard that would be possible if the relatively easy mitigation actions were implemented for the site.

Accessibility, water availability, and fire protection response are factors that relate to active suppression of a wildfire. In some situations active suppression may not be effectively available for a structure. In the initial moments of a moderate to severe fire event, fire suppression forces are not likely to be on-site and in position to deliver protection. Also, the wildfire situation may be severe enough so as to present a significant life threat to fire fighters if they attempted to protect a structure. In those situations, the structure would have to survive on its own. Thus, in addition to the overall hazard rating for a site, a rating of the wildfire hazard to a structure is produced in which the suppression factors of accessibility, water availability, and fire protection response do not enter into the hazard rating. The hazard rating with no-suppression represents the relative hazard to a structure if the structure needed to survive on its own. Again, the rating is produced on a scale of 0 (no hazard) to 10 (maximum hazard).

A rating for each primary factor is also produced. That is, a hazard rating relative to each of the primary factors taken separately, such as topography and fuels, construction elements, or landscaping, etc. is calculated and reported for each parcel. Here again the factor ratings are on a scale from 0 (no hazard) to 10 (maximum hazard). By looking at the individual factor ratings for a site, it can be determined which factors are the most significant in contributing to the overall hazard rating for a site. The topography and fuels, accessibility, water availability, and fire protection response factors are not easy to 'mitigate'. For the topography and fuels factor only significant fuel reduction programs applied to the landscape could affect the hazard rating relative to this factor. The factors most amenable to mitigation actions are landscape maintenance and construction elements. Maintenance efforts, such as defensible space applied to the vegetation and firewood storage areas immediately around a structure, or remodeling efforts applied to components of the structure construction are activities that can most easily be implemented for effective reduction of the wildfire hazard to a site.

Quality Control - Errors and Missing Data

Model Configuration Must Match Questionnaire Version

There are currently two versions of the WHIMS' questionnaire used in the field - version 2 and version 3. The number sequence of some questions and some response options for certain questions are slightly different between the two versions. The WHINFOE (Hay, 1998) model program is separately configured for each of the questionnaire versions. The model is configured for the specific questionnaire version by the use of a model configuration file. The configuration file needs to be appropriately matched to data from the matching questionnaire version. If different versions of the questionnaire are used within a given fire protection district, the parcel data needs to be grouped according to questionnaire version and separate model runs need to be made for each questionnaire set. Version 1 of the questionnaire was only used in the original pilot study area and all of that data was permanently transformed into questionnaire version 2 format.

During the running of the WHINFOE model program, the program does a limited check of the input file to make sure that the correct configuration file is matched to the specific questionnaire version of the input data. If an attempt is made to run the model for a set of data using an inappropriate model/questionnaire version configuration file, then the mismatch is detected and an error message is displayed to the user. The user can then restart the program using the appropriate model/questionnaire configuration file. It is still possible that certain sequences of data could get past the program's data checking. Thus it is possible that the program will process the data using an inappropriate model configuration file. Post-processing checking of the results is recommended to verify that the data was processed with the appropriate model configuration file.

Out of Range Response Values

During the WHINFOE model's analysis of the questionnaire data, response values are checked to insure that the responses are within the valid range for a given question. If an out-of-range value is detected, that parcel is flagged as having missing data and the specific question that is missing is identified. A missing data file is generated as one of the outputs from WHINFOE so that the user can check the input data for errors. If a parcel has missing data that is detected during the 'missing data' check, the parcel's data are processed according to the user-specified option for processing missing data. The options for the processing of missing data are:

1) Flag the data as missing and do not process this question's data
2) Flag the data as missing, but process the question using the minimum response value (best case) for the question
3) Flag the data as missing, but process the question using the mean of the response value range for the question
4) Flag the data as missing, but process the question using the maximum response value (worst case) for the question

The missing data file is an ASCII file that contains a list of specific parcels and specific questions for each parcel that lack valid responses. The user should review the missing data file after a model run. If every parcel has significant missing data, or if a specific question is listed as missing for a large number of parcels, then the data input file should be checked to verify that it is properly formatted, and that the correct model configuration file was used.

Incorrect Data File Formatting

If an input data file is incorrectly formatted and manages to pass the above-described automated error checks, the WHINFOE model program will terminate, most likely with a DOS runtime error message. If the program is run under WINDOWS™[7], the DOS error message may not be displayed, since the WINDOWS™ screen will return too rapidly for the user to view the DOS error message. The user should check the sequence of parcel numbers in the output data file to make sure that every parcel in the input file was processed. If certain parcels were skipped or the first or last parcel records were not processed, then most likely the input file contains formatting errors. A newer WINDOWS™ version of the WHINFOE model calculation program is under development. The WINDOWS™ program version does more extensive error checking and flags all data records in error and lists those records in an error report.

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[7] WINDOWS™ is the registered trademark of the Microsoft Corporation.

Chapter 7 : USING THE WHIMS INFORMATION

"Getting the Information Out And Used"

Distribution of the WHIMS Data

The WHIMS parcel data will be provided to all of the fire protection districts within Boulder County that have signed a data sharing agreement with the County (see Appendix E). Homeowners within the districts, either individually or as a group, can most easily review or examine the WHIMS data for their parcels through interaction with their local fire protection district officials. Additionally, the WHIMS data and information is available to the Boulder County Fire Fighters Association - Chiefs' Working Group through their representatives in the Boulder County Wildfire Mitigation Group (BCWMG). Close interaction among all interested players within the county will facilitate not only the timely distribution of the maps and database, but also allows for training on use of the information, and updates to the data, etc. In short, a strong local network is the efficient method for the dissemination and use of the WHIMS information.

Suggested formats, mediums, forums

A variety of formats for the WHIMS data are available. Hard copy paper maps of the questionnaire data and model results information are provided to each district that completes their questionnaires and returns the data to the County. In addition, electronic spreadsheet tables of the encoded questionnaire data and model results information are available. ARCVIEW™ shape files of the parcel data, the topographic and fuel type data are also available.

Development of Wildfire Hazard Awareness - Integrating WHIMS Information into the Community

Other Related Information (Brochures, Videos)

Several brochures and videos discussing the wildfire hazard and the mitigation efforts that a homeowner can take to reduce the hazard are available through the Boulder County Land Use Department Office of Fire Management. Copies of the videos are also available for loan through the Boulder Public Library.

Integrating WHIMS Information into Planning

County Planning Level

On a countywide basis, a wildfire hazard assessment based upon the fire behavior index (FBI) of the WHINFOE model (see Figure 4 on page 6-2) has been produced to guide planners in an initial assessment of a site for which a building permit has been requested. That hazard evaluation which only takes into account the topographic and fuels situation for a site provides a pre-screening evaluation of a site to help flag the need for any subsequent, more specific evaluations on site.

Fire Protection District Level

The WHIMS data and information can be used to inform homeowners about the wildfire hazards to their homes. The WHIMS data can also be used for strategic pre-attack planning. The information in a district's WHIMS database can be used to develop pre-attack plans for a district and to make triage more efficient during an actual wildfire event.

Neighborhood Defensible Space Projects - Mitigating the Hazard

Shortly after the Pine Brook Hills pilot assessment was completed, a presentation was conducted for interested landowners and residents. The WHIMS data, maps and survey results were shared with the attendees. Residents were keen to locate their specific lot to see how they "scored". "Is our lot red, tan, yellow or gray", was the question of the evening. Others asked, "How does the neighboring area around our house look in terms of wildfire hazard?"

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After explaining to the landowners how the hazard assessment was conducted and what the results meant, landowners wanted to know what they could do to lower their risk. Personnel from Boulder County Land Use Department and fire protection services, the CSFS, and the local fire protection district explained the mitigation efforts that they could implement to reduce their risk. At that time it was suggested to the audience that if several contiguous landowners wanted to work together, a demonstration project might be funded through the State/County Mitigation Grant Program. One particular landowner took the challenge to heart and soon had 25 interested landowners ready to "sign up".

A 50/50 matching grant was procured through the Colorado State Forest Service and through Boulder County under the auspices of the Boulder County Wildfire Mitigation Group. After meeting individually with each landowner to determine their objectives, concerns and specific property needs, CSFS personnel marked trees for removal and pruning. This phase of the project involved implementing defensible space around each of the homes and reducing ladder fuels around trees to be kept. All slash generated from this part of the operation was dragged to the driveway or road for chipping. State Forest Service crews, and a locally sponsored Americorps Team performed most of the thinning and pruning work. For safety reasons, Public Service Company crews removed or pruned trees near power lines.

The second phase of the project involved creating a shaded fuel break below the participating homes since their greatest exposure to wildfire came from a canyon located down slope from the homes. A local firewood contractor removed trees felled as part of the shaded fuel break operation. The slash generated in the area was piled and burned during the winter months over the next two years. Prior to burning, the piles were covered with heavy plastic to keep them dry and ready for burning when an opportunity arose. The piles were uncovered and burned after a good snowfall so that the risk of escape was negligible.

The project demonstrated how the WHIMS information could be used to motivate communities to conduct mitigation work. It also proved that such projects could be difficult to implement in regards to funding, need for constant crew supervision, obtaining landowner acceptance of pile burning, etc. However, such projects are well worth the effort in order to reduce the risk of wildfire to homes in the UWI. The Pine Brook Hills Project was the first mitigation project conducted around private homes. As such it allowed local resource managers to ascertain the more challenging aspects of such a mitigation project so that future projects can be operated more efficiently and effectively.

Chapter 8 : MAINTAINING WHIMS

"Keeping the System Current and Dynamic"

A maintenance plan for periodic updates to the WHIMS project database has not yet been developed. Most of the data collection and evaluation effort has been focused on acquiring a first time look at the sites within the participating fire protection districts. Thus, while the need for periodic updating of the WHIMS data is recognized, no plans have been developed or resources identified or committed that would support such a maintenance effort.

The remainder of this chapter presents only an outline of the topics/items that need to be addressed in the development of a maintenance plan for the WHIMS project.

Implementation Feedback

Feedback from the districts that have completed their data collection efforts needs to be systematically gathered and organized to help the WHIMS project coordinator develop a clear picture of the successes, failures, and frustrations of the first data gathering effort. Internal review of the data processing and database management procedures needs to be conducted so that revisions to the processing and management procedures can be developed and implemented where needed. An example of the result of one such review effort is the newly proposed data management/processing protocols presented on page 5-6. As more districts complete their questionnaires and join the WHIMS project, situations have come to the forefront which suggest that a review of the database structure definition is in order. For example, the original definition of the database structure did not take into account the fact that some parcels actually have multiple dwelling units on them. Each of these dwelling units are evaluated, but tying the evaluation data to a spatial record is currently problematic since the original database structure definition did not plan for such occurrences and therefore did not design an attribute field into the database to record such data. The idea solution is to develop a house pad location data layer and to tie all data to the house pad location as opposed to the parcel. However, while the need for house pad locations is recognized, resources to collect that data are not currently available.

Follow-ups

Periodic follow-up meetings with homeowners in districts that have completed their initial survey should be conducted. Such meetings would keep the goals of the WHIMS project actively in the homeowners' attention. Currently, that activity is left solely to the fire protection districts.

Database Management and Updates

Who?

The WHIMS questionnaire data items should be maintained and updated by the fire protection districts since they are in the closest contact with their homeowners. The updates can be maintained in the spreadsheet database and periodic updated copies should be supplied to the Boulder County Land Use department for inclusion in the countywide spatial database.

As wildfires, prescribed fires, and large-scale mitigation efforts take place, the fuel type data layer needs to be updated if those activities effect a fuel model change. Updates to the fuel type data layer should be coordinated by the Land Use Department GIS Division to ensure that the countywide fuels data stays current. In addition, a mitigation activity data layer should be developed to keep track of any mitigation efforts that are taking place within the county. The wildfire coordinator for the county could coordinate the development and maintenance of that data layer in conjunction with the GIS Division of the Land Use Department.

Parcel data updates are handled by the County Assessor's office. However, changes detected in the WHIMS field data collection process need to be conveyed to the Assessor, since data in the Assessor's electronic database are not always current.

When and How

How often the sites within a district should be reviewed and updated depends upon the district's use of the database and the development pattern/frequency of the district. For districts that are actively developing pre-attack and strategic

defense plans for their districts, such updates may be justified on a 1 – 2 year cycle. Certainly the outside limit for a periodic update of the WHIMS data should not be greater than every 5 years. Beyond that time frame the data cannot be considered to be current and viable.

Irregular updates can be triggered by the sale of a piece of property. The benefit of such a trigger is that new residents to the mountains can be provided information on the wildfire hazard to their property in a timely manner and this trigger serves as an efficient means of identifying parcels for an updated review.

If a homeowner performs significant site maintenance or structure remodeling on his/her parcel, that homeowner can request an updated WHIMS review by the district's chief. The announcement of the availability of such reviews can be handled through homeowner association newsletters or fire protection district mailings to their subscribers.

Improvements in Methodology

Changes in procedures are implemented as they arise within the project. An example of a proposed change in methodology is the encoding of the WHIMS questionnaire data discussed above (see page 5-6). Other changes in methodology require the addition of data layers to the spatial database, and are on hold until such data is available, for example the addition of house pad locations to the database (see page 10-1).

Chapter 9 : CASE STUDY

City of Boulder Wildland Fire Hazard Identification and Mitigation (FIRMIT)

Adoption in an urban setting - From WHIMS to FIRMIT

In 1993 several City of Boulder land management departments decided to join with Boulder County's WHIMS program to address the City's wildland fire concerns relative to neighborhoods and City owned properties within the urban-wildland interface. City of Boulder departments joining in the effort included the Open Space Department, the City's Fire Department, and the Mountain Parks Division, a division of the Parks and Recreation Department. The City of Boulder in adopting the Boulder County WHIMS' concept set up a project specific to the City of Boulder that was called FIRMIT.

The Open Space Department received budget approval for the 1994 budget year from the City Council for funding of the FIRMIT project. In doing so, Open Space committed money and personnel to develop a plan to inventory the wildfire hazards within neighborhoods and adjacent publicly owned lands that lie within the urban-wildland interface. The final products developed under FIRMIT have been used to help educate, motivate, and assist homeowners, City staff, and fire fighters in mitigating the wildfire hazard concerns. The City of Boulder Open Space Department, City of Boulder Fire Department and the City of Boulder Mountain Parks Division have worked closely with the Boulder County Land Use Department, Colorado State Forest Service, Boulder County Sheriff's Department, local volunteer fire protection districts, and the U.S. Forest Service in coordinating the FIRMIT effort.

Project Scope of FIRMIT

Current responsibility for the City's FIRMIT project lies with the Boulder Fire Department's Wildland Fire Mitigation Supervisor. Monies and time were allotted to a GIS position within the Open Space Department. Initially a time line of two years was planned for the initial phase of the project, which included project setup and completion of an area along the southern edge of the City. A follow-up phase is also planned and will extend the time-line beyond the first two years. The extended project area will again only include neighborhoods that border City-owned lands or facilities, and will only include homes that are affected by the urban-wildland interface. Strong support has been received from the City of Boulder Fire Department, City of Boulder Mountain Parks Division, as well as from the county, state, and federal agencies that participate in the Boulder County Mitigation Group and the WHIMS Technical Working Group.

The How's of FIRMIT

The basic philosophy behind Boulder County's WHIMS questionnaire and data collection and processing techniques was adopted for the FIRMIT project. Simple changes to better fit a more urban neighborhood situation with higher density of homes were needed to adapt the County's WHIMS questionnaire to the city needs. This included addition of questions or changing the WHIMS' questionnaire to cover these differences. These changes included a housing density question, proximity of fire protection access to natural areas behind the homes, and gas utility differences. Homes and parcels were easy to access for the FIRMIT survey work with a total of 99% of the homes in the mapped area being surveyed. Close to 40% of the homes surveyed involved some type of direct homeowner contact. The remaining percentage of homeowners had the opportunity for direct contact but for whatever reason did not take advantage of the opportunity.

There were 7 basic steps involved in the various aspects of the FIRMIT project. They are as follows:

1. ***Publish a notice of proposed project in local newspaper.*** The public notice included a description of the project, the reason behind FIRMIT, the area that would be immediately surveyed and names and phone numbers of City of Boulder contact persons that could answer questions about the project and the process. The public notice step was done prior to any contact with neighborhood individuals.

2. ***Facilitate a public information meeting.*** It was important during the early phase of the project to bring together as many interested parties as possible to briefly explain the project, to answer any

questions, and address any concerns. The object of the public information meeting was to present, as soon as possible, the established FIRMIT goals to the neighborhoods involved.

3. ***Mail packet of materials to homeowners within the survey area.*** The packet included a letter to the homeowner describing the project, the reason behind the project, and the names and numbers of City of Boulder contact persons. A sample questionnaire to get the homeowner thinking about the wildfire hazard was included with several educational brochures developed by the city and county to aid the education process.

4. ***Train possible volunteers that would be needed to gather survey data.*** Volunteers may include individuals from the general public as well as fire department personnel. Training included a description of the characteristics of wildfire behavior as well as material familiarizing the trainee with all elements that needed to be considered in the development of the database for integration into the GIS spatial database.

5. ***Data collecting and hazard evaluations for each individual site.*** Data was collected relative to water availability, topography of the area, construction characteristics of the structure, fire protection accessibility, or vegetation density and composition immediately around the home. During the data collection process, if the homeowner was present on site or wanted further contact, the collected information was shared with him or her at that time.

6. ***Analysis of the data and production of the Hazard Rating and other GIS information products.*** Maps were produced using the Open Space Department's GIS system that included the collected data and interpreted hazard information.

7. ***For each delineated neighborhood, an additional public meeting was conducted.*** At the follow-up neighborhood meetings, homeowners were given a chance to discuss the outcomes of the project and the results generated by the hazard analysis. Questions were answered and awareness of the wildfire hazard discussed.

Education is a strong element in each of the above-described steps. The education aspects of the project permeate all levels of the project, and include all involved departments, and each level of management, including Boards and Councils, as well as the homeowners themselves.

Public Reaction

Reaction to the FIRMIT project has generally been good. Following the hazard survey phase of FIRMIT within the project neighborhoods, a follow-up public reaction survey was conducted. The objective of the follow-up survey was to ascertain what perceptions existed within project neighborhoods regarding the FIRMIT project and what perceptions existed in reference to wildland fire hazard in general.

FIRMIT Project Participation Survey Totals

Questionnaires were sent to approximately 400 homeowners that participated in the Wildland Fire Hazard Identification and Mitigation project. The initial project area encompassed the south end of the City. Of the 400 public reaction survey questionnaires, 93 residents (23%) responded to the questionnaire in a very constructive manner. A 25% response-rate to a survey is normally considered a good response-rate. Thus, the 23% response-rate to the FIRMIT public reaction survey shows a high level of public interest in the issue of wildfire hazard.

The public reaction survey questionnaire was designed to provide answers for several aspects of the FIRMIT project. First, it was designed to determine if the homeowners in the specific participation unit felt safe from the possibilities of a wildland fire. Second, several questions tried to determine how aware the public was of the FIRMIT project and the public's desired level of participation. We wanted to see if the public felt that this type of program was effective in providing everyone with the necessary information to become adequately aware of wildfire mitigation, and to see if they felt the program was beneficial or not. In addition, the survey attempted to ascertain the public's opinion on prescribed fire as a management tool for public lands administered by the City.

A tabulation of the responses to each follow-up public reaction survey question, along with an interpretation of what we think we can and have learned from these responses is presented in Appendix G.

Usage of the information/outcomes

FIRMIT Information is currently not in a form that is easy for non-Open Space/Fire Department persons to use. That situation is being remedied by an effort that will produce a report in which the FIRMIT information is compiled along with a description of the FIRMIT data collection and analysis processes, and the resultant tables and maps. The report form will make it easier for interested parties to use the FIRMIT data and information. The FIRMIT report will be disseminated to appropriate people for their use. The Fire Department has already, on several occasions, made use of the FIRMIT information. The Fire Department has used the FIRMIT information to present a clearer picture of the wildfire hazard to City of Boulder neighborhoods, so that the public and city department managers can determine the need for a Public Safety tax. The voters subsequently approved a Public Safety tax. Mountain parks, or to be more specific, the Chautauqua Association, has used this information to identify issues that need to be addressed within their annual landscaping maintenance and management plan. The City of Boulder Open Space Department will use the FIRMIT data and information to develop their Area Management Plans when the plan development takes up the neighborhood areas covered by the initial phase of FIRMIT. The FIRMIT project information is constantly being shared with other municipalities and land management agencies throughout the region and country. Joint mitigation projects will be implemented between the City of Boulder Mountain Parks Department and Open Space Department, once the associated plans have been developed.

Chapter 10 : WHAT'S NEXT?

Expanded Capabilities

House Pad Locations

As discussed earlier in the "Implementation Feedback" section on page 8-1, there is a need to acquire the location of house pads within a parcel that has a structure on it. Not only would such data improve the analysis of topographic data relative to structure location on large parcels, it would also solve the multiple structure per parcel problem in the most efficient way. Active discussions about how to acquire this data within the available resource limits, are currently taking place. This is a resource limitation issue not an available technology issue.

Countywide Dangerous Topography Layer

Recently the Boulder County Land Use Department identified the need to produce a wildfire **hazard** 'first look' classification for the entire county. Using just the DEM topographic data and the fuel type data layer that was produced to support WHIMS, a wildfire hazard classification was produced by applying the topographic and fuels factor (TOPO) evaluation from the WHINFOE (© C.M. Hay, 1999) model. A major limitation of the current, countywide hazard classification is the lack of an evaluation for proximity to dangerous topography. That evaluation is a part of the parcel-based evaluations, but is evaluated directly on site for each structure. This short fall in the countywide hazard classification is due to the fact that a dangerous topography data layer has not been developed as yet for the entire county. Plans to acquire this information are currently being developed.

Countywide Risk Evaluation

The county is currently undertaking a countywide **risk** 'first look' evaluation to be combined with the hazard classification for a countywide integrated hazard-risk evaluation to be used to guide planners in the site plan review process for new or remodel building permits.

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Appendix A: WHIMS QUESTIONNAIRE FIELD GUIDE

Claire M. Hay with Illustrations by Peter D. Slack
The Wildfire Interface Group

Introduction

Data are collected for each residential parcel in the mountainous area of Boulder County. The data are evaluated using a wildfire hazard-rating model that was developed specifically to rate parcels within the urban wildland interface. The wildfire hazard-rating (WHR) model is a combination of theoretical-empirical fire behavior components and experiential components. The theoretical-empirical components are based upon the USDA Forest Service's **BEHAVE** (Rothermel, 1972; Andrews, 1986) fire behavior model for wildfire propagation. The experiential components are based upon the knowledge and experience of numerous fire management experts within Boulder County fire management agencies, the Colorado State Forest Service, and the USDA Forest Service. The experts were queried regarding their knowledge about, and experience with specific environmental and structural factors, and those factors' relationship to wildfire behavior and hazard. The results of the query were used to develop the WHINFOE (Hay, 1998) wildfire hazard-rating model, and to assign factor weights to the model variables.

Input for the model consists of twenty-nine data items. Twenty-four of the data items are collected in the field using the WHIMS Questionnaire (WQ), and five data items are extracted directly from digital, spatial data using a geographic information system (GIS). This appendix describes the WHIMS questionnaire in general, and each of the data items contained on the questionnaire. To date there have been three versions of the WHIMS' Questionnaire for Boulder County. Version 1 was used on one sub-division only. All of the data from that sub-division has been transformed to version 2 of the WHIMS questionnaire. Version 3 is the latest version and is being used by the most recent fire protection districts that have joined the project. Both version 2 and version 3 forms of the questionnaire are in current use within the county depending upon when a specific fire protection district joined the project. There are some minor differences between version 2 and version 3 of the questionnaire. Most notable is the sequence order of the questions. Additionally, the response options under some of the questions have been slightly modified and renumbered and/or reordered. The following description of the WHIMS questionnaire will focus primarily on version 3, the most current version, of the questionnaire. Table 5 shows a brief list of the 29 questions and the sequence order relationship between version 3 and version 2 of the questionnaire.

Questionnaire Organization

The WHIMS Questionnaire is divided into three sections based on the type and source of data to be gathered. The three sections are:

1) the VOLUNTEER FIRE FIGHTER SITE VISIT SECTION
2) the FIRE CHIEF SECTION, and
3) the GIS RESPONSE SECTION.

For ease of use, each of the sections is printed on its own identifying page color, and labeled with the section title. The Site Visit section is 'goldenrod' in color, the Fire Chief's section is 'peach' in color, and the GIS section is 'light green' in color.

Table 5: Comparison of Question Sequence Order between WHIMS Questionnaire[8] Versions

Question # Version 3r	Description	Question # Version 2r
1	Building or Lot Identification Sign Type	15
2	Distance of Structure to Steep Slope	1
3	Distance of Structure to Chimneys, Ridges, Saddles, V-Shaped Canyons	2
4	Roof Material	3*
5	Siding Material	4*

[8] Asterisk indicates renumbered, reordered, or modified set of responses for the question from version 2 to version 3.

6	Eaves & Overhangs Classification	5
7	Balcony & Deck Classification	6
8	Property-Level Access (Driveway) to Structure	7
9	Propane Gas Utility Location	8*
10	On-Lot Utility Line (Phone & Electric) Location	9
11	Defensible Space Around House	10
12	Vegetation Density Around House	11*
13	Vegetation Near Roof Conditions	12
14	Firewood Storage Location	13
15	Vegetation Near the Chimney or Stovepipe Condition	14
16	Water Hydrant Locations	16*
17	Permanent Stream Locations	17*
18	Water Draft Sources	18*
19	Fire Protection Response Time	19*
20	Primary Route Ingress/Egress Classification	20*
21	Primary Route Road Width Classification	21*
22	Maximum Grade of the Primary Route to Structure	22*
23	Nature of Primary Road Terminus to Driveway	23*
24	Off-Lot Utility Line (Phone & Electric) Location	24*
25	Average Slope Class of the Site	25*
26	Predominant Aspect Class of the Site	26
27	Average Lot Size	27*
28	Predominant Fuel Type Classification of Vegetation near Structure/Lot	28[9]
29	Average Slope Value (Percent Slope), (actual value)	29[21]

Title and Property Identification Section

At the top of the first page of the questionnaire is the form title:

WILDFIRE HAZARD QUESTIONNAIRE
for the
Wildfire Hazard Identification and Mitigation System (WHIMS)
Boulder County, Colorado
(Version 3.0) *[or no version number for version 2]*
NAME FPD fire protection district being surveyed, e.g. 'LEFT HAND FPD'

STREET ADDRESS:_____

If applicable, **SUBDIVISION NAME:**_____ **BLOCK/LOT #:**_____/_____

(PARCEL ID:_____**)**

The recorded **street address MUST** correspond to the **County's Mountain Addressing System (MAS)**. Properties in the mountainous areas of Boulder County are assigned a street address based upon their distance in 1/10ths of mile units from a specific road/street junction. A property's street address in the MAS is the official address for that

[9] This question did not actually appear on version 2, but the data was extracted from the GIS database.

property and **must** be the address used to identify the property on the questionnaire form. If it is not possible to determine the MAS address for a property then use whatever address seems to be the next best alternative for identification of the property. **Make a clear note** that the MAS address was not clearly determined. The field person surveying a specific property is responsible for identifying the MAS street address at the time of the site visit and recording that information in the space provided on the questionnaire. The **PARCEL ID** number is a number used by the County Assessor to identify the property on the tax records. The **PARCEL ID** information will be supplied by the WHIMS project office and does not need to be recorded by the field person.

Site Visit Section

The Site Visit Section immediately follows the property identification section of the questionnaire. The Site Visit Section ('goldenrod' color) contains 15 questions numbered 1 through 15 plus a comment page at the end of the section for use by the field person. Information gathered in the Site Visit Section is very specific to the actual site location of the property. In general, the data collected in the Site Visit Section consist of data about:

1) name of field observer/data collector,
2) whether data was gathered on-, or off-site
3) specific **topographic features** affecting the site,
4) **construction** details of the main structure(s) on the property,
5) **'on-site' access** to the structure(s) on the property,
6) **utility** features located directly on the property, and
7) **landscaping/defensible space** and general lot maintenance features.

At the end of the Site Visit Section is a comment page where field surveyors are encouraged to record general remarks about the site or comments about specific questions. If the field observer feels that the response options for a specific question do not accurately reflect the observed situation, the field person needs to record that fact along with an indication of what the deviant conditions were. It is very important for the field observer to record information about deviant conditions or inadequate response options. The comment information is important to data encoders in the WHIMS Project office or fire protection district office should there be questions on how to decipher the field data.

Fire District Chief Section

Following the Site Visit Section is the Fire District Chief Section ('peach' color) that contains nine questions numbered 16 through 24 followed by a comment section for use by the District's Fire Chief. Information gathered in the Fire District Chief Section is broader in nature than the information gathered in the Site Visit Section. In general, the data collected in the Fire District Chief Section consists of data about:

1) **water supply resources** in the neighborhood of the property,
2) **public right-of-way access** to the property and
3) **utility lines** in the general (neighborhood) area of the property.

The Fire District Chief Section is to be answered specifically by the Fire District Chief or his/her designated assistant. The purpose of using one specific person to gather the data in this section is to maintain consistency in the responses for those data items that apply collectively to several properties within an area. Many of the questions in the Fire District Chief Section can be answered in the office with map information as opposed to requiring a specific site visit.

At the end of the Fire Chief Section is a comment section where the District's Chief is encouraged to record additional remarks about the neighborhood's water resources and access, or comments about specific questions within this section of the questionnaire. If the chief feels that the response options under specific questions do not accurately reflect the situations within his/her district, the chief needs to record that fact along with an indication of what the deviant conditions were that were not adequately covered under the response selections provided. The comment information from both the Site Visit Section and the Fire Chief Section is important to data encoders in the office to rectify ambiguities in the recorded questionnaire data. The comments are also important to improve and revise any future versions of the data questionnaire.

GIS (Computer-Derived) Response Section

Following the Fire District Chief Section is the GIS (Computer-Derived) Response Section that contains five data items numbered 25 through 29. Information gathered in the GIS Section is again broader in nature than the information gathered in the Site Visit Section. In general, the data collected in the GIS Section consist of data about:

1) the average **topographic environment** of the property, and
2) the **density of development** within the neighborhood of the property.

Information extracted in the GIS Section is most efficiently and consistently measured using 'digital' topographic and vegetation information stored within a computer in what is called a geographic (or spatial) database. The information is extraction using a software package called a Geographic Information System (GIS) to do spatial analysis on the data. However, it needs to be noted that if a GIS is not available, the GIS data items can be estimated using USGS 7.5' topographic quadrangle maps and/or in the field during the site visit.

Marking Responses on the Questionnaire

When marking the questionnaire for a given site, circle the most appropriate response for each question or put an X on the single, most appropriate response for the question. **DO NOT BLACKEN OVER** the response number that you select. Blackening out the response number can lead to possible 'mis-reads' by the human data encoder, thus leading to errors in data recording.

If more than one response 'seems' to apply, circle the **single, most appropriate response value** for the question, and add a comment about other responses that you feel might apply to the site. Please note that you must select **only one** response value – the most appropriate one, and indicate possible alternatives under the comment section or in the questionnaire margins. Novice interns are often used for data encoding. If multiple responses are circled on the form, there is possible confusion on the part of the data encoder that leads to possible errors in the database. We are asking you, the field observer, to indicate the single most appropriate response, since you are the most qualified person at the time of the site visit to make the critical decision on how to score a given question. If response adjustments are need, such decisions will be aided by your written comments when supervisory staff reviews the data.

Note also, that if multiple responses seem to apply, some questions ask you to select the higher (more dangerous) applicable response value, while other questions ask you to select the lower (less dangerous) applicable response value.

Description Of Questions

The following sequence of questions is ordered as they appear on version 3 of the WHIMS Questionnaire. See the comparison table (Table 5) for the renumbering guide for questionnaire version 2. Where the question response set has been modified, the questionnaire version 2 form is presented along side of the version 3 form. The following material describes each section and sub-section of the questionnaire in general terms, lists the specific questions relating to each sub-section, and describes how each of the questions is to be answered for a site.

Site Visit Section

There are six sub-sections under the Site Visit Section.

Address

The first sub-section of the Site Visit Section deals with lot sign posting. There is one question in this sub-section that relates to the lot identification sign for the site.

Q1 Building or Lot Identification (CLEARLY VISIBLE from road): *{Q15 - version2}*

0) NO STRUCTURE/DWELLING on site
1) Standard COUNTY issued ADDRESS PLATE displayed
2) NAME or NUMBER displayed
3) NO name or number displayed, or NOT VISIBLE from the road

Purpose

To identify the type of lot identification sign that is present for the structure or lot.

Critical Issues

The identification sign **must be easily visible** from both directions of the main road at the point of access to the lot. The more easily a lot can be identified and located from the main road, the more easily fire protection resources can locate the structure. This is particularly important when 'mutual aid' resources are involved that are not familiar with a particular district.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has installed this mitigative feature.

Variant Situations

None.

Topography

The second sub-section of the Site Visit Section deals with topography. There are two questions in this sub-section that relate to the topographic situation of the site. The intent of these two questions is to identify dangerous topographic features that will influence the behavior of a wildfire on the site.

Q2 STEEP SLOPE ***{Q1 on version 2}***

The set back distance of the structure from a STEEP SLOPE (greater than 30% or 17^{o}) is:

0) greater than or equal to 500 feet OR Not Applicable (i.e., NO STRUCTURE/DWELLING)
1) less than 500 feet but greater than or equal to 100 feet
2) less than 100 feet but greater than or equal to 30 feet
3) less than 30 feet

Purpose

To identify the distance relationship between a structure and steep slopes.

Critical Issues

Steep is defined to be slopes greater than 30% (17^{o}).

Situations where the structure/dwelling is uphill from or on a steep slope are of the most concern here, however, structures downhill from steep slopes are of interest also.

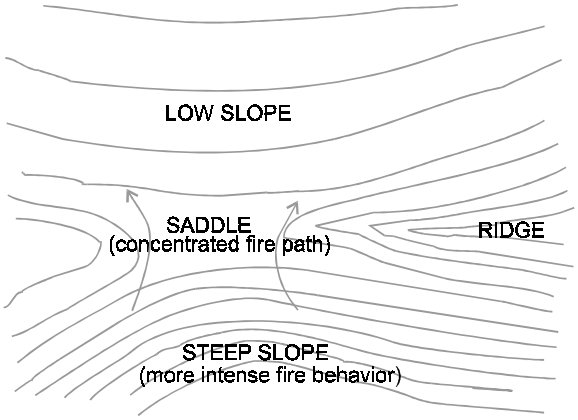

Figure 5: Topography – Example of Dangerous Features

Intent

The highest (worst case) response value that applies to the site should be selected.

Variant Situations

None.

Q3 DANGEROUS FEATURES ***{Q2 on version 2}***

The distance between a structure and identified dangerous topographic features such as a chimney, V-canyon, saddle, or ridge top is:

0) **greater** than or **equa**l to **500** feet; OR Not Applicable (i.e., NO STRUCTURE/DWELLING)
1) **greater** than or **equal** to **100** feet, but **less** than **500** feet
2) **greater** than or **equal** to **30** feet, but **less** than **100** feet
3) **less** than **30**

Purpose

To identify the distance relationship between a structure and dangerous topographic features, in particular, chimneys, ridge tops, saddles, and V-Canyons**.**

Critical Issues

Note that steep slopes are not included within the scope of this question.

Intent

Choose the highest (**worst case**) response value that applies to the site.

Variant Situations

If other non-listed dangerous topographic features are identified during the field visit then they should be included within the scope of this question.

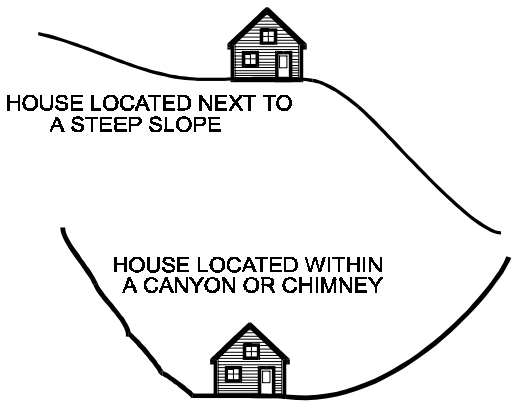

Figure 6: Structures Located in Close Proximity to Dangerous Features

Comments about the nature of the unlisted dangerous topographic feature should be made in the area provided for comments.

Construction

The third sub-section of the Site Visit Section deals with the construction elements of the primary dwellings or structures on a site. There are four questions under this sub-section. The intent of these questions is to identify the significant construction elements that influence the ignition potential for the dwelling.

Q4 ROOFING material classification:
{Questionnaire Version 3 form}

Roofing material is:

0) NO STRUCTURE/DWELLING on site
1) Metal or tile
2) Composite, asphalt, gravel, or fiberglass
3) Wood Shake Shingle (YEAR Installed: 19__ / unknown)

Purpose

To identify the type of **roofing** material covering the structure.

Critical Issues

The intent of this question is to score a roof relative to its most vulnerable elements.

Intent

The highest (worst case) response value that applies to the site should be selected.

Variant Situations

If more than one roofing material is used, select the highest response value that is

Q3 ROOFING material classification:
{Questionnaire Version 2 form}

Roofing material is:

0) NO STRUCTURE/DWELLING on site
1) Metal or tile
2) Composite, asphalt or gravel
3) Treated **shake**
4) Untreated **shake**

appropriate for any significant area covered by a specific material. For example, if a structure's roof is part metal (70%), and part untreated shake (30%), choose the untreated shake response (value 4), and make a note in the comment section about the dual nature of the roofing material. The exact proportion below which a specific material would not be considered 'significant' is dependent upon the situation that you find at the site.

Q5 SIDING material classification:
{Questionnaire Version 3 form}

Siding material is:

0) NO STRUCTURE/DWELLING on site
1) Masonry, concrete, or "real" stucco
2) Fiberglass, metal, or tile
3) Log or log stack types
4) Composite or "synthetic" stucco
5) Wood sheeting or planking
6) Shake Shingles

Q4 SIDING material classification:
{Questionnaire Version 2 form}

Siding material is:

0) NO STRUCTURE/DWELLING on site
1) Masonry/concrete
2) Fiberglass, metal, or tile
3) Log or log type
4) Composite
5) **Wood** sheeting or planking

Purpose

To identify the type of **siding** material covering the structure.

Critical Issues

The intent of this question is the siding relative to its most vulnerable elements.

Intent

The highest (worst case) response value that applies to the site should be selected.

Variant Situations

If more than one siding material is used, select the highest response value that is appropriate for any significant area covered by a specific material. For example, if a structure's siding is part masonry (30%), and part wood sheeting (70%), choose the wood sheeting or planking response (value 5), and make a note in the comments section about the dual nature of the siding material. The exact proportion below which a specific material would not be considered 'significant' is dependent upon the situation that you find at the site

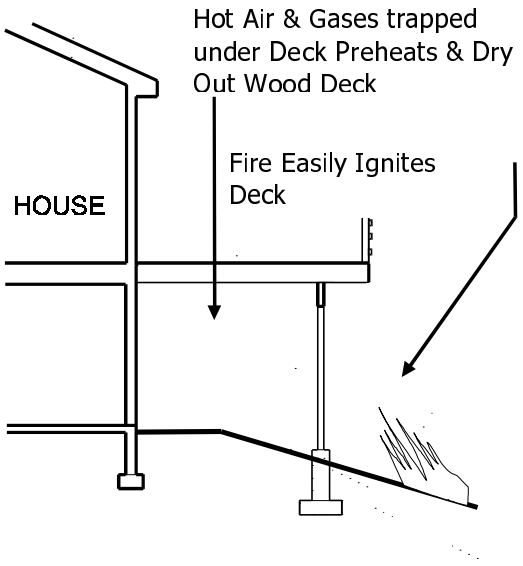

Figure 7: Unenclosed Balcony and Deck

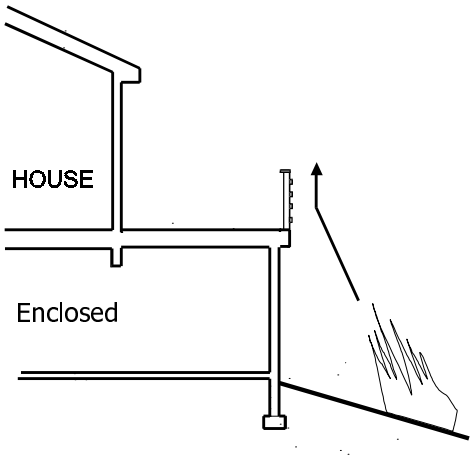

Figure 8: Enclosed Balcony and Deck

Q6 BALCONY & DECK Classification: *{Q5 on version 2}*

Balconies and Decks are:

0) Not Applicable (i.e., no balconies or decks) OR NO STRUCTURE/DWELLING on site
1) **Enclosed** underneath
2) **Unenclosed** underneath

Purpose

To identify the nature of the enclosure underneath balconies and decks.

Critical Issues

Flying burning embers and **hot gases** can collect under unenclosed balconies and decks, thereby fostering ignition of the structure.

Intent

In cases where more than one enclosure method has been used, select the highest response value that is most appropriate for any significant area underneath balconies or decks.

The intent of this question is to score structures relative to the **most vulnerable situation** found.

Variant Situations

Make a note in the comment section about the dual nature of the balcony and deck enclosure methods.

Q7 EAVES & OVERHANGS Classification ***{Q6 on version 2}***

Eaves and Overhangs are:

0) Not Applicable (i.e., no eaves or overhangs) OR NO STRUCTURE /DWELLING on site
1) Enclosed
2) Unenclosed

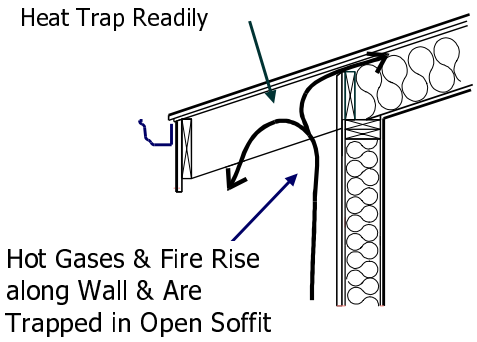

Figure 9: Open Soffit

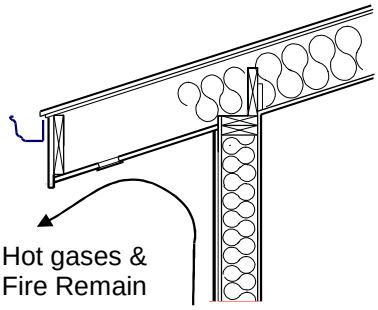

Figure 10: Enclosed Soffit

Purpose

To identify the nature of the enclosure of eaves and overhangs.

Critical Issues

Embers and **hot gases** can gain entry into a structure through unenclosed eaves and overhangs, thereby potentially **fostering ignition** of the structure.

Intent

In cases where more than one enclosure method has been used, select the highest response value that is most appropriate for any significant area of eaves or overhangs.

The intent of this question is to score structures relative to the **most vulnerable situation** found.

Variant Situations

If multiple responses apply, choose the highest applicable response value, and make a note in the comment section about the dual nature of the eaves and overhangs enclosure method.

On-Site Access

The fourth sub-section of the Site Visit Section deals with ***On-Site Access*** to the primary dwellings or structures on a site. There is one question under this sub-section. The intent of this question is to determine the quality of the *On-Site Access* to the structure by fire fighting vehicles.

Q8 ON-SITE ACCESS classification (the ACCESS to the structure/dwelling from the road; this may through a driveway on the lot or not): ***{Q7 on version 2}***

0) NO STRUCTURE/DWELLING on site
1) **High** accessibility for fire vehicles
2) **Medium** accessibility for fire vehicles
3) **Low** accessibility for fire vehicles

Purpose

To identify the nature of the On-Site Access to the structure.

Critical Issues

Many elements can contribute to the ease and safety of access to the structure by fire-fighting personnel with equipment. The response to this question indicates an integrated assessment of the On-Site Access to the structure. Elements that contribute to a dangerous or difficult situation for fire-fighting personnel lessen the quality of the *On-Site Access* for a site.

Intent

The intent of this question is to score structures relative to the **most vulnerable situation** found.

Variant Situations

The response to this question indicates an integrated assessment of the situation after taking into account the many elements that contribute to on-site accessibility. Make a note in the comment section or in the questionnaire margin of any specifically dangerous or difficult situations considered in making the assessment.

Since this is an integrated, qualitative assessment of the situation, multiple responses should not apply.

On-Site Utilities

The fifth sub-section of the Site Visit Section deals with *On-Site Utilities* installed for the primary structures/dwellings on the site. There are two questions under this sub-section. The intent of these questions is to collect information about the location of electric and propane utilities on a site.

Q9 PROPANE Location:
{Questionnaire Version 3 form}

0) Not applicable (i.e., no propane present) OR NO STRUCTURE/DWELLING on site.
1) MORE than 50 feet DOWNHILL from structure/dwelling
2) LESS than 50 feet DOWNHILL from structure/dwelling
3) MORE than 50 feet and EVEN with the structure/dwelling
4) LESS than 50 feet and EVEN with the structure/dwelling
5) MORE than 50 feet UPHILL from the structure/dwelling
6) LESS than 50 feet UPHILL from the structure/dwelling

Q8 PROPANE Location:
{Questionnaire Version 2 form}

0) Not applicable (i.e., no propane present) OR NO STRUCTURE/DWELLING on site.
1) **MORE** than **50** feet **DOWNHILL** from structure/dwelling
2) **LESS** than **50** feet **DOWNHILL** from structure/dwelling
3) **MORE** than **50** feet **UPHILL** or **EVEN** with the structure/dwelling
4) **LESS** than **50** feet **UPHILL** or **EVEN** with the structure/dwelling

Purpose

To identify the **spatial relationship** between the location of propane tank(s) on the site and the primary structure/dwelling on the site.

Critical Issues

Propane is heavier than air. In the event of a leak, the possibility for propane seepage into the structure exists, if the tank is located uphill from the structure. It is preferred (i.e., less dangerous) for the propane tank(s) to be located on a side contour from the structure.

Intent

The highest (worst case) response value that applies to the site should be selected.

Variant Situations

Since the possible responses for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Q10 ON-SITE ELECTRIC UTILITY LINE across lot from main line to structure/dwelling:
{Q9 on version 2}

0) NO CONSTRUCTION on site
1) All UNDERGROUND
2) Part underground & part above ground
3) All ABOVE GROUND

Purpose

To identify the location of electric utility lines that cross a site to a structure.

Critical Issues

Above ground electric lines could interfere with access to the structure by fire-fighting personnel and equipment, and can be an ignition source in a forest fire.

Intent

The single, most appropriate response value that applies to the site should be selected.

Variant Situations

Since the possible responses for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate

Landscaping

The sixth sub-section of the Site Visit Section deals with the landscaping and defensible space elements near a structure/dwelling on the site. There are six questions under this sub-section. The intent of these questions is to determine the nature of vegetation and ground cover around a structure that influences the vulnerability or defensibility of the structure from wildfire.

Q11 DEFENSIBLE SPACE around structure/dwelling**: *{Q10 on version 2}***

0) **GREATER** than or EQUAL to **200** feet, OR NO CONSTRUCTION on site
1) **GREATER** than or EQUAL to **100** feet, but **LESS** than **200** feet
2) **GREATER** than or EQUAL to **60** feet, but **LESS** than **100** feet
3) **GREATER** than or EQUAL to **30** feet, but **LESS** than **60** feet
4) **GREATER** than or EQUAL to **30** feet, but **LESS** than **20** feet
5) **LESS** than **20** feet.

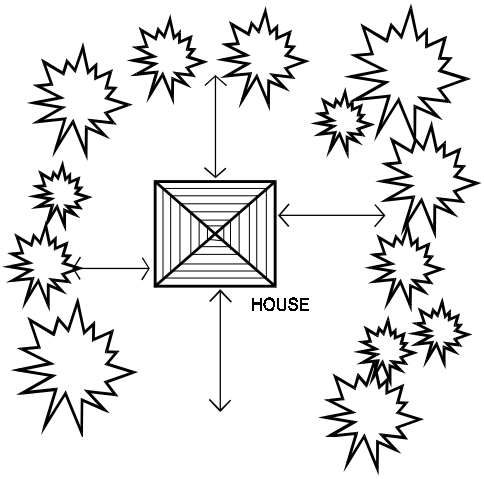

Figure 11: Defensible Space around a Structure

Purpose

To identify the amount of defensible space surrounding a structure.

Critical Issues

Many factors determination the quality of defensible space for a structure. Factors that allow a wildfire to reach a structure such as continuous runs of fuels up to the structure detract from the effectiveness of the defensible space. Thinned vegetation, or large areas of non-combustible materials, on the other hand, interrupts the fire's access to a structure. Your response to this question represents your integrated assessment of the situation after taking into account the many contributing factors that

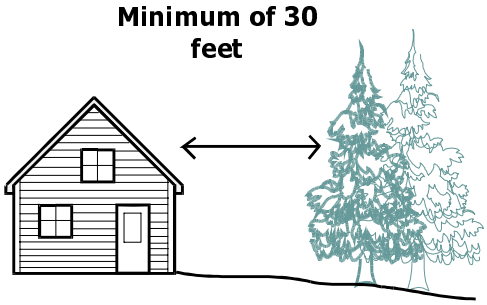

Figure 12: Defensible Space Separation between a Structure and Flammable Vegetation

create an effective defensible space. Comments on any specific factors that either detract from or contribute to the effectiveness of the defensible space for a given structure should be made.

Intent

The single, most appropriate response value that applies for this question should be selected.

Variant Situations

Since this is an integrated, qualitative assessment of the situation, multiple responses should not apply. Make any comment to the contrary that you feel are appropriate.

Q12 VEGETATION DENSITY within a 30 feet minimum distance of the structure/dwelling (including deadwood):
{Questionnaire Version 3 form}

0) Not Applicable (i.e., no vegetation within 30 feet of the structure/ dwelling), OR NO STRUCTURE/ DWELLING on site
1) **GRASS** with deciduous tree groves
2) **GRASS** with scattered trees or brush
3) **LIGHT** density of **CONIFERS** and/or **BRUSH**
4) **MODERATELY** dense **CONIFERS** and/or **BRUSH**
5) **DENSE** continuous **CONIFERS** and/or **THICK BRUSH**

Q11 VEGETATION DENSITY within a 30 feet minimum distance of the structure/dwelling (including deadwood):
{Questionnaire Version 2 form}

0) Not Applicable (i.e., no vegetation within 30 feet of the structure/ dwelling), OR **NO STRUCTURE**/ **DWELLING** on site
1) **GRASS** with deciduous tree groves
2) **GRASS** with scattered trees or brush
3) **THINNED CONIFERS** (i.e., 10 feet. between)
4) **SAGEBRUSH**/Other **BRUSH**/**WILLOW**
5) **MODERATELY** dense **CONIFERS** or **OAKBRUSH**
6) **DENSE** continuous **CONIFERS** and/or **THICK OAKBRUSH**

Purpose

To describe the vegetation density and fuel profile within an area surrounding a structure that extends from the structure to a minimum of 30 feet but up to 150 feet from a structure.

Critical Issues

The more dense and heavy the fuels, the higher the wildfire hazard to the structure.

Intent

The highest (worst case) response value that applies to the site should be selected. The intent of this question is to score structures relative to their most vulnerable elements.

Variant Situations

If multiple responses apply, choose the highest applicable response value, and make a note in the comment section about the dual nature of the surrounding vegetation density.

Q13 VEGETATION near ROOF: ***{Q12 on version 2}***

0) Not Applicable (i.e., No vegetation near the roof), OR NO STRUCTURE/DWELLING on site
1) Branches & limbs **WITHIN 5 feet**. of roof, but not overhanging
2) Branches & limbs **OVERHANGING** roof

3) Leaf & fine needles **COLLECTED ON roof** and in gutters

Purpose

to describe any vegetation that **overhangs** or is present on the roof of the structure.

Critical Issues

Overhanging branches on a roof serve as a ladder for ignition should the tree become involved in flame. Vegetation material such as leaf and needle litter in a gutter or on a roof serve as sites that can harbor flames that can ignite a roof.

Intent

The highest (worst case) response value that applies to the site should be selected. The intent of this question is to score structures relative to their most vulnerable elements.

Variant Situations

If multiple responses apply, the highest applicable response value should be selected, and a note made in the comment section about the dual nature of the vegetation-roof relationships.

Q14 FIREWOOD STORAGE location: ***{Q13 on version 2}***

0) Not Applicable (i.e., No firewood storage on site), OR NO STRUCTURE/DWELLING on site
1) MORE than 15 feet. away from structure/dwelling
2) LESS than 15 feet. away from structure/dwelling, but not next to the structure/dwelling
3) UNDER or NEXT to structure/dwelling

Purpose

To determine the distance between the structure/dwelling and any firewood stored on the site.

Critical Issues

A pile of stored firewood is particularly vulnerable to ignition from burning embers and sparks. If such a firewood pile becomes involved in flame, and is adjacent to a structure then the structure is highly likely to also become involved in flame.

Intent

The highest (worst case) response value that applies to the site should be selected. The intent of this question is to score structures relative to their most vulnerable elements.

Variant Situations

Since the possible responses for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Q15 VEGETATION near the CHIMNEY or STOVEPIPE: ***{Q14 on version 2}***

0) Not Applicable (i.e., no stovepipe or chimney), OR **NO STRUCTURE/DWELLING** on site
1) Vegetation **MORE** than **15** feet. from the stovepipe or chimney
2) Vegetation **LESS** than **15** feet. from the stovepipe or chimney

Purpose

To describe any vegetation that is near a stovepipe or fireplace chimney of the structure.

Critical Issues

Overhanging branches are vulnerable to ignition from sparks or flame escaping from a stovepipe or fireplace and are thus a possible ignition source for starting a wildfire. The perspective for this question is different from that for all of the other questions in the questionnaire. This question is focused more on a fire starting from a given structure as opposed to a structure being at risk from an approaching wildfire.

Intent

The highest (worst case) response value that applies to the site should be selected. The intent of this question is to score structures relative to their most vulnerable elements.

Variant Situations

Since the possible responses for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Fire Chief Section

There are three sub-sections under the Fire Chief Section of the data questionnaire.

Water Supply

The first sub-section of the Fire Chief Section deals with *Water Supply Resources* that are available for protection of the structure/dwelling on the site. There are three questions under this sub-section. The intent of these questions is to determine the capacity of the water supply, and the distance relationship between that supply and the given structure.

Q16 WATER HYDRANT location from structure:

0) **500 GPM LESS** than **1000** feet away
1) 500 GPM GREATER than 1000 feet away
2) **LESS** than **500 GPM** hydrants available
3) No hydrants available for a reasonable direct connection

Purpose

To identify the nature (capacity and distance relationship) of the closest pressurized hydrant available for a 'directly connected' supply of water to the structure/dwelling.

Critical Issues

Pressurized hydrants are reliable sources of water for the protection of a structure. Hydrants with a capacity of 500 GPM (gallons per minute) or greater are considered the minimum required for protection of a residential 2-story structure.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has this mitigative feature.

Variant Situations

Comments noting any variant situations not covered by the response options should be made in the comment section.

Q17 PERMANENT STREAM, pond, or cistern location from structure:

0) **500 GPM LESS** than **1000** feet away
1) 500 GPM GREATER than 1000 feet away
2) **LESS** than **500 GPM** hydrants available
3) No permanent stream or draft source available for a reasonable direct connection

Purpose

To identify the nature (capacity and distance relationship) of the closest permanent stream, permanent pond, cistern or other water-drafting source available for a 'directly connected' hose line to the structure/dwelling, i.e., a water source not needing tender shuttle for supply).

Critical Issues

The draft sources must be reliably permanent sources of water for the protection of the structure, and must provide year-round access and water supply. Streams that can supply 500 GPM (gallons per minute) or greater are considered the minimum required for protection of a residential 2-story structure.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has this mitigative feature.

Variant Situations

Comments noting any variant situations not covered by the response options should be made in the comment section.

Q18 Distance of approved water DRAFT SOURCES of 1500 gallons or more:

0) Within direct supply distance and easily available [Note: Property line location not relevant]
1) Draft sources within **20 minutes round-trip**
2) Draft sources within **21-45 minutes** round-trip
3) Draft sources greater than **46 minutes** round-trip
4) No draft sources available

Purpose

To identify the round trip time required to the nearest draft water source that is beyond a direct hose line connection distance for the structure/dwelling.

Critical Issues

The 'other' draft sources are located at a sufficient distance from a structure so that a directly connected hose water supply is not possible. Instead a water tender vehicle must travel to the draft location to fill its tank and then return to the structure/dwelling.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has this mitigative feature.

Variant Situations

Since the response choices for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Off-Site Access

The second sub-section of the Fire Chief Section relates to *Off-Site Access* features that determine the ease and speed of access to the primary structures on the site. There are five questions under this section. The intent of these questions is to categorize the quality of the *Off-Site Access* to the structure by fire-fighting personnel and equipment.

Q19 Fire protection RESPONSE TIME to the structure or vacant lot (from the station):

0) Within 15 minutes
1) Within 16 to 30 minutes
2) Greater than 30 minutes
3) No organized fire district

Purpose

To determine the time required to travel to a given structure/dwelling from the nearest fire station from which an initial response is expected.

Critical Issues

None.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has this mitigative feature.

Variant Situations

Since the response choices for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Q20 INGRESS/EGRESS to the driveway or point of access to the lot:

0) **Two or more points of access** to the road (primary route) leading to the property
1) Only **one point of access** to the primary road leading to a property; this could be a loop road with only one access point on the loop
2) **One way in and out**; a dead end, one point of access to road to the property

Purpose

To determine the characteristics of the primary access route to the lot. This question applies to the main, primary road network that allows access to the property.

Critical Issues

This question applies to the main, primary road network that allows access to the property. This question does **NOT** apply to a driveway across the property to the structure/dwelling on the property.

Intent

The lowest (best case) applicable response value that applies to the site should be selected. The intent of this question is to give credit to a structure/lot that has a good situation relative to this item.

Variant Situations

Since the response choices for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Q21 ROAD WIDTH to the driveway or point of access to the lot:

0) Good two-way road
1) Narrow two-way road
2) One-way road

Purpose

To determine the **minimum width** of the primary access route to the lot.

Critical Issues

If most of a road is a good two-way road, but a significant stretch along that route is a narrow one-way road that then opens out again into a good two-way road, then the road would be rated as a 'one-way road'. The goal of this question is to identify the most hazardous width condition that occurs along the primary route to the property. This question applies to the main, primary road network that allows access to the property. This question does **NOT** apply to a driveway or private road across the property to the structure/dwelling on the property.

Intent

The lowest (best case) applicable response value that applies to the site. The intent of this question is to give credit to a structure/lot that has a good situation relative to this feature within the context of the critical issues discussion.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply.

Q22 MAXIMUM GRADE of the primary route to the driveway or vacant lot:
*(Choose the **highest** response value that applies for this question)*

0) 0% to 5% (0^o to 3^o)
1) 6% to 8% (4^o to 4.5^o)
2) 9% to 12% (4.5^o to 7^o)
3) Greater than 12% (greater than 7^o)

Purpose

To determine the **maximum road grade** that will be encountered anywhere along the primary, road network from the responding fire station(s) to the driveway or other point of access to the lot.

Critical Issues

The maximum grade reported under this question may apply to only one relatively short stretch of route to the site or it may apply to the entire route.

Intent

The highest (worst case) applicable response value that applies to the site should be selected. The intent of this question is to characterize those grade features that significantly slow a response to the site.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply. Make any comments to the contrary that you feel are appropriate.

Q23 CONNECTION between **PRIMARY INGRESS/EGRESS ROUTE** leading to a property and a **DRIVEWAY** (less than or equal to 200 feet) across the property leading to the structure/dwelling or vacant lot: *{Questionnaire Version 3 form}*

0) Driveway directly links off a continuous primary ingress/egress route through a district, no dead-end terminals
1) Driveway directly connects to a loop or non-dead-end connecting road (not part of the identified continuous route through a district)
2) Driveway directly connects to a dead-end road less than or equal to 200 feet in length with a cul-de-sac with turn-around radius GREATER than 45 feet
3) Driveway directly connects to a dead-end road less than or equal to 200 feet in length with a cul-de-sac with turn-around radius LESS than 45 feet; OR
4) Driveway directly connects to a dead-end road greater than 200 feet in length, but the driveway connection is within 200 feet of a continuous, Non-dead-end loop or connecting route
5) Driveway directly connects to a dead-end road greater than 200 feet in length, and is not within 200 feet of a connection to a continuous or non-dead-end loop or connecting road

Q23 SECONDARY ROAD terminus: *{Questionnaire Version 2 form}*

0) No secondary road
1) Loop roads or cul-de-sacs with turn around radius GREATER than 45 feet
2) Cul-de-sacs with turn-around radius LESS than 45 feet
3) Dead-end roads less than 200 feet in length
4) Dead-end roads more than 200 feet in length

Purpose

To determine the ease with which one can gain access to or accomplish egress from the driveway for a structure/dwelling.

Critical Issues

If a 'driveway' is greater than 200 feet in length, then the portion farthest from the structure and beyond a 200 foot distance from the structure and leading back to the main ingress/egress route (public or private) is considered part of a private road system and is characterized as a road not a driveway. Such private access roads are often dead-end roads and should be considered as such in selecting the most appropriate response value for this question. Whether a road is **public** or **private** is **irrelevant** in this question. The main goal of this question is to characterize the main road network to the structure(s) on a lot.

Intent

The intent of this question is to characterize the dangers associated with gaining access to or egress from the lot. The most appropriate response value that applies to the site should be selected.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply

Off-Site Utilities

The third sub-section of the Fire Chief Section deals with *Off-Site Utilities* installed for the development of an area in general. There is one question under this sub-section. The intent of the question is to determine the nature of utility features for the general 'neighborhood' area in which a specific lot is located.

Q24 UTILITY LINE (Electric) in the area EXCLUDING the line to the structure/dwelling:

0) All UNDERGROUND
1) Part underground and part above ground
2) All ABOVE GROUND

Purpose

To identify the location of off-site electric utility lines that run through a development as part of the main electric power supply to an area.

Critical Issues

Above ground electric lines could possibly interfere with access to the lots by fire-fighting personnel and equipment.

Intent

The single most appropriate response value for the site should be selected.

Variant Situations

The possible choices for this question are mutually exclusive, multiple responses should not apply. Comments should be recorded about specific potentially dangerous situations that the data gatherer feels are appropriate.

GIS (Computer Measured Response) Section

While the questions in this section are intended to be measured directly using the spatial analysis or data query capabilities of a GIS, in situations where a GIS is not available, questions #25 through #29 can be 'estimated in the field'.

Topography and Fuels

Q25 Average SLOPE range over the area within 150 feet of the structure/dwelling:

0) Less than 8% (less than 4.6^{o})
1) Between 8% and 20% (4.6^{o} to 11^{o})
2) Between 21% and 30% (12^{o} to 17^{o})
3) Between 31% and 50% (18^{o} to 27^{o})
4) Between 51% and 75% (28^{o} to 37^{o})
5) Greater than 75% (greater than 37^{o})

Purpose

To determine the slope class of the average slope percent within 150 feet of the structure/dwelling.

Critical Issues

The slope class data are not used in the calculation of the Wildfire Hazard Rating. Question #25 is a 'back-up' question for question #29 - the actual average slope percent measured using a GIS. If

digital elevation data are not available, or if a spatial analysis program is not available, then question #25 is used to estimate the actual average slope percent. If the data gathered in question #25 is to be used in place of question #29, then the maximum slope percent for a given slope class is used in the calculations in which question #29 data are used. For example, if the slope class recorded in the field is class_2 (between 8% and 20%, then the value of 20% is used as the average slope percent in place of the question #29 data. Alternatively, manual analysis of 1:24,000 7.5-minute USGS topographic map sheets for the area can be used to estimate the slope class information.

Intent

The highest (worst) response value for the site should be selected.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply.

Q26 Predominant ASPECT_CLASS of the area within 150 feet of the structure/dwelling:

0) Flat
1) NW to NE (i.e., NORTH)
2) SE to NE (i.e., EAST)
3) SW to NW (i.e., WEST)
4) SE to SW (i.e., SOUTH)

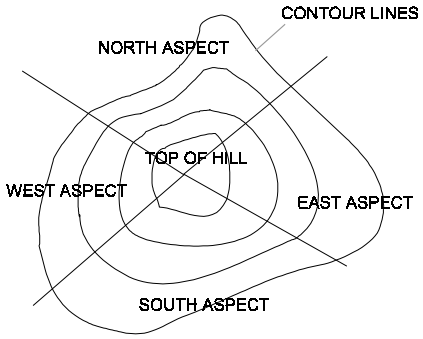

Figure 13: Topography – Orientation Aspect of Slope

Purpose

To determine the aspect class of the predominant slope direction within 150 feet of the structure/dwelling.

Critical Issues

The aspect class data can be determined from digital elevation data using the analysis capabilities of a GIS. If a GIS or digital elevation data are not available then the aspect class can be determined during the field visit to the site, or alternatively through manual analysis of 1:24,000 7.5 minute USGS topographic map sheets for the area.

Intent

The single most appropriate response value for the site should be selected.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply.

Q27 Average LOT SIZE:

1) More than 10 acres
2) Between 1 and 10 acres
3) Less than 1 acre

Purpose

To determine the average lot size within a 'neighborhood'.

Critical Issues

These data are not currently used in the calculation of the Wildfire Hazard Rating, but the information is gathered for potential future use. The information has relevance to possible an ignition hazard from an adjacent neighboring structure in the case of small lot sizes and high housing densities. The information is also relevant to the limits of mitigation that can be accomplished on a lot. If a lot is small, the amount of effective defensible space that can be developed without cooperation from neighboring parcels is limited due to the size of the lot.

Intent

The single most appropriate response value for the site should be selected.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply.

Q28 Predominant fuel model class over the area within 150 feet of the structure/dwelling:

0) No combustible vegetation
1) FM 1 - Grass

…

…

13) FM 13 - Heavy Slash.

Purpose

To determine the predominant fuel type classification for an area surrounding a structure/dwelling with a radius extending to approximately 150 feet around the structure.

Critical Issues

The fuel type class assigned with this question is one of the 13 standard fuel models (plus 0 for No Fuel) used within the **BEHAVE** fire behavior model (Andrews, 1986; Andrews and Morris, 1986; Rothermel, 1983; Albini, 1976; Rothermel, 1972). It will be combined with the slope percent and aspect class information for input into **BEHAVE** using a reference temperature, relative humidity, and wind scenario. It is intended that the fuel type information for a district will be gained by a separate field effort by a person experienced in the mapping and determination of fuel type.

Intent

The single most appropriate response value for the site should be selected.

Variant Situations

Since the possible response choices for this question are mutually exclusive, multiple responses should not apply.

Q29 Average Actual SLOPE percent over the area within 150 feet of the structure/dwelling:

Purpose

To measure the actual, average slope percent (i.e., the tangent of the slope angle times 100) for a 150 feet (approximate) radius area surrounding a structure/dwelling.

Critical Issues

The 'scale' of focus for this question is not restricted to just the individual structure but includes an area around the structure out to about a radius of 150 feet. The reason for the 'broader scale' focus is that the fire behavior model, **BEHAVE,** characterizes an approaching fire at the broader scale.

In order to measure the average slope percent for an area using a GIS, it is necessary to have digital elevation information with a spatial resolution of 30 meters (98 feet) or less. In addition, in order to measure the average slope percent for an area focused upon the structure, it is necessary to have the digitized structure/dwelling pad locations within the spatial database. If structure pad locations are not available within the database, then an alternative procedure can be used to estimate the average slope percent around the structure. The alternative procedure measures the average slope percent over the area bounded by the boundary of the lot. This alternative procedure could lead to a significant over or under estimation of the average slope for the 150-foot area around the structure if the lot is particularly large or small. In addition, if structures/dwellings are located nearer than 150 feet of the lot boundary, information about the slope on the adjoining lot area that is within 150 feet of the structure/dwelling is not being used as is preferable. Output from the GIS analysis for this question should be in the form of an integer value.

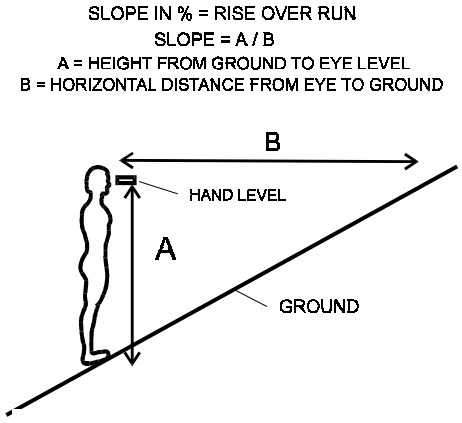

Figure 15: Determining Slope with a Hand Level

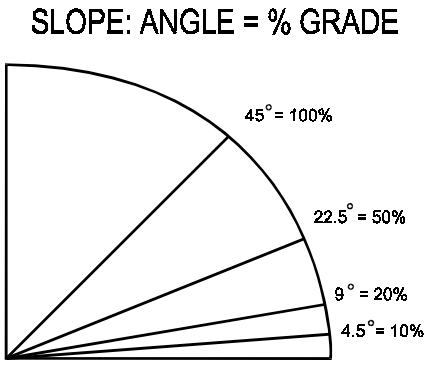

Figure 14: Relationship between Slope in Degrees and Slope in Percent

The appropriate formulation for slope percent is:

Slope_Percent = ROUND (TANGENT (Slope_angle) * 100, 0), or alternatively

Slope_Percent = ROUND (Rise/Run * 100, 0)

where

Slope_Angle = the angle of the average slope within the area

Rise = the Vertical (elevation) distance difference between two points,

Run = the Horizontal distance between the same two points,

ROUND = a function that rounds the value of the first argument, to the number of decimal places specified in the second argument. In this case, rounds to 0 decimal places, since we want the output to be an integer value.

Intent

Calculated directly within a GIS or other spatial analysis program.

Variant Situations

None.

Appendix B: FUEL MODELS FOR COLORADO

- A GUIDE FOR THE HOMEOWNER

Rich Gray[10]
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Introduction

The purpose of this guide is to identify and describe fuel types specific to the Northern Front Range of Colorado, and to associate them with the 13 standard fuel models described by the National Wildfire Coordinating Group (NWCG). Of the 13 standard NWCG fuel models, 8 are represented in the Front Range of Colorado. The frequency of occurrence of the 8 represented models varies and can range from slightly represented to common throughout an area. In many cases, the less common fuel models may be represented as a sub-unit within a more common extensively occurring fuel model.

The following guide contains a general background description of fire behavior, a fuel model key, and description page for each fuel model. Each fuel model description page contains a section on the descriptive characteristics of the fuel model, a description of specific vegetation types found within the fuel model type, a description of expected fire behavior within the fuel model type, and visual references. Using this guide, a homeowner can determine the fuel model that represents the vegetation environment of their home site, and make an educated assessment of how a wildfire will affect the area.

Fire Behavior

This section examines several factors that influence the way a fire burns or behaves over a given area. Three factors that have the greatest influence on fire behavior are weather, topography and fuel type. Each of these factors has several variables, which in turn has an effect on fire behavior.

Weather

Weather conditions greatly affect wildland fires. In many cases the effects of weather will determine if a fire has the potential to ignite and spread. Because weather is a long-term factor, its effects can be compounded over time. An example of this would be short and long term droughts. Weather on a day-to-day basis also greatly affects behavior. Winds, temperature and relative humidity all have a significant effect on wildfire. The following describes the effect different weather elements can have on fire behavior.

Wind

The speed and direction of wind greatly affects a fire's rate and direction of spread. With increased wind speed, fire spreads at a greater rate and burns with much higher intensity. The direction of spread is also dependent on wind direction.

Relative Humidity

Humidity affects a fire in several ways. Low humidity results in drier fuel and lower moisture content in the air. Such a situation leads to a greater probability of ignitions and allows fires to spread faster and burn with greater intensity.

Temperature

Temperature also has an effect on fires, but not to the extent that wind and humidity do. Higher temperatures can dry out fuels more quickly and in turn can cause greater fire intensity.

Topography

Topography is a major contributor to fire behavior and influences fire behavior in several ways. The topography of an area will determine the direction and rate of spread, as well as influence the overall fire intensity.

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[10] Formerly with the Colorado State Forest Service, Boulder Ranger District

Slope

As the amount of slope or steepness of an area increases the intensity of the fire increases. Fires burning up-slope spread at a much faster rate than fires burning down-slope or on level terrain. Steep narrow gullies or "chimneys" compound the effect of slope by funneling wind, heat, and fire up the slope. This funneling effect pre-heats and dries fuel in front of an approaching fire, making the fuels ignite more easily and burn with greater intensities.

Aspect

The direction a slope faces also affects fire behavior. The aspect of a slope determines the type of fuel that exists, the amount of moisture in the soil and vegetation on that slope, and to some extent certain weather patterns such as humidity and temperature. South facing slopes are generally drier and warmer, and have lower humidity. Fuels tend to be more volatile to some extent. North slopes are more moist and cooler, and have higher humidity. Fuels tend to be somewhat less volatile than those on south-facing slopes. Fires burning on south-facing slopes will tend to be more intense than those on north-facing slopes.

Fuel Type

Fuels greatly affect fire behavior. The type and density of vegetation, the amount of dead vegetation present, the presence of ladder fuels, and the arrangement and continuity of all fuel components relates directly to the rate of fire spread and fire intensity.

Vegetation

Different types of vegetation burn in different ways. Fires ignite and burn through grasses quickly, but with low intensity. In brush and timber, fires do not ignite as readily, but they burn with much greater intensity. Different species of shrubs and trees can also burn with varying intensity. The density of vegetation affects wildfire. In general, the more dense the vegetation the greater the rate of spread and the greater the intensity of the fire.

Dead Fuels

Areas with large amounts of dead or cured fuels will burn with greater intensity and the fire will spread more rapidly.

Ladder Fuels

Ladder fuel is vegetation or other burnable material that leads vertically from the surface fuel up into the crown of trees. The presence of ladder fuels is dangerous because it allows fire to spread to the crowns of trees and thus increase the risk of a crown fire. If this occurs, rates of spread and fire intensity are greatly increased.

Fuel Arrangement

This factor has a key influence on fire behavior. If fuels are continuous, the fire will spread uninterrupted. Continuous fuels also increase a fire's rate of spread. Areas that have several layers of fuels also burn with more intensity. An example of this would be areas that have surface fuels such as pine needles, grasses, and limbs, with mid-level "ladder" fuels; and an upper level of fuels such as tree crowns. When all of these levels of fuels become involved in flame, fire behavior can be very erratic and intense.

Fire behavior is a function of a fire's overall intensity, rate of spread, and direction of spread. Three major factors in the equation are weather, topography, and fuel. Weather is a variable we cannot control. Topography can be controlled to some extent by informed selection of a building site. Fuels on the other hand can be manipulated in many ways in order to change fire behavior. By modifying fuels around the home site, the overall fire behavior response is changed, thereby making the site more fire-safe. This is the principle underlying the recommendation to create defensible space around home sites.

How To Use This Guide

The first step in using this guide is to conduct an on-site visit to the home site. During this inspection, examine the fuels and topographic features that will most affect the site in the event of a wildfire. Examples of critical features or elements of the site are areas down slope of the building site, draws or "chimneys" leading to the building location, and an area of approximately 200 feet around the home. Review the pertinent sections above, and note the type of vegetation i.e., tree species, shrubs, and grasses. Determine the relative thickness of the vegetation. Look at the amount of forest litter, i.e., needles, small twigs and larger limbs. After making a visual assessment of the fuel conditions, go to the fuel-model key and "key out" your fuel model. Examine the corresponding fuel model description sheet to determine if that model is, in fact, the fuel model most affecting the home.

Fuel Model Key

I. The site is open to mostly open with grasses and/or open grown trees. Should a fire occur, the primary carrier would be grasses.

A. Grass has a relatively fine structure, is generally below knee level, and is easy to walk through. Trees and shrubs may or may not be present and are widely scattered **MODEL 1**

B. Trees are open grown. The understory is grass, forest litter, or both. There are few understory trees or shrubs. **MODEL 2**

II. The site has a large amount of brush, or very dense small trees. Should a fire occur, the primary carrier would be surface fuels, or tree crowns.

A. The area is heavily forested with small diameter trees that are relatively short 15 feet or less. This would include areas of thick regeneration. There is a large amount of dead lower limbs on trees. Understory has forest litter and may contain grasses. **MODEL 4**

B. The area is a low brush type. Shrubs are generally short 3 - 5 feet. Shrubs are deciduous and may or may not retain cured leaves. Grasses are usually present in the understory. **MODEL 5**

III. The site is forested with trees being of various sizes from small to large. Tree density ranges from partially open to thick closed stands.

A. The area has a closed canopy of pine, mainly Lodgepole. There is little understory growth, and amounts of forest litter are low. **MODEL 8**

B. The area has a closed canopy stand of pine or mixed conifer. Several size and age classes are represented. An understory is present and includes small trees, grasses and shrubs. Higher amounts of needle and woody litter may be present. **MODEL 9**

C. The area has a closed canopy of Douglas-fir, pine or mixed conifer. There is a greater density of understory vegetation, as well as higher amounts of forest litter and large dead material. Tree densities and fuel loadings are greater than in Model 9 **MODEL 10**

IV. The site is forested. The stand has been severely damaged by insects or disease and there is a large amount of standing and down, dead material.

A. The area has a high amount of dead trees. This model is best represented by beetle or budworm killed stands of pine or Douglas-fir. There are large amounts of dead, downed fuels. This includes small limbs as well as large diameter branches and trees. There may be a large component of dead standing timber. Understory will include grasses as well as light to moderate amounts of regeneration. **MODEL 11**

Fuel Model Descriptions

Fuel Model 1

Characteristics

This type consists of short grasses one foot tall or less. The area has very few shrubs or trees, any that are present are widely scattered. This type occurs on the plains, the first hogbacks of the foothills and mountain meadows.

Common Types/Species

Included in this fuel type are: prairie and mountain grasses, shrubs such as Currant, Buckbrush, Bitterbrush and Mountain Mahogany, and trees such as Ponderosa pine.

Fire Behavior

Surface fires that spread rapidly. Fire is carried by the fine herbaceous fuels that are cured or nearly cured.

Photo by R. Gray

Figure 16: Fuel Model 1 - Grass

Photo by R. Gray

Figure 17: Fuel Model 1 - Grass

Fuel Model 2

Characteristics

This type consists of open grown pine stands. Trees are widely spaced with few understory shrubs or regeneration. Ground cover consists of mountain grasses/and or needles and small woody litter. This model occurs in open-grown and mature Ponderosa pine stands in the foothill to montane zone.

Common Types/Species

The predominate tree species is Ponderosa pine. This type may include some scattered Douglas-fir. Other tree and shrub species include Common and Rocky Mountain Juniper, Buckbrush, Bitter brush, and Mountain Mahogany. Mountain grasses are included in this model.

Fire Behavior

Surface fires that spread easily. Clumps of fuel may generate higher fire intensities. Fire is carried by grasses and/or woody litter.

Photo by R. Gray

Figure 18: Fuel Model 2 – Grass with Downed Stemwood

Photo by R. Gray

Figure 19: Fuel Model 2 – Grass with Downed Stemwood

Fuel Model 4

Characteristics

This model is best described by thick stands of "dog-haired" Ponderosa or Lodgepole pine. This model consists of stands of small diameter trees with continuous closed crowns. There may be high amounts of small dead limbs retained on the lower portion of trees. There may also be high amounts of woody and needle litter associated with the stand. This model occurs in areas of thick continuous regeneration or in dense suppressed stands, in the montane zone.

Common Types/Species

Trees that are most associated with this model are Ponderosa and Lodgepole pine. There may be shrubs such as Common Juniper present in this model.

Fire Behavior

High rates of spread can be experienced in this model. Fire is carried through the foliage as well as the fine live and dead woody material of tree crowns. Fire spread is also enhanced by the amount of dead woody material on the ground.

Photo by R. Gray

Figure 20: Fuel Model 4

Photo by R. Gray

Figure 21: Fuel Model 4

Fuel Model 5

Characteristics

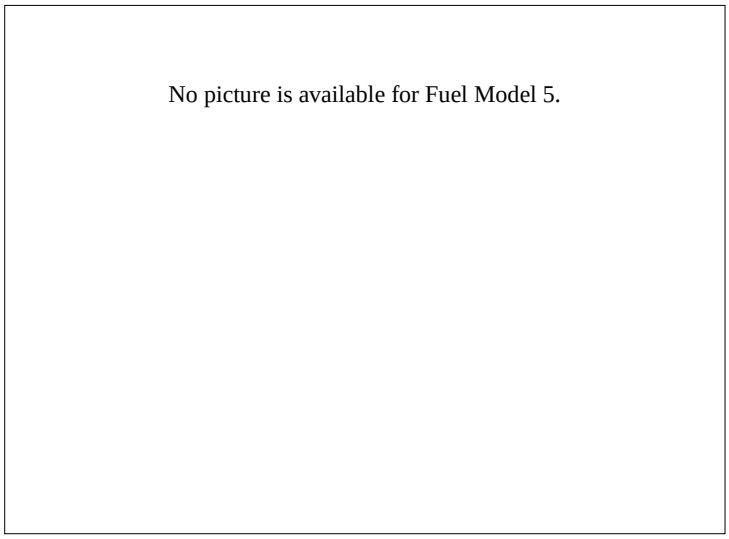
This model consists of continuous stands of low brush. Generally, heights do not exceed six feet. The stands will have a grass or scattered grass understory. Widely scattered Ponderosa pine may be present. This model occurs in draws and south slopes along the foothills and lower montane zone.

Common Types/Species

This type includes mountain shrub communities such as, currant, Bitterbrush, Buckbrush, and mountain mahogany. mountain grasses are also associated with this type.

Fire Behavior

Fires are generally low intensity. Fire is carried in the surface fuels that are made up of grasses and leaf litter. Cured leaves retained on shrubs can cause greater intensities.



Fuel Model 8

Characteristics
This model is represented by closed canopy stands of Lodgepole or Ponderosa pine with little under growth. Amounts of needle and woody litter are also low. This model occurs at higher elevations in the montane zone.

Common Types/Species
This model is most often represented by Lodgepole pine. Ponderosa pine can be included. There are little or no understory plants.

Fire Behavior
These are slow burning low intensity fires burning in surface fuels. Fuels are mainly needle and woody litter. Heavier fuel loadings can cause flare-ups. These have the potential to develop crown fires in extreme burning conditions.

Figure 22: Fuel Model 8 USDA Forest Service Photo

Figure 23: Fuel Model 8 Photo by R. Gray

Fuel Model 9

Characteristics

This stand is represented by closed canopy stands of Ponderosa pine and mixed conifer. Understory may consist of small trees and shrubs, grasses, and moderate concentrations of down, dead woody litter. High amounts of needle litter may be present. This model can exist from foothills to subalpine.

Common Types/Species

This model can include Ponderosa pine, Lodgepole pine, and a mixture of Douglas-fir spruce and pine. Some mountain shrubs and grasses are present.

Fire Behavior

Fires run through surface litter, torching of individual trees is possible. Under high burning conditions, crown fires can be encountered.

Photo by R. Gray

Figure 25: Fuel Model 9

Photo by R. Gray

Figure 24: Fuel Model 9

Fuel Model 10

Characteristics

This model is represented by dense stands of over-mature Ponderosa pine, Lodgepole pine, mixed conifer and continuous stands of Douglas-fir. In all stand types, heavy down material is present. There is also a large amount of dead, down woody fuels. Reproduction may be present, acting as ladder fuels. This model includes stands of budworm killed Douglas-fir, closed stands of Ponderosa pine with large amounts of ladder and surface fuels. Stands of Lodgepole pine with heavy loadings of downed trees. This model can occur from the foothills through the subalpine zone.

Common Types/Species

All types of vegetation can occur in this model, but primary species are, Douglas-fir, Ponderosa pine, and Lodgepole pine.

Fire Behavior

Fire intensities can be moderate to extreme. Fire moves through dead, down woody material. Torching and spotting are more frequent. Crown fires are quite possible.

Photo by R. Gray

Figure 26: Fuel Model 10

Photo by R. Gray

Figure 27: Fuel Model 10

Fuel Model 11

Characteristics

This model occurs in areas of heavy surface fuel loadings. This model best fits where a stand has high concentrations of down, woody material. Generally, Douglas-fir stands that have been killed by budworm and beetle killed stands are represented. These stands have a greater build-up of fuels than does model 10.

Common Types/Species

Budworm and beetle killed stands of Douglas-fir and pine.

Fire Behavior

Rapidly spreading fire with high intensities where fuels are continuous. Firebrands and spotting can occur.

Photo by R. Gray

Figure 28: Fuel Model 11

Photo by R. Gray

Figure 29: Enlarged Section of Figure 28.

Appendix C: FOREST FIRE BEHAVIOR IN FOUR MILE CANYON[11]

Margaret Hansen, Chief, Four Mile Fire Department offers a primer on fire behavior[12]

Chief Margaret Hansen
Chief, Four Mile Fire Department

Forest Fire Behavior Is Determined By A Combination of Factors: Weather, Terrain, And Vegetation.

The only factor we can modify is the vegetation - what the fire sees as fuel. That is why creating defensible space around your house is so important. An understanding of how weather and terrain affect fire behavior can help you locate the safest escape routes for your family.

Weather Is the Primary Determinant of Forest Fire Behavior in Our Area.

Hot, dry weather, and the accompanying, low humidity - our typical weather from midsummer through early fall - make ideal conditions for the fast spread of a forest fire.

Wind is usually the most important factor in fire behavior. Our local winds are often strong enough to push the fire downwind regardless of the other factors. A large fire creates its own wind which reinforces its movement uphill. Wind also carries burning embers (pine cones and small branches) long distances. These embers start spot fires when they land in the dry forest. We have found embers half a mile from the main fire on several occasions; hot embers a mile away are not uncommon.

Terrain Magnifies the Effects of Weather.

Sloping ground increases fire spread. Because hot air rises, the fire heats the fuels above it. The steeper the slope, the drier the fuels in front of the fire, so the faster the fire moves.

The direction the ground slopes is also important. Slopes facing southeast through southwest are driest because they receive the most sun. It is easiest for fires to start here and the fire spreads more rapidly here.

Gulches, even shallow gullies, concentrate wind and heat in them. Fire spreads more quickly up a gully.

Vegetation Is the Fuel for the Fire.

The primary way to stop a forest fire is to remove fuel so that the fire has nothing to burn. This is called "cutting a fire line." Water slows down the fire, giving us time to cut the line.

The purpose of defensible space around your house is to remove fuel before the fire reaches your house. It gives us two possible ways to save your house: One is to cut a quick line between your house and the fire. The other is to spray enough water on your house so that it is too wet to burn when the fire reaches it.

Fuels burn in a forest fire the same as they do in your wood stove or fireplace. Little pieces are easier to ignite than big ones. If the kindling burns long enough and hot enough, it will ignite bigger pieces. This is why the enclosed Forest Service brochure is so concerned about ladder fuels and pruning off lower tree branches. The needles and twigs of a pine tree are easier to ignite than the trunk. If the fire cannot reach the parts of the tree it can burn, it will burn more slowly and stay on the ground.

The Fire Resistance of Native Trees and Bushes Varies.

Mountain Mahogany is the only local species of bush that is fire resistant, and the resistance is only in its live branches. Most Mahogany bushes include a lot of dead branches which burn rapidly.

Cottonwood and aspen trees only grow in wet locations. They hold a lot of moisture so they are difficult to ignite.

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[11] Reprinted with permission from the Four Mile Fire Protection District Newsletter, Winter, 1997

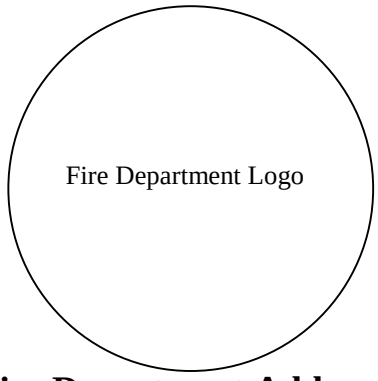
[12] Editor's comment: This article is included in the WHIMS manual because it describes critical wildfire issues of concern in a concise and effective format.

The bark of Ponderosa pine becomes a good insulator from fire as it thickens. Its sap is very volatile, so the needles burn easily. As its lower branches die and break off it becomes more fire resistant.

Douglas Fir has finer twigs and needles than Ponderosa as well as more low branches, so it is a better fire carrier.

Junipers look like fireworks in a forest fire. They have lots of dead wood, twigs, needles, and volatile oils. Since they will grow in the shade, they are often at the base of larger trees making them ideal fire ladders. If you prune Junipers up 10 feet, they are a 'pompom on a stick.' The only fire-safe location for a juniper is as a single tree in an open area.

Appendix D: SAMPLE COVER LETTER TO HOMEOWNERS



<Fire Department Address>

BOULDER, CO <zip code>

<Date>

Dear <Fire Department Name> Resident:

The <Name> Fire Department, under the supervision of the Board of Directors and Fire Chief <Chief's Name>, will be conducting a Wildfire Hazard Survey of the homes and property within the Fire District beginning next month. 'The <Fire Department Name> Volunteer Fire Fighters would like to visit your property so that they may survey any conditions which could contribute to wildfire hazards.

This Wildfire Hazard Survey is a visual inspection using, a format designed by the Boulder County Wildfire Mitigation Group and its working group called WHIMS (Wildfire Hazards Identification & Mitigation System). Both of these groups consist of representatives from a variety of agencies: Colorado State Forest Service, Boulder County Sheriffs Department, Boulder County Land Use Department, U.S. Forest Service, various fire protection districts, and others.

The Board of County Commissioners created the Boulder County Wildfire Mitigation Group immediately after the Black Tiger Fire of 1989 with the mission to mitigate wildfire hazards. The Board supports this study of wildfire hazards in order to determine ways in which County residents may reduce the dangers and losses resulting from another wildfire.

The <Fire Department Name> District will be the <number> area in the County to be evaluated for wildfire hazards (Pine Brook Hills FPD; Four Mile FPD; High Country FPD; and, Boulder Heights FPD). The survey will identify areas in need of mitigation from the danger of wildfires and suggest ways to reduce that danger. Such conditions that would be of concern include vegetative/fuel conditions conducive to the ignition and spread of wildfires, water resources to fight the fires, and road conditions. A copy of the survey is included with this letter so that you may get a preview of what the freighter will be looking at on the lot. **Please keep this copy (the survey) for your own use.**

Chief <Name> and <his or her> volunteer fire fighters will be approaching the residents within the <Fire Department Name> District beginning anytime after <date>. This will continue until all the surveys have been completed. They will be asking for your permission to be on the property. **Your participation is encouraged!** No entrance to your home or any other structure on your property is needed. Information pamphlets on living in an area with wildfire dangers will be distributed throughout the <Fire Department Name> area during this survey. This could be a good opportunity for you to get some of **your** fire-related questions answered.

If you would like more information on this survey of <Fire Department Name> or any of the wildfire mitigation efforts in Boulder County, please feel free to contact your fire chief, <Chief's Name> at <Fire Department Phone Number>; assistant chief, <Assistant Chief's Name> at <Phone Number>, Craig Jones

of the Colorado State Forest Service at 442-0428; or Gary Fager of the Boulder County Sheriff's Department Emergency Services Group at 441-3646. You may also contact Chris White or<Chief Building Department Official Name> of the Boulder County Land Use Department at (303) 441-3930.

Sincerely,

<Fire District Chief's Name>, Chief
<Fire Department name> FPD

<President's Name>, President
Board of Directors

<WHIMS Coordinator Name>
WHIMS Coordinator

Attachments:
Wildfire Hazard Survey
"Where to Get Information"
List of Publications & Videos
(2) Wildfire Brochures

Appendix E: EXAMPLE LICENSE AND EXCHANGE AGREEMENT FOR GEOGRAPHIC DATA

THIS AGREEMENT made and entered into this _____day of_____200_, by and between the County of Boulder, Colorado (County), and the _____ Fire Protection District, Colorado (District).

For and in consideration of the mutual covenants, promises, terms and conditions and other good and valuable consideration, the parties hereto agree hereby as follows:

1. Definitions. For purposes of this Agreement, unless the language or context clearly indicates that a different meaning is intended, the words, terms or phrases stated below shall be defined as follows:

"DATA" means those graphic or tabular data in digital electronic or digital optical format specified in Exhibit A. It excludes any computer programs or source codes, which intellectual properties are not covered by this agreement. DATA do not include the information contained in public records, which have been converted to digital format, but only their digital form.

"Donor" means the party, which created the DATA and is allowing the other party to use it.

"Parties" means the _____ Fire Protection District and the County of Boulder.

"Recipient" means the party to whom the Donor has given the Data.

"Hard copy" means a reproduction of the DATA in a visual format. including without limitation photographic, xerographic, blueprint, Mylar, diazo, printed, linedrawn, or any other representation which can be read by the eye.

"Soft copy" means a reproduction of the DATA in a digital electronic or digital optical format whether on tape, disc, by wire transfer, or in some other copy or transfer medium which preserves their digital character.

"Third party" means any legal person other than the _____ Fire Protection District or the County of Boulder.

2. Purpose. The purposes of this Agreement include defining the rights and obligations of the parties with respect to sharing of DATA between the parties, protecting the rights of the Donor in the DATA, controlling the reproduction of the DATA by the Recipient, the availability to third parties from the Recipient of copies of such shared DATA, and the control over further copying of such DATA through a cross-licensing system. The DATA were and are being developed with a significant expenditure of public funds, and the parties have an interest in preserving their opportunities to recoup some of their costs of developing and maintaining these DATA.

3. Term.

   A. The term of this Agreement shall be for ten years from the date of execution, but either party may cancel this Agreement upon six months written notice to the other party.

   B. Regardless of the date of execution hereunder, this Agreement shall be in effect with respect to any particular DATA from the date of receipt of the DATA by the Recipient from the Donor until the return or certified destruction of the DATA by the Recipient, unless earlier terminated by law or according to the terms herein.

   C. The terms of this Agreement shall apply to Recipient's receipt of the DATA or any portion thereof, whether prior to, concurrent with or subsequent to the date of execution. Portions of the DATA received after execution of this Agreement shall be covered the same as if originally included herein.

4. Termination.

   A. Upon termination of this Agreement, Recipient shall, within five days, return all soft copies of the DATA, with any additions and modifications, to Donor and shall certify, in writing, that all other soft copies thereof have been destroyed.

B. Recipient's obligations respecting confidentiality of the DATA shall survive termination of this Agreement.

5. Layers. Recipient will keep Donor's DATA in one or more discrete and separate layers readily identifiable as Donor's DATA and protected from unauthorized access, tampering, or copying in soft copy format, and will not store it, other than temporarily for purposes of manipulation or printing, merged with other electronic data. Recipient will use its best efforts to keep and maintain the DATA in a secure manner so as to preclude unauthorized use, dissemination or disclosure.

6. Ownership. The DATA is the property of Donor, and Donor reserves all rights of ownership, title and control to the DATA under common law, federal copyright law or other law relating to confidential and/or trade secret information. The parties agree that the development of the DATA required the skilled efforts of professionals in its design and compilation and the end product is the result of the original work of Donor, its employees and agents. Pursuant to Colorado law, the DATA is a trade secret of Donor and may only be used as authorized herein.

7. Obligation of Confidentiality. Recipient acknowledges and agrees that Donor reserves all rights of ownership, title and control of the DATA. Recipient agrees that it will treat the DATA as confidential and trade secret information. Except as authorized in this Agreement, Recipient shall not under any circumstances disclose or disseminate the DATA or any portion thereof to 1) any other (including governmental, educational or non-profit) person, firm or entity or organization, or 2) any employee of Recipient who does not need access thereto in connection with Recipient's exercise of its rights under this Agreement.

8. Assistance. At the request of the Donor, Recipient shall use good faith and reasonable efforts to assist the Donor in identifying any use, copying, or disclosure of the DATA by any current or former Recipient personnel - or anyone else who may have come in possession of the DATA while the same was in Recipient’s possession - in any manner that is contrary to the provisions of this Agreement so long as the Donor shall have provided Recipient with information reasonably justifying the conclusion of the Donor that such contrary use may have occurred.

9. Injunctive Relief. Recipient acknowledges and agrees that disclosure or use of the DATA in breach of this Agreement could cause irreparable harm and significant injury to Donor, which maybe difficult to measure with certainly or to compensate through damages. Accordingly, Recipient agrees that Donor may seek and obtain against Recipient and any other person or entity, injunctive relief for the breach or threatened breach of any of the terms and conditions of this Agreement, in addition to any other equitable or legal remedies which may be available to Donor.

10. License. The Donor hereby grants to Recipient a non-exclusive, non-transferable license to the DATA to be used strictly and only in accordance with the provisions stated in this Agreement.

A. Recipient shall only use the DATA for purposes in connection with its own projects and developments and not on behalf of any other person, corporation or entity of any nature whatsoever.

B. Recipient shall keep a record of the location of each soft copy.

C. Recipient may not use, copy, modify assign or transfer the DATA or any copy, modification or merged portion thereof, in whole or in part, in soft copy format except as provided for in this Agreement. Unless done in conformity with the following subparagraph, if Recipient transfers possession of any soft copy, modification, or merged portion of the DATA to a third party, the rights granted under the terms of this Agreement are automatically terminated as to Recipient.

D. Recipient may make soft copies for the use of its contractors and consultants only if the contractor or consultant signs an agreement, in a form acceptable to Donor, with Recipient for the benefit of Donor which fully protects Donor's rights under this agreement and limits the contractor's or consultant's use of the DATA as if the contractor or consultant were merely an extension of Recipient. Copies of all such protective agreements shall be filed by Recipient with Donor before the effective date of such protective agreement.

E. Recipient shall not, in whole or in part, assign, sublease, extend, absorb or otherwise transfer this License Agreement, or any right granted under this Agreement.

F. This license gives Recipient the right to give or sell hard copies of the Donor's DATA to third parties, whether pursuant to a request under the Public Records laws of the State of Colorado or otherwise, but subject to the requirements of this Agreement concerning inclusion of copyright and disclaimer notices on all such hard copies.

11. Copyright notice. Recipient shall attach the following notice on all copies of the DATA in such a manner and location to give notice:

Copyright 199_ by (name of Donor), Colorado. All rights reserved. No part of this DATA may be copied, reproduced, or transmitted in any form or by any means whether graphic, electronic, or mechanical, including photocopying, recording, or by an information storage and retrieval system, without written permission from the (name of Donor), Colorado.

12. Disclaimer Notice. Recipient shall attach the following notice of disclaimer on all copies of the DATA in such a manner and location to give notice:

THE (DONOR) IS FURNISHING THE DATA ON AN "AS IS" BASIS, WITHOUTANY SUPPORT WHATSOEVER, AND WITHOUT REPRESENTATION OR WARRANTY, INCLUDING BUT NOT IN ANY MANNER LIMITED TO, FITNESS, MERCHANTABILITY, OR THE ACCURACY AND COMPLETENESS OF THE DATA.

13. Fees. Recipient may sell hard copies of the Donor's DATA, whether or not merged with other data of Recipient, at whatever price it chooses. Since Recipient may not sell soft copies of the Donor's DATA, this Agreement makes no provision for a fee for soft copy.

14. Disclaimer.

A. All other terms of this License Agreement to the contrary not withstanding, Donor disclaims any and all liability of any nature whatsoever arising out of the terms and conditions, operation of this License Agreement, and/or the use of, or reliance on by Recipient of the DATA. Recipient acknowledges and specifically agrees to the terms of this provision. Further, Recipient agrees not to attempt to or seek to, directly or indirectly, claim or pursue legal relief for any claims of any nature whatsoever against Donor pursuant to this License Agreement; or to assist any other parties in claiming or pursuing legal relief for any claims of any nature whatsoever against Donor pursuant or relating to this License Agreement.

B. **THE DONOR IS FURNISHING THE DATA ON AN "AS IS" BASIS, WITHOUT ANY SUPPORT WHATSOEVER, AND WITHOUT REPRESENTATION OR WARRANT'F, INCLUDING BUT NOT IN ANY MANNER LIMITED TO, FITNESS, MERCHANTABILITY, OR THE ACCURACY AND COMPLETENESS OF THE DATA.**

C. The DATA is neither a legally recorded map or a survey and is not intended to be used as such. The DATA is a unique compilation of records, information and data from various city, county, state, and federal offices and other sources and should be used for reference only. No representation is made that features presented, accurately reflect true location. Donor or any other entity from whom data was obtained assume no liability for any errors or omissions herein. If discrepancies are found, Recipient agrees to contact Donor.

Because the DATA are inherently complex, constantly changing, and may not be completely free of errors, Recipient is hereby advised to verify its work. In no event shall Donor be liable for any direct, indirect, special, incidental, or consequential damages arising out of the use of or inability to use the DATA even if advised of the possibility of such damages. Specifically, Donor is not responsible for any costs including, but not limited to, those incurred as result of lost revenues, loss of use of data, the costs of recovering such programs or data, the cost of any substitute program, claims by third parties, or for similar costs.

D. Donor's sole liability and Recipient's exclusive remedy for any substantial defect which impairs the use of the DATA for the purpose stated herein shall be the right to terminate this Agreement.

15. Colorado Law to Govern. This Agreement shall be governed by and construed in accordance with the substantive and procedural laws of the State of Colorado. Venue for all trial court proceedings related to this Agreement shall be in Boulder County, Colorado.

16. Independent Status. It is agreed that nothing herein contained is intended or should be construed in any manner as creating or establishing the relationship of agents, partners, joint venturer or associates between the parties hereto or as constituting Recipient as the employee of Donor for any purpose or in any manner whatsoever.

17. Rights Cumulative. All remedies available to either party under the terms of this Agreement or by law are cumulative and may be exercised concurrently or separately, and the exercise of any one remedy shall not be deemed an election of such remedy to the exclusion of other remedies.

18. No-Continuing Waiver. The waiver of any default by either party, or the failure to give notice of any default, shall not constitute a waiver of any subsequent default or be deemed to be a failure to give notice with respect to any subsequent default. Waiver of the breach of any provision of this Agreement shall not be construed to be modification of the terms of this Agreement unless stated to be such in writing and signed by authorized representatives of the Donor and Recipient.

19. Notices. At the time of execution of this Agreement, the parties hereto shall provide each other written information regarding their respective authorized representative and the respective addresses for purposes of any notices. Said information shall be kept current at all times.

20. Modifications. Any alterations, variations, modifications, or waivers of the provisions of this Agreement shall only be valid when they have been reduced to writing, and signed by authorized representatives of the Donor and Recipient.

21. No-Third Party Beneficiary. This agreement is for the benefit of the parties only, and conveys no rights upon persons not parties to it.

22. Indemnification. The Recipient shall be solely responsible for all damages to persons or property which may in whole or in part be caused by the Recipients or its agents or employees, or which may result or arise in whole or in part from their use or the Data hereunder, and shall indemnify and hold harmless the County, its elected and appointed officials, and its employees, agents and representatives, from any and all liability, damage, loss, cost or expense, including but not limited to attorney's fees which the County, its elected and appointed officials, and its employees, agents and representatives may suffer as a result of any or all claims, demands, actions, costs or judgments made or brought against them by any person or entity, and which arise either in whole or in part from use of this DATA by Recipient under this agreement. By demanding this right to indemnification, the County, in no way waives or intends to waive the limitations on liability which are provided to the County and its employees under Colorado Governmental immunity Act §C.R.S. 24-10-101. et seq., as amended.

IN WITNESS WHEREOF, the parties have executed this Agreement effective the date and year first above written.

COUNT'Y'OF BOULDER. COLORADO

_____.
Authorized Signature

_____.
Title

_____.
Date

_____ FIRE PROTECTIONDISTRICT

_____.
Authorized Signature

_____.
Board President

_____.
Date

Attest: _____.
Board Secretary

_____.
Date

Exhibit A.

Data Data provided in electronic format shall be as follows, but other data not listed may be exchanged under this Agreement provided both parties agree in writing.

A. County Data The following data is owned by the County.

Control Data - The Control Survey Data is any land measurement data including but not limited to control survey data and subsequent adjustment, PLSS section structure survey data and subsequent adjustments, and section breakdowns as available.

Parcel Data - The Parcel Data represents property boundaries, street center lines, hydrographic features, and other elements which may have in the past been included as apart of the hard copy parcel maps of Boulder County.

Assessor Data - The Assessor Data represents data maintained by the County Assessor including all land and property improvement descriptions. This includes but may not be limited to legal property descriptions, owner's name, postal and mailing addresses, political and taxing jurisdictions, land and building class codes, land description and area, improvement descriptions, and assessed valuations.

Planning Data - The Planning Data is electronic geographic data that has been developed in support of the County's planning efforts including, but not limited to, land use, zoning, natural resources and political boundaries.

License and Permit Data - The License and Permit Data is data pertaining to building permits, land use approvals, rental licenses and various County Health Department permits.

Natural Resource Data - The Natural Resource Data is electronic geographic and tabular data concerning natural resources including surface water, groundwater, soils, geology, air, vegetation, and topography.

Building Data - The Building Data is data concerning County owned buildings.

Open Space Data - The Open Space Data is electronic geographic and other data that has been developed in support of the County's management of designated open space lands.

County Derivative Data - The Derivative Data is electronic data developed from sources of data including in this agreement.

B. District Data The following data are owned by the District.

Quality Control Data are data generated by the District to maintain, correct, supplement, augment, or otherwise update data received from the County. The County is especially interested in these data for maintaining the quality of its database.

Wildfire Hazard Data are data developed by the District in coordination with the Boulder County Wildfire Hazard Identification and Mitigation System (WHIMS). The County is especially interested in all updates, corrections, and other changes to these data made by the District based on their local knowledge and information. These data will be used by the County to keep the WHIMS current and consistent with the District.

Planning Data are electronic geographic and other data that have been developed in support of the District's planning efforts, including, but not limited to, service capacities, facility location, and financial plans.

Digital Photographic Data are aerial or other digital photography which the District may have acquired in the course of performance of its planning, engineering, or other programs.

Utility Data are electronic geographic and other data concerning the District's water, waste water, electric or other utility services provided by the District including pipes, cables, service points, valves, hydrants, and other utility infrastructure.

Service Data are electronic geographic, demographic and other data developed or collected by the District in the course of its operation. Service data may include flow, capacity, route, consumption, generation, saturation, or other data as applicable to the particular services provided by the District.

Building Data are data concerning District owned buildings.

District Derivative Data are electronic data developed or derived from other sources of data included in this agreement.

Appendix F: ELEMENTS OF MITIGATION

Peter D. Slack and Claire M. Hay
The Wildfire Interface Group

In general, mitigation actions can be described as those steps that "reduce the probability of occurrence of a hazard event, or those [steps] that reduce the impacts of hazard occurrence" (Petak, et. al., 1982). Within the WHIMS project, mitigation activities are focused upon both types of actions. Through fuel reduction and modification efforts, in general, the probability of occurrence of a wildfire is reduced. Through construction design and the use of appropriate building materials, and through the development of adequate defensible space around a structure, the impact of a wildfire is reduced.

Building Design and Materials

Building design refers to the shape, (e.g., cube, or sphere), and configuration, (e.g., intersection of two cubes, or intersection of a sloping plane with a cube), of the constituent elements of a structure. Building materials are the substances, e.g., wood planking, stone, cement, that make up the actual surfaces of the structure. Both building design and materials determine a structure's vulnerability to wildland fire. Building design affects a structure's vulnerability to wildland fire by the arrangement of the constituent components and shapes. The intersection of shapes and components of a structure create "nooks and crannies" that can trap and ensnare airborne burning embers and super heated gases. Building materials affect a structure's vulnerability to wildland fire by the combustibility of the exterior surface materials of a structure. Hot gases from a wildland fire impinge upon a structure in the path of the fire. The hot gases can raise the temperature of a structure's surface material close to their ignition temperature, making it easier for the material to ignite. The lower the ignition temperature of a material, the less time it takes to raise its temperature close to ignition. The entrapped burning embers serve as ignition sources for the heated materials so that the structure catches fire. The critical components, and potentially the most vulnerable elements of a structure, are the roof and roofing material, the window sizes, arrangement and material, siding materials, arrangement and design of eaves and overhangs, and the arrangement, materials and design of balconies and decks.

Roofs and Roofing Material

The most vulnerable component of a structure is its roof. The roof of a structure is subject to a 'rain' of burning embers during a wildfire. If the roof material has numerous "nooks and crannies", as is the case with shake shingle roofs, and/or, if the flammability of the material is high, the falling embers can quickly ignite a roof. When one-quarter or more of a roof is engaged in flame, the survivability of the structure is critically threatened. In fact, if fire fighters during their triage of structures determine that a structure's roof is already one-quarter or more involved with flame, then the structure is considered not savable. Resources are redirected to other structures that have a higher probability of being saved.

Modification of roofing materials has the greatest effect on reducing the wildfire hazard to a structure. From a limited number of structure survivability studies following serious wildfires (Foote, 1994,), it has been shown that there was a 90% survivability rate for structures with non-flammable roofs. Since roofs have a limited life span, they are periodically replaced on a moderately frequent (i.e., 20 to 30 years) basis. This periodic need for replacement means that over a period of time, individual homeowners at the unit level, and sub-divisions or developments at the community level, can significantly reduce their wildfire hazard by replacing roofs with non-flammable roofing materials. Replacing wood roofs with composite, metal, or tile roofs is the single most-effective mitigation action that a homeowner can take. Composite material, fire resistive roofs cost the same as wood roofs. Many artificial roofing materials are designed to look like natural-material roofs so that aesthetics is really not an issue any more.

Type of roofing material is one of the important pieces of data collected with the WHIMS questionnaire.

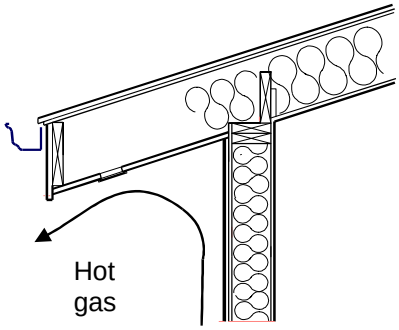
Windows

The second most vulnerable element of a structure is its windows. The amount of heat to which windows are subjected during a wildfire is high enough to break the windows and allow the penetration of hot gases and burning embers into the interior of a structure. During a wildland fire, once the interior of a structure becomes involved in flame, the structure is doomed. Fire fighters cannot safely enter a burning structure when a major wildfire is burning in the neighborhood. The fire fighters would be risking their life and safety. There would be no escape options either in the interior of the structure or in the exterior neighborhood of the structure.

Standard single- and double -pane plate glass windows are particularly vulnerable to breakage in the presence of high heat fluxes. The larger the window the more vulnerable it is. Tempered glass is much more resistive to breakage in the presence of high heat. Tempered glass is the glass used for fireplace doors.

Type and size of window data are not currently collected with the WHIMS questionnaire. Due to limitations on the time available for field data collection, window data could not be included in the current implementation of WHIMS. It is hoped that critical window information will be added in future expansions of the WHIMS data collection effort.

Eaves and Overhangs



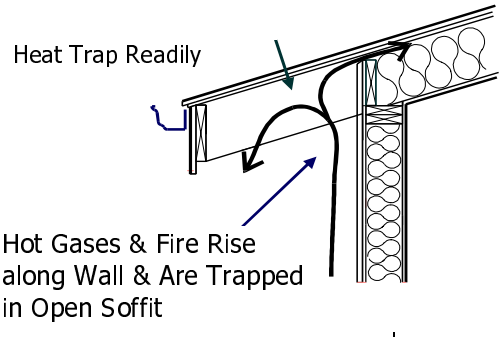


Figure 31: Enclosed Soffit

Figure 30: Open Soffit

Eaves and overhangs are one of the two most common forms of exterior heat traps for structures. Eaves and overhangs that are not boxed or enclosed can allow burning embers and hot gases to enter the spaces under the roof or elsewhere of a structure. The boxing or enclosing of eaves and overhangs can reduce the wildfire hazard to a structure by preventing the embers and gases from entering the void spaces of a structure.

Another possible avenue of entrance for hot gases and burning embers is through the soffit vents. In order to retard and inhibit burning embers from entering a structure through vents in eaves and overhang areas, all vents should be screened with non-flammable material i.e., metal, with a pore size no greater than 1/8th inch.

Certain standard designs for eaves and overhangs can trap hot gases and burning embers.

Eaves and overhangs enclosure data for a structure is collected with the WHIMS questionnaire. The screening of vents is not. However, in most new construction, it is a standard practice to screen vents.

Balconies and Decks

Balconies and decks are the second most common form of exterior heat traps for structures. Balconies and decks that are not boxed or enclosed can allow burning embers and hot gases to congregate and become trapped under the balconies and decks. This allows the hot gases to raise the temperature of the structure's siding to the ignition point, if the siding is made of combustible material. Any live hot embers then serve as direct ignition souses for combustible material under the balcony or deck, such as patio furniture, firewood, or debris. The boxing or enclosing of balconies and decks can reduce the wildfire hazard to a structure by preventing the embers and gases from entering the spaces under the decks, and, thus prevent the trapping of the hot gases and live embers next to combustible materials. Unlike eaves and overhangs, the cost and level of effort required to enclose and protect balconies and decks, is significantly higher.

Similarly to roofs, balconies and decks are also susceptible to direct ignition from infalling firebrands. Unless constructed of non-combustible materials or heavy log materials, balcony and decking are usually constructed of wooden materials 1-1/2" in size with spaces (i.e., air spaces) between the members. The spaces or gaps maintain a relatively high surface-to-volume ratio for the decking, making it more susceptible to ignition and continued burning.

The arrangement of balconies and decks on a structure in relation to specific topographic features near a structure is of critical importance. Locating a balcony or deck above or on a steep slope exacerbates the entrapment of the hot gases or embers. The location of fuels near or under a balcony or deck also increases the hazard relative to the balcony or deck. Enclosing of the area under a balcony or deck or at a minimum maintaining a non-combustible ground cover under the balcony or deck will heal reduce the hazard due to the balcony or deck.

Information on whether balconies and decks are enclosed on a structure is collected with the WHIMS questionnaire.

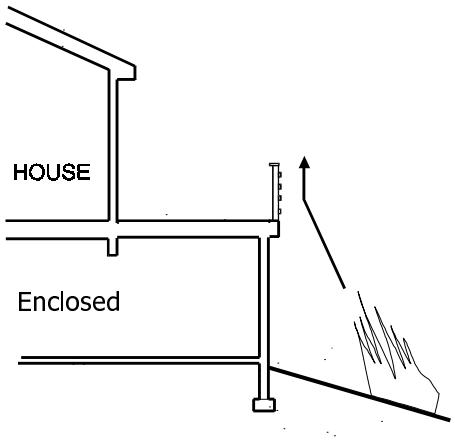


Figure 32: Enclosed Balcony and Deck

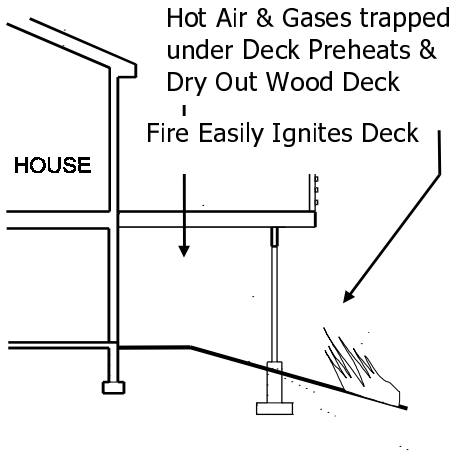


Figure 33: Unenclosed Balcony and Deck

Siding Material

The flammability of siding material is another important factor in a structure's vulnerability. Siding material has a longer life span than roofs, so it is not often replaced unless a major remodeling effort is undertaken. Replacing wood siding with non-combustible siding can be a costly affair. Most non-combustible siding material is more costly than standard wood siding.

The vulnerability of siding material can be easily mitigated, however, by removing combustible vegetation and other flammable materials from close proximity to the siding. Other flammable material would include firewood or yard prunings and waste stored next to or in close proximity to the structure.

Type of siding material and firewood storage location information is collected with the WHIMS questionnaire.

Fuels Modification and Reduction

Wildland fuels include dead vegetative material either collected on the ground or still affixed to trees, shrubs, and brush. Live vegetation, particularly under drought conditions, can also become a part of the active fuel complex. The structure and distribution of wildland fuels affects the rate of spread and the heat output from a wildfire. The density (i.e., distribution) of wildland fuels directly affects the intensity or heat produced by a wildland fire. Continuity of the fuels, both horizontally and vertically, is an important factor in the rate and ease of spread of a wildland fire. Horizontally continuous fuel situations provide direct, continuous routes for wildfire propagation. Vertically continuous fuel arrangements, e.g., dead limbs on a tree from the ground to the live canopy, can bring fire into the canopy of trees making the fire harder to control. In the case of structures, a tree with continuous dead branches from the ground to the roof of a structure can lead fire to that structure's roof.

Reducing the amount of vegetation, both live and dead, reduces the fuel available to the fire. Reducing the amount of fuel reduces the heat intensity produced by a wildfire. Fuel modification and reduction means developing a mosaic of patches of different fuel types and configurations. Some patches would contain heavier fuels such as trees and brush, while others patches would be contain finer fuels such as grasses and forbs, and still other patches may contain low or non-fuel areas such as rocky outcrops or soils. A wildland fire running through an area that has been modified as described-above moves more slowly and with less heat production. This allows fire fighters to more effectively confine, contain or control the fire.

Data on the distribution and structure of fuels near a structure is collected as part of the WHIMS questionnaire. Questions relating to vegetation density, the proximity of vegetation to roofs and stovepipes or fireplace chimneys, attempt to partially characterize a structure's wildfire hazard due to fuel characteristics near the structure.

Concepts of Defensible Space

There are two different concepts of defensible space that are often confused due to the usage of the same term, 'defensible space', for both concepts. The original defensible space concept refers to the creation of a 'relatively safe zone' in which fire fighters can safely operate in their defense of a structure. To defend a structure, fire fighters often need to use pieces of equipment such as chain saws to perform additional fuel reduction, or to apply foam or water to a structure and its surrounding vegetation that often involves needing to lay hose up to the structure. In other words, the original concept of defensible space involved the idea that a fire fighter would be present at the structure to perform active protection and suppression types of activities. In addition, in order to carry out those protection activities, a safety zone 'for the fire fighters' needed to exist around the structure.

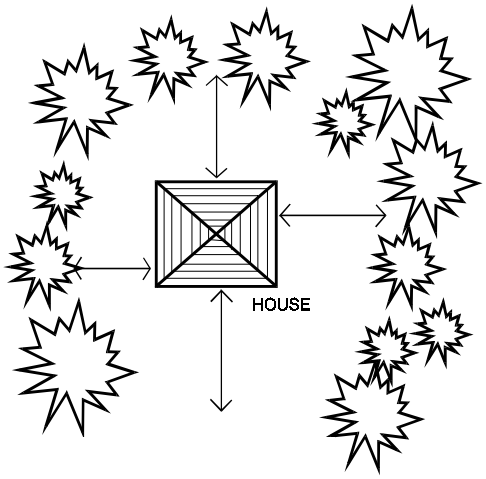


Figure 34: Defensible Space around a Structure

Under the newer concept of defensible space, the fuels modification and reduction principle is brought to the immediate area of the structure itself. The newer usage of the 'defensible space' term refers to the creation or existence of a fire behavior modification zone (FBMZ). If a structure is to survive a wildfire, it must have a degree of separation from the most intense heat outputs of a wildfire. Within a zone immediately surrounding a structure, the goal is to reduce the heat intensity of a wildfire and to break up the continuity of the fuel bed around a structure, so that a fire will not be lead directly to the structure. A fire fighter may not want to be in this zone when a fire passes. However, structures can tolerate much higher heat than the human body. It is possible through the creation of an adequate FBMZ to reduce the very high heat possible in a wildland fire to a lower level of heat intensity. The lower heat level may still not be safe for a human, but may be tolerable for a reasonably designed structure. Creation of an adequate FBMZ can be accomplished through appropriate fuel modification and reduction. With an adequate FBMZ, a structure will be able to survive the passage of a wildfire through its site.

To create an adequate FBMZ, fuels directly adjacent to the surfaces of a structure must be removed. In addition, it is desirable to break the direct path of the fire to the structure by creating a discontinuous distribution of fuels in the area immediately around the structure. Modification of the fuel surrounding a structure does not mean 'clear-cutting' all of the vegetation around a structure. In fact, clearance of all vegetation around a structure is not desirable. Some intervening vegetation within the FBMZ buffers the structure from the heat output of the fire. In addition, the intervening vegetation partially screens a structure from the flaming brand shower in front of a wind-driven wildfire.

Data on the quality of the 'defensible space' around a structure, both the original concept and the newer FBMZ concept, are collected as part of the WHIMS questionnaire. There is only one question relating to defensible space in the WHIMS questionnaire. The question asks the field volunteer to assess the defensible space around a structure and to determine adequacy of the space based upon an integrated evaluation of the site. Collection of information on the adequacy of defensible space needs to be expanded and improved from the current WHIMS implementation. Ideally, a structure's defensible space would be evaluated relative to the two operative concepts of defensible space separately. Further improvements in the collection of data on this aspect of a structure's wildfire hazard must await additional development in the concept of defensible space as a fuel behavior modification zone, and the availability of additional resources for field data collection.

Appendix G: FIRMIT FOLLOW_UP SURVEY RESULTS

Greg Toll
City of Boulder Fire Department

1. How safe do you feel from wildland fires?

Response Option	Number of Respondents	Percent of Respondents
Very Safe	18	27.7%
Somewhat Safe	39	60.0%
Neither Safe nor Unsafe	1	1.5%
Very Unsafe	7	10.8%
Total # of Responses	**65**	**100%**

The responses to this question are difficult to interpret. It is not clear what the response pattern to this question signifies. We had hoped to infer whether the City was doing a good job in educating the citizens relative to the threats of a wildland fire. However, in hindsight, this question was not adequately formulated to make that determination. Do the high frequency of responses in the *'very safe'* to *'somewhat safe'* categories indicate that the majority of respondents feel that the City's fire suppression ability is capable to the task of protecting the homes from a wildfire or does it mean that the homeowners in the interface don't feel there is a threat? This question could have been better formulated as two separate questions to better determine the desired information. For example: *Do you feel that the city and fire protection districts have adequate personnel and equipment to protect your home and neighborhood in the event of a wildland fire?* And, *given where your home is situated, do you feel safe relative to the threat of a wildland fire?*

2. Were you aware of the City of Boulder's Wildland Fire Hazard Identification and Mitigation efforts in your neighborhood?

Response Option	Number of Respondents	Percent of Respondents
Yes	62	66.7%
No	31	33.3%
Total # of Responses	**93**	**100%**

To help people looking at these results a brief detail on the process used to inform the homeowners of this project follows. First, a letter went out to each resident in the project area, informing them of the project and what the project was intended to accomplish. Included in this letter was an invitation to attend a public meeting to present the actual project and how the data was to be collected. Following the meeting, each house was visited and if the homeowner was there, the field data collector talked to the homeowner while walking around the property collecting information and answering homeowner's questions on mitigation techniques. Once the data was collected and the results were displayed on GIS maps, a follow-up public meeting was scheduled and homeowners were invited to discuss the results and ask questions. The field data collector also made himself available to return to the homes if invited by the homeowner to share the information. Several people have taken advantage of this avenue of response.

Two-thirds of the people were already aware of the program when the visits took place. Comments from homeowner unaware of the project before the site visit were that the homeowners were either out of town or that they get so much junk mail they usually throw a lot of material away. They didn't necessarily blame the program for not informing them of the mitigation project.

3. Did you implement any of the fire mitigation ideas given to you either by City of Boulder staff or from the educational materials you may have received? If 'yes' what type of mitigation did you perform?

Response Option	Number of Respondents	Percent of Respondents
Yes	30	34.5%
No	57	65.5%
Total # of Responses	**87**	**100%**

Response Option	Number of Respondents	Percent of Respondents
Construction	15	38.5%
Roof	13	33.3%
Other	2	5.1%
Landscape	24	61.5%
Access	0	0.0%
Water	0	0.0%
Topography	0	0.0%
Total # of Responses	**39**	**100%**

Although most people in the sample group did not perform any fire mitigation, given the type of effort required for such mitigation, a significant number of people did affect some sort of mitigative action. About 35% of the respondents actually took mitigation suggestions to heart and completed some type of mitigation effort. This compares to approximately 25% of respondents who responded to a questionnaire distributed within an unincorporated area of the county. The type of mitigation effected was broken out into five categories that relate to the primary factors that affect the hazard risk rating.

It is interesting to note that 13 homeowners replaced their wood shake roofs with noncombustible materials. Generally most people did minor work relative to the vegetation immediately around their home.

4. How would you rate the effectiveness of the Wildland Fire Hazard Identification and Mitigation Program in helping to reduce, or making you aware of the risk of fire?

Response Option	Number of Respondents	Percent of Respondents
Very Effective	20	23%
Somewhat Effective	34	39%
Somewhat Ineffective	13	15%
Very Ineffective	10	11%
Unsure	10	11%
Total # of Responses	**87**	**100%**

Here again almost twice as many people thought that the program was either *'very effective'* to *'somewhat effective'*. In processing the survey responses, it was noted that respondents, who were not aware of the project, were more likely to choose the *'somewhat ineffective'* or *'ineffective'* response options. For the most part, people who were aware of the project thought that the project was effective.

5. Overall, how would you rate the Wildland Fire Hazard Identification and Mitigation Program?

Response Option	Number of Respondents	Percent of Respondents
Very Good	16	19%
Good	28	33%
Neither Good Nor Bad	24	28%
Poor	7	8%
Very Poor	3	3%
Unsure	8	9%
Total # of Responses	**86**	**100%**

There was generally a feeling from respondents that the program deserved a relatively high overall rating. Here again those that were unaware of the program tended to give the program a poorer rating. The neither good nor bad response was fairly evenly divided between those that were aware and those that were not.

6. What is your opinion on using fire, by prescriptive means, as a management tool to enhance ecological values and help reduce the hazards associated with natural wildfires?

Response Option	Number of Respondents	Percent of Respondents
Supportive	52	60%
Somewhat Supportive	20	23%
Somewhat not Supportive	2	2%
Not Supportive	1	1%
Unsure	12	14%
Total # of Responses	**87**	**100.00%**

It must be noted that this project did not go into great detail in providing information on prescribed fire as a management tool for 'ecosystem health' or wildfire hazard reduction. Some discussion with the homeowners revolved around the fact that one of the techniques that land management agencies will use in mitigation on their lands involves the use of fire. Most of the knowledge or awareness of prescribed fire would have been obtained from other sources or possibly through other educational channels that have been employed by the Open Space Department, Mountain Parks, the Fire Department, and other land management agencies. Articles about large wildfires, such as the Yellowstone fires, and the subsequent benefits to the ecosystem may have had some bearing. Whatever the process, based upon the results of this question, it seems that the surveyed public seems to have grasped the importance of using fire as a land management tool. The *'supportive'* to *'somewhat supportive'* response numbers show an overwhelming support for prescribed fire and its implementation.

Some of the public's comments associated with this question, specified support for prescribed fire when applied only by qualified experts and only during appropriate seasonal periods. Those that were unsure did not have the benefit of information on this subject or had yet to make up their minds whether or not prescribed fire was good or bad.

7. Do you have any other comments you would like to make about the Wildland Fire Hazard Identification and Mitigation program?

The following is a compilation of the comments received in response to this question.

"Not aware of the effort due to own [*house holder*] negligence."

"Prescribed fire is OK when it is safe to do so."

"Believes in fire mitigation. Would like to see rules about open fires on open space land printed in the Daily Camera."

"Prescribed fire OK only when there are no winds."

"Would like to see written report of FIRMIT project."

"Sounds like [*a*] good program, but [*I*] didn't know anything about it."

"This area is vulnerable due to so many inaccessible locations where homes have been allowed to be built."

"What is it! Unless house holder was already aware and interested, I think the program did not make sufficient effort to make them aware of the dangers on their property."

"A notice was left on my door that the inspector had been here - it was up to me to follow through. Perhaps a letter listing, specific corrections could have been sent."

"Need case by case prescribed fire information."

"My neighbor showed me pruning done in his yard by recommendation from this program."

“May have lost my survey in the flood of mail, neighbors say my junipers are not close to the house, as his are.”

“I thought it was very good and was surprised at the poor turnout at the library meeting and also when our neighborhood plan was presented at the school.”

“How is the city patrolling for fires - especially at night" I worry about kids building bonfires in the Skunk Creek Wildlands.”

“Did you miss me in the initial information?”

“Poor attendance to public meeting. There were a great number of our neighbors who did not attend [*the*] meeting to explain findings. A copy of [*a*] reduced chart [*to be sent*] to those not in attendance would be a good idea.”

“Living in Devil's Thumb, there is much awareness and attention to this subject. We will be remodeling in 1998 and definitely changing roof components.”

“Post signs prohibiting smoking in Open Space relative to fire danger.”

“I would like to see as much as possible, the removal of deadwood along the trails. What happened to the idea of a fire break/trail behind the Shanahan area? [*I*] would like to see information again.”

“[*I*] want to replace [*the*] roof, but HOA has not approved new roofing material.”

“Get NCAR to mow [*its*] grass.”

“Don't limit your targets to just a few of us. In our old established neighborhoods, there are many trees and shrubs. Get on everyone.”

“The program has the value at minimum of reminding us of the dangers.”

“Direct contact has the most value. Unfortunately the weak link was me [*meaning the homeowner*]. I was out of town during [*the*] inspection and have not reviewed [*the*] findings.”

“I didn't think any mitigation efforts had been taken in our immediate areas. But had read in the Daily Camera of some efforts to reduce combustible materials in forests by removing some trees.”

“Since the program was addressed to homeowners who back onto open space, it was not very meaningful for us when we attended the meeting.”

“Thank you so much for doing this program. I appreciate all your efforts.”

“No prescribed fires immediately adjacent to neighborhoods bordering Greenbelt. The gentlemen who checked outside my home was pleasant and helpful, taking time to answer my questions.”

“We attended a meeting to learn more about this. The gentlemen who staffed it were very articulate and helpful. Having an educational meeting with informed staff was very helpful and I would encourage it. I thought it was advertised well.”

“A controlled burn would be good for the greenbelt's in this area. I think it is critical to remove the small trees that have been growing up in the Open Space in the Shanahan area.”

“Ignorant. I am sorry. Wish I knew more.”

"I think you need to work more on getting the word out and summarizing the results in a few-page memo that could be mailed out."

"Awareness is important. Need follow up and more information."

"I appreciated a presentation made by an official to our neighborhood several years ago when the fire danger was high."

"The new rule adopted by City Council-regarding requiring non-wood roofing by the year 2014 - is CRAP' and stupid."

"Good information. Wish more people were interested. Continue with it. Wow!"

"A plan is needed and needs to be disseminated, concerning what procedures would/should be followed if a grass or forest fire should break out on city Open Space land behind the neighborhoods."

"Most Boulderites are too busy speeding around in their SUV's [*sport utility vehicles*] to be concerned. This attitude, unfortunately, may put others at risk!"

"The City's effort is good. People sometimes only learn when it is too late. All the new housing developments, where houses are built only 6 or 7 feet apart, is asking for disaster. I guess money is more important than common sense."

8. How long have you lived at your present residence?

Response Option	Number of Respondents	Percent of Respondents
Less than one year	1	1%
1 - 4 years	8	9%
5 - 9 years	20	21.5%
10 - 14 years	17	18%
15 years or more	47	50.5%
Total # of Responses	**93**	**100.00%**

This survey question without a doubt indicates that those homeowners that have lived in the neighborhood for a longer period of time, 15 years or more, display more interest in the subject matter than those that have only resided there for a short period, 1- 4 years. This can be attributed to several reasons with knowledge of area, past experiences and a higher degree of ownership in the home relative to risks associated with it could be some of the more dominate reasons for this obvious difference in numbers.

Appendix H: FIRE SUPPRESSION IN BOULDER COUNTY

Craig Jones
Colorado State Forest Service

Fire suppression in Boulder County and in Colorado generally comes under three primary authorities. Responsibility for fire suppression on federal public lands, such as national parks and national forests, falls to the specific federal agency involved. State and private forests, such as county or city lands, fall under the authority/responsibility of local jurisdictions. The rural and mountainous areas of Boulder County are serviced by 23 Fire Protection Districts (FPD) that are local taxing districts. Mostly volunteer fire fighters provide local fire protection within the rural FPDs.

Cooperation for both initial and extended attack occurs via several interagency agreements and local operating plans. Fire Control Agreements, Initial Air Attack Agreements, Emergency Fire Fund, and Mutual Aid Agreements, along with local Operating Plans clearly define roles, responsibilities, reimbursement procedures and response procedures. When coupled with local education, training, resource sharing and cooperation, the system is quite effective and efficient. Cost to the taxpayer is minimal, and the preparedness and skill level is high throughout the northern Front Range and Colorado in general.

Through Boulder County's Operating Plan, initial attack suppression occurs primarily by the local fire protection districts with direct suppression assistance from the USDA Forest Service. The USDA Forest Service will always respond when the fires are initially identified on US Forest Service lands. The USDA Forest Service does, however, generally respond initially to all forest fires during the primary fire season when engine and engine personnel are available. Mutual aid agreements are key to this working relationship.

The Sheriff's Department (Emergency Services) responds to all wildland fires. In a majority of cases, the fires remain small (mode 1 or 2)[13] and direct assistance may be minimal. In mode 3[14] and above or when an incident's location or weather conditions warrant, Sheriff's Department personnel routinely serve as overhead or overhead support and are also key in ordering resources. In mode 4[15], the Sheriff's department actually takes control of the incident and mode 5[16] occurs through the Emergency Fire Fund Declaration, the State (through CSFS) and county assume a unified (joint) command scenario.

Generally speaking, during mutual aid response, resources from any and all sources can be utilized as long as standard operating procedures for ordering such resources are used.

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[13] Mode 1 through Mode 5 are county level designations that indicate management responsibility level for a fire. Mode 1 is a fire where only one volunteer fire department responses, and Mode 2 is a fire where the volunteer fire department is still in charge, but mutual aide is actively assisting in the suppression effort.
[14] Mode 3 is a fire in which the Sheriff's Department assumes responsibility for the fire.
[15] Mode 4 is a project level fire in which an overhead team is called in and outside resources are brought in as part of the suppression effort.
[16] Mode 5 is a *very large* fire.

Appendix I: PROGRAM WHINFOE: USER'S GUIDE (version 4.00.6)

(A program to calculate the Wildfire Hazard Rating for parcels in the Wildland/Urban Interface)

Claire M. Hay[17]
The Wildfire Interface Group

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Introduction

Program **WHINFOE** (**W**ildfire **H**azard **INFO**rmation **E**xtraction) is a **WINDOWS 32** application program that implements the **WHINFOE** model developed by C.M. Hay and is briefly described in the section below. Program **WHINFOE** calculates the wildfire hazard rating for a set of sites for which WHIMS questionnaire data have been gathered, and produces an output record for each site. The output records can easily be imported to other databases using software packages such as spreadsheets or Geographic Information System packages. Program **WHINFOE** calculates and outputs the value of the **Overall Wildfire Hazard Rating**, (**OW_HAZ**) as well as a '**What-if-Mitigated' Hazard Rating** (**IF_MIT**) for each site. In addition, the individual model component values are calculated. The nested, individual component variables are:

1) Overall Wildfire Hazard Rating (**OW_HAZ**), composed of:
   a) No Suppression HAZARD (**NoS_HAZ**), composed of:
      i) BASE HAZARD (**BASE_HAZ**), composed of:
         (1) TOPO_&_FUEL (**TOPO_FUEL**)
            (a) DANGEROUS TOPO INDEX ((**DTI**)
            (b) FIRE BEHAVIOR INDEX (**FBI**)
               (i) SURFACE FIRE INDEX (**SFI**)
               (ii) Crown Fire/Spotting Potential (**CSI**)
         (2) CONSTRUCTION (**CONSTRU**)
         (3) LANDSCAPING (**LANDS**), and,
      ii) DEFENSIBLE SPACE ADJUSTMENT (**DFSP_ADJ**), composed of:
         (1) DEFENSIBLE_SPACE (**DEF_SPACE)**
   b) SUPPRESSION ADJUSTMENT FACTOR (**SUPP_ADJ**), composed of:
      i) ACCESSIBILITY (**ACCESS**)
      ii) FIRE_PROTECTION_DISTRICT_RESPONSE (**FIRE_PROT**), and
      iii) WATER_AVAILABILITY (**WATER**),

The NO_SUPPRESSION HAZARD Rating, composed of:

1. BASE HAZARD (**BASE_HAZ**), and
2. DEFENSIBLE SPACE ADJUSTMENT FACTOR (**DFSP_ADJ**).

is based upon the Base Hazard Factor and the Defensible Space Adjustment Factor. The No_Suppression Hazard Rating only takes into account the passive protection afforded to a structure by the defensible space around it. This is in contrast to the Suppression Adjustment Factor, which rates the active suppression elements of protection – Access, Water Resources, and Fire Protection.

Program **WHINFOE** uses a 'parameter' file to configure the model for each specific user's requirements. The parameter file specific to your institution's implementation of the model was delivered to you with the **WHINFOE** executable code. If changes to the model structure are required/desired then a new parameter file must be generated. Contact the program developer for assistance.

What's New in WHINFOE V 4.00

The biggest change in **WHINFOE** v 4.00 is that it is a WINDOWS application program as opposed to versions 3.x and earlier that were DOS application programs. In addition, there has been a change in the input and output file formats. The file formats have been changed to add a [MetaData Section] at the beginning of the files. The [**MetaData Section]** of the input and output files stores information about the data contained in the **[Data Section]** of each file. The metadata for the input file records the Fire District or other analysis area's name, the date the data was finalized, and the name of the person who prepared the data. The metadata for the output file records information similar to the input file's metadata plus the name of the parameter file used to set up the **WHINFOE** model, the **WHINFOE** model program version used to process the data, and the date that the data were processed. The inclusion of the [MetaData Section] in the input and output files should make database maintenance and management easier.

WHINFOE v 4.00 has replaced the POLY_ID and PARCEL_ID field names with the more generic ID_FIELD1 and ID_FIELD2, respectively. In addition, ID_FIELD1 and ID_FIELD2 field can now be of any

length of characters as opposed to the 12-character limit on the PARCEL_ID field of previous versions of the **WHINFOE** program.

IMPORTANT NOTE

This WINDOWS[tm] program has **not** been tested on a **WINDOWS 3.x** systems and **no** representation for the use of **WHINFOE** on a **WINDOWS™ 3.1** system is being made.

Program WHINFOE - Getting Started

If You Need Help

You should not have any problems installing and running program **WHINFOE**. However, rare circumstances can occur, so if you have a problem running the program, email the program developer at cmh_twig@excite.com. Send your name and phone number and a brief message describing the problem and we will get back to you. Before sending email:

1. Check the *User's Guide* to make sure that you have followed instructions.
2. Try to duplicate the problem, and note any error messages that appear on the screen, or describe other symptoms of the problem.
3. **Double check** your input data file format. **Most** problems are associated with improperly formatted input data files (see the Input File Input File section of this appendix).

Features of the Program

With this program, you can easily calculate the Wildfire Hazard Rating for a set of parcel data. You can:

- Calculate the Overall Wildfire Hazard Rating (**OW_HAZ**) values for each parcel
- Calculate the individual component variable values, e.g. **TOPO_FUEL**, **CONSTRUCTION**, etc.
- Calculate a **'What-if-Mitigated'** wildfire hazard rating **(IF_MIT)** value for each parcel
- Obtain a list of parcels with missing data items
- Display your input and output data in a tabular format
- Allow you to view your input and output files as ASCII text files
- Interactively change the default settings used when data for a parcel is missing

Package Contents

Your program **WHINFOE** distribution package includes the following items:

A Zipped file **WHNF4WIN.ZIP** file that contains the following files.

Software

a 3-1/2 inch program distribution disk containing the following set of files:

Program Executable files or Batch files

- **WHNF4win.EXE:** the **WHINFOE** program executable file;
- **Whnf2.bmp:** a bitmap file that is used by the program.

[TM] Trademark of Microsoft Corporation.

Model Parameter Files

- ***.PRM:** an ASCII parameter file or files that specifies or specify the model configuration or configurations to be used. Some institutions or agencies have more than one model parameter file depending on the number of questionnaire versions in use.
- For the Boulder County WHIMS project, there are 2 parameter files at the present time, **WHIMS241.PRM** and **WHIMS341.PRM**

Example Data

- **EXAMPLE.DAT:** an ASCII file which represents an example data input file;
- **EXAMPLE.WHF:** an ASCII output file from program **WHINFOE** for the **EXAMPLE.DAT** input file. This file contains the calculated Wildfire Hazard Rating value, the Wildfire Hazard Rating value if mitigative action is taken, as well as the hazard level values for each of the individual component variables, e.g., TOPO_FUEL, CONSTRUCTION, etc. in the model;
- **EXAMPLE.MIS:** an ASCII output file from program **WHINFOE** for the **EXAMPLE.DAT** input file; this file contains a list of parcels for which missing data was detected.

Documentation

- **Program WHINFOE User's Guide**

Installing The Program

Before you install program **WHINFOE** on your computer, make a backup copy of the distribution disk for safekeeping. Although you shouldn't have any problem installing **WHINFOE** from the distribution disk, make a backup copy in case the original disk becomes damaged or lost.

System Requirements

In order to install and operate **WHINFOE** successfully, your system must meet the following minimum requirements:

- An IBM or 100% compatible personal computer with 640 KB of RAM.
- 1.30 MB of hard disk space.
- WINDOWS 95 or later.

The Installation Steps

WHINFOE under WINDOWS9x '

To install the program:

1) Make a separate directory on your hard drive for program WHINFOE - suggested name ‘whinfoe’.
2) Unzip the Whnf4Win.Zip file using WINZIP® or other unzip utility to the drive and directory you set up for the program.
    a) Extract all of the files in the zipped file to the same drive and directory.

Running the Program

Starting and Exiting the Program

To start **WHINFOE**,

1) Start your computer.

2) From the **START** menu, choose **RUN**

   a) Choose the **Browse** button and navigate to the directory to which you extracted the **WHINFOE** program and parameter file(s).

   b) Choose the **Whnf4Win.exe** executable file, OR

   c) Double click the **Whnf4Win.exe** executable file when you display the list of files in your whinfoe directory using WINDOWS EXPLORER.

   d) When you are finished using WHINFOE, exit the program by selecting File|Exit from the menu bar at the top of the program window.

Using the WHINFOE Program

After starting the WHINFOE program you will see a tabbed page form in a full screen window. Two tabs are initially visible - the ***Current Settings*** tab and the ***Input Data*** tab. The *Current Settings* page is the tabbed page that displays initially.

On the *Current Settings* page you will see two buttons – a 'Select' button under the 'Current Settings/Input Data' section and an 'Edit' button under the 'Calculation Options' section.

Choose the 'Select' button to bring up the 'Open' dialog box. The automatic filter for the 'Open' dialog box is *.dat. You can navigate to any directory or file using the standard WINDOWS buttons and menu options in the 'open' dialog.

Select the desired data input file. The program reads the information in the MetaData Section of the file and sets up the appropriate model configuration for the data. If the MetaData Section is missing then the user is asked to supply the name of the appropriate parameter file to be used for model configuration. Selection of an incorrect parameter file for a data file can result in the program terminating or at the very least incorrect processing of the input data.

After you run the calculations for one set of input data you can save the output data and run another set of input data.

Description of Files

Output Files

Program **WHINFOE** produces two simultaneous ASCII output files. The first file (***.WHF - Results Output File**) contains the calculated output values from the Wildfire Hazard Rating Model and the second file (***.MIS - Missing Data Output File**) contains a list of parcels for which some of the data elements were missing and had to be calculated using default values.

Results: Output File

The Results Output File contains the 'unique record identifier (ID_FIELD1)', the ID_FIELD2 code, the calculated output values for the individual component variables, the Overall Wildfire Hazard Rating values, and the 'What-if-Mitigated' Hazard Rating values. The Results Output File has a ****.WHF*** file extension, and carries the file name assigned by the user during program execution. The data columns are separated by commas so that the ****.WHF*** output file has a 'Standard Data File' format (**SDF file**) which can be used with the **IMPORT** command of the **INFO** database software package. The ****.WHF*** file can also be brought into any spreadsheet software package.

Table 6 contains a summary description of the column headings in the output file. Figure 35 is an example of the data output file. The 1st column in the ****.WHF*** output file is the 'unique polygon ID number'. This is an unsigned integer field that can take on values between 0 and 65767. The 2nd column in the ****.WHF*** output file is the 'ID_FIELD2' field. This is a character field that can be up to 255 characters in length. If the particular database or spreadsheet package that you are using requires different text delimiters, e.g., a double-

quotation symbol ("), then use the global search and replace capabilities of a word processing package to insert the ("")'s into the output file prior to importing the file into the desired database/spreadsheet package. If you desire a custom version of Program **WHINFOE** that will insert text delimiters as needed by your other software packages, please call the program developer at **1-303-545-9915** to arrange for a custom version of **WHINFOE** with the text delimiter of your choice. There may be a fee assessed for a custom version of **WHINFOE**.

The output file contains a [MetaData Section] which precedes the calculated output records in the [Data Section] of the output file. The [MetaData Section] contains information on which data input and parameter files were used to process the data, and which questionnaire version is represented in the data. The [MetaData Section] is followed by the [Data Section]. The first line of the [Data Section] contains the column headings which identify the sequence of calculated variable values. Remove the [MetaData Section] prior to import into **ARC/INFO.** You can use the **IMPORT** command of **INFO** to import the data into **ARC/INFO.**

The **'What-if-Mitigated' hazard rating** (IF_MIT) value (in column labeled "WF__MIT") is the overall wildfire hazard rating (**OW_HAZ**) that would result if the **LANDS** and **DEFENSIBLE SPACE** elements were mitigated to a reasonable extent. In order to accomplish the 'What-if-Mitigated' evaluation, the parameter file specifies the response values that a data item for a parcel can reasonably be expected to achieve. (See Table 7 for the values used in your implementation.)

The value output for each variable is the 'unweighted' value for that variable. That is to say, each individual component variable has a value range from 0.00 to 10.00 except Defensible Space Adjustment Factor (**DFSP_ADJ**) which ranges 0.75 to 1.00 and the Suppression Adjustment Factor (**SUPP_ADJ**) which ranges from 0.86 to 1.00. Together the **DFSP_ADJ** and the **SUPP_ADJ** give a total adjustment factor that ranges from 0.645 to 1.00. Each variable also has an associated importance weight that determines how much of its value contributes to the calculation of the overall wildfire hazard rating. Thus, if a specific component value is reported to be 5.00 in the output, and the weight for that component in the model is 0.23 then the amount contributed to the overall hazard rating score by that variable would be 0.23 * 5.00 or 1.15.

Missing Data Output File

The second output file (****.MIS*** file) contains a list of parcels for which missing data was detected. Only Parcel records that contained missing data are listed within the 'Missing Data Output' file. This file carries a ****.MIS*** file extension and the same before extension file name that was assigned to the ****.WHF*** output file.

[MetaData Section]
Output_File_Name=D:\A_WHIMS\EXAMPLE.WHF
Output_Processing_Date=8/2/1999
Output_Processor=cmh
Calculation_Model_Name=WHINFOE
Calculation_Program Version=4.00
Compile_Date=27 July 1999
Configuration Version=BoCoLU
Parameter_File=WHIMS241.PRM
Default_Fuel_Type=9
Default_Slope=30
Missing_Calc_Opt=MAX
Input_Data_File=D:\A_WHIMS\EXAMPLE.DAT
Loc_District_Name=Pine Brook Hills
Loc_City=N/A
Loc_County=Boulder
Loc_State=CO
Loc_Country=USA
QVer_Org= Boulder County Land Use
QVer_Org_Code=BoCoLU
QVer_Number=Qver2
Data_Finialization_Date=
Data_Preparer=
Preparer_Organization=

[Data_Section]
ID_FIELD1,ID_FIELD2,FSI,DTI,FBI,TOPO_FUEL,CONSTRU,LANDS,DEF_SPACE,ACCESS,WATER,FIRE_PROT,BASE_HAZ,DFSP_ADJ,SUPP_ADJ,NoS_HAZ,OW_HAZ,If_Mit
9, 146111000013, 1, 3.74, 8.10, 7.70, 8.10, 7.16, 2.64, 5.00, 7.35, 8.49, 4.00, 6.13, 0.88, 0.95, 5.37, 5.12, 3.95, 3.50, 3.50, 5.00, 4.00, 5.10,
10, 146111000016, 1, 4.79, 5.37, 4.04, 5.37, 7.16, 6.43, 10.00, 7.35, 8.49, 4.00, 6.31, 1.00, 0.95, 6.31, 6.02, 5.47, 5.00, 5.50, 6.00, 5.50, 4.36,
22, 146111000021, 1, 4.39, 3.25, 2.60, 3.25, 9.68, 2.72, 2.50, 1.64, 3.75, 4.00, 5.34, 0.81, 0.90, 4.34, 3.91, 5.60, 4.50, 5.50, 7.00, 6.00, 3.69,
35, 146112000047, 1, 5.57, 2.17, 3.27, 2.45, 9.68, 1.02, 2.50, 1.09, 3.75, 4.00, 4.55, 0.81, 0.90, 3.70, 3.32, 5.47, 4.50, 6.00, 6.00, 6.00, 3.32,
36, 146110000003, 1, 4.51, 5.37, 3.93, 5.37, 4.46, 3.03, 5.00, 8.05, 8.49, 4.00, 4.35, 0.88, 0.96, 3.81, 3.64, 5.23, 4.50, 7.00, 4.00, 6.00, 3.59,
44, 146111003004, 1, 5.42, 5.37, 4.30, 5.37, 2.68, 3.64, 5.00, 3.79, 8.49, 4.00, 3.91, 0.88, 0.93, 3.42, 3.19, 5.00, 4.50, 5.50, 5.00, 5.00, 2.95,
47, 146112000046, 1, 5.63, 3.25, 3.30, 3.25, 7.16, 2.02, 2.50, 1.16, 3.75, 4.00, 4.25, 0.81, 0.90, 3.45, 3.10, 5.00, 4.50, 5.50, 5.00, 5.00, 2.88,

The first 3 columns are the 'Unique Record Identifier', i.e., the Polygon Number, the Parcel ID, and the Unit Number, respectively. The intervening columns are the component variable values. The number of intervening columns depends upon the number of component variables in the specific model applied. For a listing of possible Output column headings and the variables to which they refer see Table 7.

Figure 35: Example of the Output from Program WHINFOE. See text for explanation.

Output Value Column Headings

Column Heading	Variable Name	Value Type and Range
POLY#	Polygon Number	**integer**: 0 through 65535
ID_FIELD2	Parcel ID Number	**character**: character alpha-numeric field; code – characters can be any printable alpha-numeric character
UNIT_NUM	Unit Number	**Integer:** 0 through 65535
SFI	Surface Fire Index	**real**: -1.00, or 0.00 through 10.00
FBI	Fire Behavior Index, includes surface fire, potential for crowning, and potential for spotting depending upon fuel type and site topography.	**real**: -1.00, or 0.00 through 10.00
DTI	Dangerous Topography Index	**real**: -1.00, or 0.00 through 10.00
TOPO__FUEL	Topography & Fuel	**real**: -1.00, or 0.00 through 10.00
CONSTRU	Construction Elements	**real**: -1.00, or 0.00 through 10.00
LANDS	Landscaping	**real**: -1.00, or 0.00 through 10.00
DEF_SPACE	Defensible Space	**real**: -1.00, or 0.00 through 10.00
ACCESS	Accessibility	**real**: -1.00, or 0.00 through 10.00
WATER	Water Availability	**real**: -1.00, or 0.00 through 10.00
FIRE_PROT	Fire Protection District Capability	**real**: -1.00, or 0.00 through 10.00
BASE_HAZ	Base Hazard	**real**: -1.00, or 0.00 through 10.00
DFSP_ADJ	Defensible Space Adjustment	**real**: -1.00, or 0.79 through 1.00
SUPP_ADJ	Suppression Adjustment	**real**: -1.00, or 0.82 through 1.00
NoS_HAZ	No-Suppression Hazard Rating	**real**: -1.00, or 0.00 through 10.00
OW_HAZ	Overall Wildfire Hazard Rating	**real**: -1.00, or 0.00 through 10.00
BHAZ_FLD	Base Hazard as calculated from factors rated directly in the field	**real**: -1.00, or 0.00 through 10.00
TOPO_FLD	Topography & Fuel as rated directly in the field	**real**: -1.00, or 0.00 through 10.00
CONS_FLD	Construction Elements as rated directly in the field	**real**: -1.00, or 0.00 through 10.00
SFP_FLD	Landscaping as rated directly in the field	**real**: -1.00, or 0.00 through 10.00
OHZ_FLD	Overall Wildfire Hazard Rating as rated directly in the field	**real**: -1.00, or 0.00 through 10.00
IF__MIT	Wildfire Hazard 'If-Mitigated'	**real**: -1.00, or 0.00 through 10.00

Table 6: Output File Column Headings

Input File Input File

The INPUT file for program **WHINFOE** is an ASCII text file. The file name must meet all DOS standard file naming conventions and the file extension MUST be **'.DAT'**. For example, valid data INPUT file names are: 'DATASET1.DAT', 'PINECFPD.DAT', 'THISDATA.DAT', and so forth.

There are 2 sections to the input file – the [MetaData Section] and the DATA section. The [MetaData Section] contains 'metadata' information about the following data records to help with database management and maintenance. In the [MetaData Section] you must use the 'before equal sign' text string exactly as in the example data file shown below. Additional comment lines can be added at the end of the [MetaData Section] and before the [Data Section]. The [MetaData Section] is followed by a blank line then by a line which contains only the text string – '[Data Section]'.

The [Data Section] contains the data records for the parcels. The data for each parcel is contained on one (1) line (record line) in the file. The first column (field) is a unique identifier, the second column is the parcel identification number, and in the case for the Wyoming State Forest Service the third column is a unit identification number used to track multiple structures on a site. Each subsequent column is the response value for the data items listed in their sequentially numbered order.

Other than the blank line separating the [MetaData Section] and the [Data Section] of the input file, there are NO BLANK lines within the file. If there is a blank line after the last data record. There must not be any blanks (spaces) before the final carriage return

MetaData Section

The first section of the INPUT file is the MetaData section and is indicated by a text string of '[MetaData Section]' on the first line of the file. The next lines can contain important information about the district (or area) to which the data pertains, the questionnaire version on which the data was recorded, the date the data were finalized, and the person who prepared the data. The [MetaData Section] does not need to be present, however it is strongly suggested that you maintain this MetaData for ease of data maintenance in the future. If the metadata information lines are missing then the metadata to be written to the output file will not be filled in. The metadata information is very important for tagging your input and output files for subsequent database management and maintenance. This information helps you and other personnel who may try to reconstruct the data processing status of districts within your project area. The value of this metadata increases over time as memories fade or project personnel change. Thus additional metadata information can be added in additional comment lines at the end of the [MetaData Section]. You are encouraged to make any additional comments on the COMMENTS: that will aid your memory or inform other persons about the data when the file is reviewed at a much later date. The comments may flow across several lines and need not be contained on the line that starts with the text string – 'Comments='. There needs to be a blank line after the last comment line and the 1st line of the [Data Section].

The token 'text string' at the start of each line of the [MetaData Section] (i.e., the text in bold type face and preceding the '=' sign) needs to be appear exactly as shown in the panel below

The text after the equal sign can be any thing you want, however, there must **NOT** be a space between the start of that text and the 'equal sign'. The exceptions are the text strings for the lines:

QVer_Org_Code=BoCoLU
QVer_Org=Boulder County Land Use Department
QVer_Number=Qver2

These need to be exactly as shown. The order of the lines is not important except that the [MetaData Section] line must be the first line, and the Comment= line must be the last line of the MetaData Section followed by a blank line, the Data Section column header line, and the [Data Section] line. An input file MetaData Section template that you can insert before your data in the input file (IN_Meta.txt) is included on the WHINFOE distribution disk. Fill in the fields that are blank and make sure that the proper questionnaire version is indicated on the Qver_Number= line. For the Boulder County WHIMS project the 'argument' should be either Qver2 or Qver3.

```
[MetaData Section]
Input_File_Name=test.dat
Loc_District_Name=CHERRYVALE (RESIDENTIAL)
Loc_City=N/A
Loc_County=Boulder
Loc_State=CO
Loc_Country=USA
QVer_Org_Code=BoCoLU
QVer_Org=Boulder County Land Use
QVer_Number=QVer2
Data_Finialization_Date=1/12/1999
Data_Preparer=JHK
Preparer_Organization=Boulder County Land Use Depart., GIS Section
Input_SFI=0
Comment=Input Data for WHINFOE.EXE (v4.0.0w) Program
Quest_Seq_Hder_line=1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31  32   33 34 35  36
37

[Data Section]
```

Data Section

The data records are contained in the data section. The first line of the data section contains only the text string – '[Data Section]' which signals the start of the data section. This line MUST be present just before the first data record line. The **second and each following line** of the data section consist of a data record for the first through the last parcel or lot in the project area. There are no blank lines between data record lines, however if there are blank lines at the end of the data input file, these blank lines should not cause a problem for the program. An example of the data section records is shown in the panel below and contained in the 'EXAMPLE.DAT' file contained on the distribution disk.

```
[Data Section]
  9 146111000013 3  2  3  2  5  2  2  3  2  3  2  3  0  0  2 -1 -1  4  4  2  1  2  1  0  4  2  3  3  0 -1
 10 146111000016 3  3  3  2  5  2  2  3  0  3  4  4  2  3  2 -1 -1  4  4  2  1  2  1  0  4  2  2  3  0 -1
 22 146111000021 2  3  1  3  5  2  2  2  0  3  1  2  1  1  0 -1 -1  1  4  1  1  0  0  0  0  2  3  3  0 -1
 36 146110000003 2  2  3  1  2  2  1  3  0  3  2  4  0  1  1 -1 -1  4  4  2  1  1  2  2  4  2  3  2  0 -1
 44 146111003004 2  1  3  2  1  0  1  3  2  1  2  3  1  0  0 -1 -1  4  4  2  1  2  0  0  0  0  3  3  0 -1
 47 146112000046 -1 3  1  2  5  2  2  1  0  3  1  2  1  0  0 -1 -1  1  4  1  1  0  0  0  0  2  4  3  0 -1
```

Within each record line in the [Data Section] of the input file, the format is as follows.

Record_Field #1 (column 1) is ID_FIELD1 and is a UNIQUE IDENTIFIER NUMBER. This can be a 'FIXED' polygon number assigned within a Geographic Information System (GIS) such as ARC/INFO or an arbitrary sequential number assigned to each data record (line). The unique identifier number is used when there are several 'polygons' with the same Assessor's Parcel Identification number. If there are several 'polygons' within the GIS database that have the same Assessor's Parcel Identification number, then each polygon in the GIS database must be uniquely identified with an identification number that does not potentially, change with each 'new build' of the database. This UNIQUE IDENTIFIER NUMBER is used as the 'link' field when relating the results of program **WHINFOE** back to the GIS database. The valid range of values for Record_Field #1 is integer values 0 through 65535. **If this is a problem, contact the program developer immediately.** Blank leading spaces can precede the Record_Field #1 values on each line of the input file. Any number of spaces can precede the value for Record_Field #1. Following Record_Field #1 is **at least one space, but there can be more than one space**.

Record_Field #2 (column 2) is ID_FIELD2 and is usually the ASSESSOR'S PARCEL IDENTIFICATION code for the lot. This is an alpha-numeric field and can contain letters or numbers intermixed. If Assessor identification codes are not available then the address or partial address of the lot can be used. However, there can be no embedded spaces within this field, i.e., Do not put a space between the number part of the street address and the street name, e.g., "1234Anywhere", without the quotation marks. The characters contained

within this code can be any printable alpha-numeric character including integers, letters either upper- or lower-case, and any of the other character symbols found on a standard keyboard, namely, ~ ` ! @ # $ % ^ & * ( ) - _ + = { [}] | \ < , > . ? / : ; " ' and a space. This field MUST be followed by a space to separate it from the following field. More than one space can be used if desired.**Record_Field_3 (column 3) through Record_Field_31 (column n)** are the 'questionnaire' or GIS data elements for the polygon, parcel or lot. Record_Field_3 through Record_Field_31 appear in the sequential order assigned to them on the data questionnaire and within the GIS database. For example, Record_Field_3 = Questionnaire_Response #1, Record_Field_4 = Questionnaire_Response #2, etc. The sequence numbering of the Record_Fields for your particular **WHINFOE** model implementation was determined at the time that your program parameter file was set up. **Do not renumber any of your Record_Fields without discussing the issue with the program developer who set up your program parameter file.**

Each line in the data INPUT file is terminated with a 'DOS end_of_line' character, that is, 'hit' ENTER or RETURN on the keyboard at the end of each line, including the last data line in the data INPUT file. The are many text or word processors available on the market today that allow transparent processing of UNIX-based text files and DOS-based (PC) text files. Make sure that your input data file is in DOS ASCII text format. UNIX text files do not terminate lines in the same way that DOS text files do. Thus, a UNIX text file will not be processed properly using the **WHINFOE** program. If you are operating totally within a PC based system this will not affect you. However, for those users transferring data between UNIX and PC based systems, pay particular attention to the text file format, i.e., UNIX text vs. DOS text file format.

The data values for Record_Field_3 through Record_Field_31 can be either signed integers or real (float) values that range in value from -1 through large values if real numbers are used. The value -1 is **RESERVED** for missing data values. If any data value is missing for a specific 'Question or GIS Response item', enter a value of -1 for that Record_Field in the appropriate location within the sequence of Record_Fields for a polygon, parcel, or lot.

The values for each Record_field are separated by at least one space. More than one space may be used if desired. For ease of editing within a variety of word processors or text editors, try to keep the length of each data line to less than 129 characters. Up to 255 characters are ok though. If using a word processor make sure you save the file as a ‘text only’ file.

Data Sequence Specific to the Boulder County WHIMS Project

Record_Field_1 (Column 1) is ID_FIELD1 (the Poly_#) field. Record_Field_2 (column 2) is ID_FIELD2 (the Parcel Identification Number). Record_Fields_3 through _31 (columns 3 through 31) correspond to the WHIMS Data Questionnaire Response Values for Questions #1 through #29.

Many users will want to store additional Record_Fields within the spreadsheet database such as the lot’s street address, the owner's name, etc. It is suggested that the additional **spreadsheet** fields be grouped together and placed either preceding or following the required record_fields in the data input file or better yet on a separate worksheet in a multi-worksheet workbook. This data grouping protocol will facilitate 'exporting' the required record_fields from the spreadsheet to an ASCII input file.

Questionnaire Version 2			Questionnaire Version 3		
Ques. #	**Question Name**	**Mit Value**	**Ques. #**	**Question Name**	**Mit Value**
#1	Steep Slope Proximity	3	**#1**	Lot Identification	1
#2	Dangerous Topo Proximity	3	**#2**	Steep Slope Proximity	3
#3	Roofing Material	4	**#3**	Dangerous Topo Proximity	3
#4	Siding Material	5	**#4**	Roofing Material	3
#5	Balcony & Decks	2	**#5**	Siding Material	6
#6	Eaves & Overhangs	2	**#6**	Balcony & Decks	2
#7	Driveway Condition	3	**#7**	Eaves & Overhangs	2
#8	Propane gas Location	4	**#8**	Driveway Condition	3
#9	On-Lot Electric	3	**#9**	Propane gas Location	6
#10	Defensible Space	2	**#10**	On-Lot Electric	3
#11	Vegetation Density	3	**#11**	Defensible Space	2

#12	Vegetation Near Roof	0	**#12**	Vegetation Density	3
#13	Firewood Storage	1	**#13**	Vegetation Near Roof	0
#14	Vegetation Near Chimney	1	**#14**	Firewood Storage	1
#15	Lot Identification	1	**#15**	Vegetation Near Chimney	1
#16	Hydrant Location	4	**#16**	Hydrant Location	4
#17	Permanent Stream Location	4	**#17**	Permanent Stream Location	4
#18	Remote Draft Sources	5	**#18**	Remote Draft Sources	4
#19	Response Time	4	**#19**	Response Time	3
#20	Ingress/Egress	3	**#20**	Ingress/Egress	2
#21	Road Width	3	**#21**	Road Width	2
#22	Maximum Grade	4	**#22**	Maximum Grade	3
#23	Road Connection	4	**#23**	Road Connection	4
#24	Off-Lot Electric	3	**#24**	Off-Lot Electric	2
#25	Predominant Slope Class	4	**#25**	Predominant Slope Class	3
#26	Predominant Aspect Class	4	**#26**	Predominant Aspect Class	4
#27	Average Lot Size	3	**#27**	Average Lot Size	2
#28	Fuel Type	13	**#28**	Fuel Type	13
#29	Average Slope (%)	300	**#29**	Average Slope (%)	300

Table 7: Question Sequence Order for Questionnaires Used by Boulder County Land Use Department

Setting up the INPUT Data File

The easiest way to set up the input data file is to:

1) enter your data into the spreadsheet. Then save the spreadsheet page with just the required data fields as described above to a 'space delimited' (e.g., 'Formatted text, Space Delimited, *.PRN' file in EXCEL) file. This will usually give you a message about losing some formatting features but ignore the message.

2) Check the resulting text file to make sure that all record fields are separated by a space. To do this, open the 'space delimited' text file in a word process or NOTEPAD. Make sure you have the required number of fields for each record. If there are some fields that are not separated by a space then go back to the original worksheet and increase the column width for the fields that did not separate. Then resave the worksheet as a 'space delimited' file.

3) Open the 'IN_META.TXT' template file included on the distribution disk. Edit the MetaData Section records (lines) to describe the actual data that is in your 'space delimited' text file. Insert the MetaData Section text lines in front of your data records.

4) Save the integrated MetaData and Data file as a 'text only' file.

5) Verify that this operation saved the file in the valid format by reopening the file in the word processor or NOTEPAD.

Verifying Processing Completion

After you have finished processing your data, verify that all input records were processed. Check to make sure that there is an output record for every input record. Usually checking the first, second and last ID_FIELD1 number processed is sufficient to identify whether all records were processed. This check is particularly important if you received any Run-Time Error Messages during the data processing. Usually errors occur when the input data file is not properly formatted.

Examine the Missing Data Output File (*.MIS) to determine whether an inordinate number of missing data records was written to the missing data file. If there was an inordinate number of missing data items for many of the records, verify that your input file is properly formatted and that you used the appropriate parameter file (questionnaire version) for the specific input data. If you discover formatting or incorrect parameter file errors, rerun the model on the corrected input data.

If you get an error message or the program does not finish correctly, look at any output file (*.WHF) that was created to see what was the last record processed. If the problem is an improperly formatted input file, which it usually is, the record containing the error is somewhere after the last full record written to the output file. The error may not be in the next record number after the last record number written to the output file. It may be a couple of records after the last record written. This is because the 'buffer' may not have fully written to the output file when it detected an error.

If you can't find your error(s) call the program developer or email a description of the problem to the developer along with the version and the date of the executable *.EXE file of WHINFOE and the parameter file you were using when the problem occurred, a copy of the input file along with any output files produced (both the *.WHF and *.MIS files) from this input file. There may be a fee for this service depending on whether you are a registered user of WHINFOE and whether your institution has used up its initial complimentary troubleshooting support hours.

Basic Structure of the Model

In order to calculate an overall wildfire hazard rating for a parcel, the 7 primary factor variables described below are separated into one of two categories. The first category is a direct hazard category. Informational variables assigned to the direct hazard category relate 1) to the characteristics of the fuel on or near a site (including the structure itself), i.e., 'the burnable stuff' and 2) to the likelihood that the 'burnable stuff' will become involved in an approaching wildfire. The first category makes up the Base Hazard Factor. The **Topographic Location and Fuels,** the **Building Construction and Design,** and the **Landscaping** factors belong to the Base Hazard category.

The second category into which the remaining 4 primary factors are assigned is a hazard reduction category. Informational variables assigned to the hazard reduction category relate to conditions or resources that help lessen the base hazard. The **Defensible Space**, **Accessibility**, **Fire Protection Response**, and **Water Availability** factors belong to the Hazard Adjustment category.

The Base Hazard Factor and the Hazard Adjustment Factor are combined to produce the Overall Wildfire Hazard Rating for a site (see Figure 36).

Primary Factors Contributing to an Interface Wildfire Hazard

There are seven primary factors that determine the nature and severity of a wildfire hazard to structures in the urban wildland interface (UWI). These factors are **Topographic Location and Fuels**, **Building Construction and Design**, **Landscape Maintenance, Existence of Defensible Space**, **Accessibility**, **Fire Protection Response Capabilities**, and **Water Availability**. The first three factors, Topographic Location and Fuels, Building Construction and Design, and Landscape Maintenance determine the base hazard for a structure due to wildfire. The base hazard is the hazard that is due just to the existence and characteristics of the first three factors. The remaining factors, Existence of Defensible Space, Accessibility, Fire Protection Response, and Water Availability, contribute to lessening the Base Hazard by providing a protective zone (Defensible Space) around a structure or by allowing fire protection resources to help defend a structure. The Defensible Space zone is an area whose function is to reduce the intensity of a wildfire approaching a structure, and to provide access for fire protection resources to help defend the structure. By evaluating information about each of the primary factors, we can develop a sense of the wildfire hazard to a structure within the UWI.

Topographic Location and Fuels (TOPO)

The Topographic Location and Fuels (**TOPO**) factor evaluates the wildfire danger to a structure or vacant-site based upon the physical setting of the site. Important elements of the physical setting can be broken

down into two main areas. The first element deals with the topographic elements of the site, and the second deals with the general fuel type, that is, the background vegetation type in the neighborhood of the structure and/or site. The topographic elements take into account 1) the **slope of the site**, 2) the **orientation (aspect) of the slope** of the site, and 3) the location of structures relative to **dangerous topographic features.** The dangerous topography information for a structure is contained in the dangerous topography index (**DTI**) for a site. The **DTI** is a sub-variable of the topography and fuel (**TOPO**) factor.

Dangerous topographic features include steep slopes (greater than 30% slope), chimneys that serve to funnel an advancing fire to the structure, V-shaped canyons, ridges, and saddles. The slope and aspect of a site help determine how fast and in which general direction a wildfire will travel across a site. The near proximity of 'dangerous topographic features' to a structure is a very hazardous situation for a structure. Aside from the increased fire intensity associated with such features, areas that are in close proximity to 'dangerous topographic features' are considered to be in a 'fire accumulation zone'. The near proximity of 'dangerous topographic features' to a structure determine the likelihood that a fire will tend to 'funnel' into the immediate vicinity of the structure, given that a fire is in the general neighborhood of the structure.

Another sub-variable of the Topography and Fuel factor is the Fire Behavior Index (**FBI**). The **FBI** evaluates the surface fire intensity and spread rate (**SFI**) and the crown fire potential and spotting potential (**CSI**) of the fuel in the neighborhood of the structure.

The **fuels/vegetation elements** that are important include the vegetation type on the site as well as how that vegetation is 'arranged' on the site. The amount, the density, and the continuity of the vegetation on the site all need to be evaluated to determine how much fuel is present, and how that fuel will burn if a wildfire occurs. The **TOPO** factor operates at the neighborhood level or scale. This means that the TOPO factor needs to be evaluated with vegetation information collected at a mapping resolution of approximately 1 to 5 acres. The slope and aspect data need to be evaluated with 50 to 100 foot (15 to 30 meters) resolutions. The elements that characterize the TOPO factor are fixed and not subject to mitigation with the possible exception of major, neighborhood-wide fuel modification efforts.

Building Construction and Design (CONST)

The Building Construction and Design (**CONST**) factor evaluates the wildfire danger to a structure based upon the materials and methods used in the construction of the structure. Specifically, the type of construction, e.g., traditional stick built or manufactured structures, the type of roofing and siding material, as well as the type of construction of balconies and decks, and eaves and overhangs are evaluated. In the case of a pre-existing structure, a significant remodeling effort would be required to reduce the level of hazard due to the CONST factor. For new construction, however, building materials and construction methods that contribute to a lower wildfire hazard can be efficiently and effectively incorporated into the initial design of the structure.

Landscaping (LANDS)

The Landscaping (**LANDS**) factor evaluates the wildfire danger to a structure based upon the nature of the 'fuels' in the immediate vicinity [within 150 feet (46 meters)] of the structure, and the quality of landscape maintenance near and adjacent to the structure. Fuel materials in the immediately vicinity of a structure include both natural and ornamental vegetation, firewood stored on-site near a structure, wooden fences leading up to a structure, leaf material and litter on the roof or in the gutters, and propane fuel tanks on-site. All of these materials can be a source of sustained ignition near a structure or can contribute to the carrying of a wildfire from the surrounding area up to the structure itself. The wildfire hazard due to the LANDSCAPING factor can easily be reduced with only a moderate maintenance effort.

Defensible Space (DEF_SPACE)

The Defensible Space (**DEF SPACE**) factor is partly related to the LANDSCAPING factor. The concept of a defensible space relates to the integrated effect of the fuels (e.g., natural, exotic ornamental, and generally burnable materials) near a structure on the behavior of a wildland fire approaching the structure. The goal of maintaining an adequate defensible space is to change the fire behavior characteristics of an advancing fire so that the intensity and rate of the spread of the fire are reduced. In other words, the

purpose of defensible space is to change the characteristics and continuity of burnable material near a structure so that if an advancing fire is propagating through a tree canopy (crown fire) then that fire will drop to the ground when it reaches the defensible space zone. As a ground fire, the situation can be controlled more easily and poses less of a threat to the structure. Additionally, defensible space is an area near a structure that is reasonably safe for firefighters to occupy while defending or treating a structure. Adequate defensible space can contribute to reducing the intensity of a wildfire within the immediate vicinity of a structure, as well as to reducing the access of a wildfire to the structure. The wildfire hazard can be significantly reduced by the development of an adequate defensible space. Often, only a moderate maintenance effort is required to develop an adequate defensible space. The difference between the LANDSCAPING factor, and the DEF SPACE factor is that the LANDSCAPING factor describes or inventories burnable materials near a structure. In other words, the LANDSCAPING factor focuses on the hazard aspect of the area immediately adjacent to a structure. The DEF SPACE factor, on the other hand, assesses the effectiveness of all of the integrated elements to effect a reduction in the intensity of fire behavior within that space. In other words, the DEF SPACE factor focuses on the mitigating aspects of the area immediately adjacent to a structure.

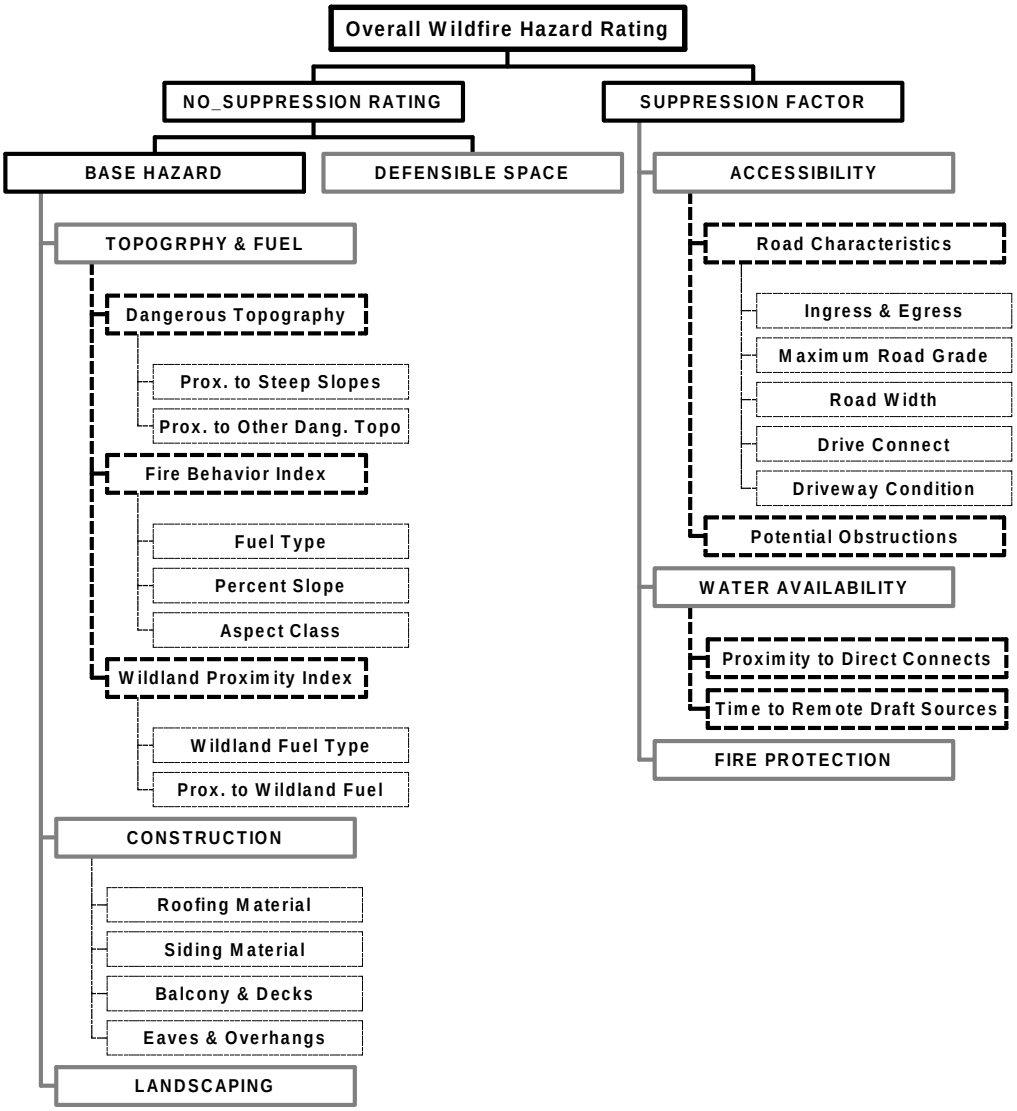

Figure 36: WHINFOE Model Structure

Accessibility (ACCESS)

The Accessibility (**ACCESS**) factor evaluates the ease of access to a structure or vacant-site by firefighters when responding from specific fire stations or other specific district-level response locations. Elements evaluated include the road characteristics of the public right-of-way such as road width and grade, private driveway condition, and where the drive is connected to the primary road network. Included in the evaluation of accessibility are elements that could cause a slowed response such as downed power lines, or lack of lot identification. The Accessibility factor is related to general characteristics of the neighborhood infrastructure, which are relatively fixed and not easily modified.

Fire Protection Response (FIRE_PROT)

The Fire Protection Response (**FIRE PROT**) factor evaluates how quickly fire protection resources can arrive at a site. The Fire Protection Response is partly related to the community infrastructure, which is relatively fixed and requires a significant effort to modify.

Water Availability (WATER)

The Water Availability (**WATER**) factor evaluates the availability of water for protection of a structure or vacant-site. Two basic types of water resources can be available to a structure. These are **direct connection (nearby) water resources** and **remote draft water resources.** The direct connection resources such as pressurized hydrants or permanent streams, ponds, or cisterns are those water resources located close enough to a structure so that a direct hose line from the source can be supplied to the structure. The remote draft resources lie at a distance from the structure, so that a tanker truck must drive to the remote location, fill its tank, and return to the vicinity of the structure. The Water Availability factor is related to the characteristics of the neighborhood and the community infrastructure and are relatively fixed and not easily modified.

Variable Weights in the Model - An Experiential (expert opinion) Model

The weight of the variables in the model were established through an extensive query of numerous fire management persons within Boulder County, CO, the Colorado State Forest Service, and the USDA Forest Service. Each expert was queried using a multi-criteria querying protocol. Each expert was interviewed regarding his or her knowledge about, and experience with, specific environmental and structural factors relating to wildfire behavior and hazard.

Participants in the Weights Query

The weights query for factor importance in the **WHINFOE** model included approximately 20 fire behavior/management experts selected from the Colorado State Forest Service, the USDA Forest Service, the Boulder County Fire Protection Districts, the Boulder County Land Use Department, the City of Boulder Fire Department, the City of Boulder Parks and Open Space Department, and the City of Boulder Mountain Parks Department. The range of experience of the queried experts collectively included more than 200 large, major event wildfires, more than 1500 small, initial attack wildfires, and numerous prescribed fires. The collective experience contained within the group spanned more than just Boulder County, Colorado experience. Many of the queried persons had national, major event wildfire experience from other western and southern states, as well as from other locations within Colorado but outside of Boulder County. Based upon the broad, national fire behavior/management experience represented by some of the experts queried, the model was designed to be applicable throughout the Western US.

Appendix J: RESOURCES LIST

WHERE TO GET ASSISTANCE		
WHO	**WHAT**	**HOW**
(your local) Protection District _____, Chief	Local fire protection district services; advice on defensible space concepts	Phone ___-____
Colorado State Forest Service Alan Owen, District Forester	Advice on defensible space concepts; plant selection; tree removal or replanting advice; advice on timber management; community wildfire mitigation plans; fire conditions; educational programs such as the 'Road Show"; administration of the Stewardship Incentive Program (SIP)	Phone 303-442-0428
U.S. Forest Service, Boulder District Christine M. Walsh, District Ranger Rebecca Parameter, Resources Program Manager Robert Nykamp, Visitor Information Specialist	Coordinating defensible space projects on U.S. Forest Service land; information on wildfires and wildland areas; wildland fire crews	Phone 303-444-6600
Boulder County Land Use Department Wildfire Mitigation Coordinator and WHIMS Coordinator	Advice on defensible space concepts; information on zoning and land use regulations; information on site plan review process and the wildfire mitigation plan requirements; wildfire mitigation projects such as the Wildfire Hazard Identification and Mitigation System (WHIMS) and the "Road Show'	Phone 303-441-3930
Boulder County Building Safety Inspection Services Division Gerry George, Chief Building Official	Advice on building in a wildland area; building code and permit information; fire codes information; wildfire mitigation projects (Boulder County Wildfire Mitigation Group	Phone 303-441-3925
Boulder County Parks and Open Space Dept. Randy Coombs, Resource Specialist	Coordinating defensible space work on County Open Space property; information on plants, wildlife and fire ecology	Phone 303-441-3950; also, 303-441-3964
Boulder County Sheriff's Department – Emergency Services Group Gary Fager, Coordinator	Coordination of work crews on fuel removal/prescribed burning; education programs on wildfire mitigation/hazards; emergency services in the county	Phone 303-441-3650
Boulder County & City of Boulder Office of Emergency Management Larry Stern, Director	Coordination of resources during major fires; coordination of disaster services; information on wildfire mitigation; information on other natural or man-made hazards; emergency operation planning	Phone 303-441-3637
Boulder County Solid Waste Division; Hilary Collins, Manager	Slash removal; chipping projects, services, contractors	Phone 303-441-3930
American Red Cross, Boulder County Branch Branch Manager	Disaster relief services; wildfire video; education and volunteer programs	Phone 303-442-0577

City of Boulder Fire Department Marc Mullenix, Wildland Fire Coordinator	Wildfire mitigation programs; information on wildfires; advice on defensible space concepts; coordinating defensible space/vegetation management/prescribed burning on City Open Space and Mountain Parks; fire code information; interagency coordination information	Phone 303-441-4353; also, 303-441-3350
City of Boulder Fire Department Greg Toll, Wildland Fire Administrator	Coordination of the FIRMIT wildfire mitigation project for the City of Boulder	Phone 303-441-3350
Safescaping Project; Edie DeWeese, Coordinator	Information on the 'safescaping" concept of landscaping gardens with more fire resistive plants and vegetation; information on the "Safescaping' video and landscaping project site	Phone 303-497-3319
Boulder County Fire Fighters Association; Bruce Mygatt, Chair	Coordination with local fire protection districts	Phone 303-530-9575
The National Wildland/Urban Interface Fire Protection Program	Web-site with useful wildfire mitigation information	http://www.firewise.org

Appendix K: PUBLICATIONS & VIDEOS

Wildfires: Living With The Reality (1993) a 23-minute video showing live footage of the Black Tiger and Olde Stage fires in Boulder County with information on fire history, fire behavior, defensible space, and what to do if caught in a wildfire. Copies can be obtained from the American Red Cross, Boulder Branch of the Mile High Chapter, 5378 Sterling Drive, Boulder, CO 80303, (303) 442-0577. The video costs $20.00 for Boulder County residents and $39.00 plus $5.00 shipping and handling for others. Copies are also available in the Boulder Public Library.

NEW! AVAILABLE SOON! Safescaping (1994) a 10-minute video about landscaping for wildfire protection. Copies can be obtained from the Boulder County Fire Fighters' Association, PO Box 94, Boulder, CO 80306 or by calling Edie DeWeese at 497-3319. The video will approximately cost $20. Copies will also be available from the Boulder Public Library.

Brochures: * Checklist for Safety and Survival. Precautions in the Wildland/Urban Interface (free) Copies available from the Boulder County Land Use Department, P.O. Box 471, Boulder, CO 80306, (303) 441-3930.

* Home Fire Protection in the Wildland/Urban Interface (free). Copies available from the Colorado State Forest Service, 936 LeftHand Canyon Drive, Boulder, CO 80302, (303) 449-5570.

Publication: Wildfire Protection in the Wildland Urban Interface (free). Copies available from the Colorado State Forest Service, 936 LeftHand Canyon Drive, Boulder, CO 80302, (303) 449-5570.

WHAT YOU CAN DO

- Practice GOOD DEFENSIBLE SPACE!
- Learn more about SAFESCAPING.
- Request FUEL REDUCTION ALTERNATIVES in your community.
- Recruit NEIGHBORHOOD LEADERS or ORGANIZE HOMEOWNERS to assist in implementing defensible space concepts at the neighborhood level.
- SUPPORT and GET INVOLVED with your local fire protection district.
- Have an EVACUATION PLAN for yourself and family as well as for the neighborhood.

INDEX