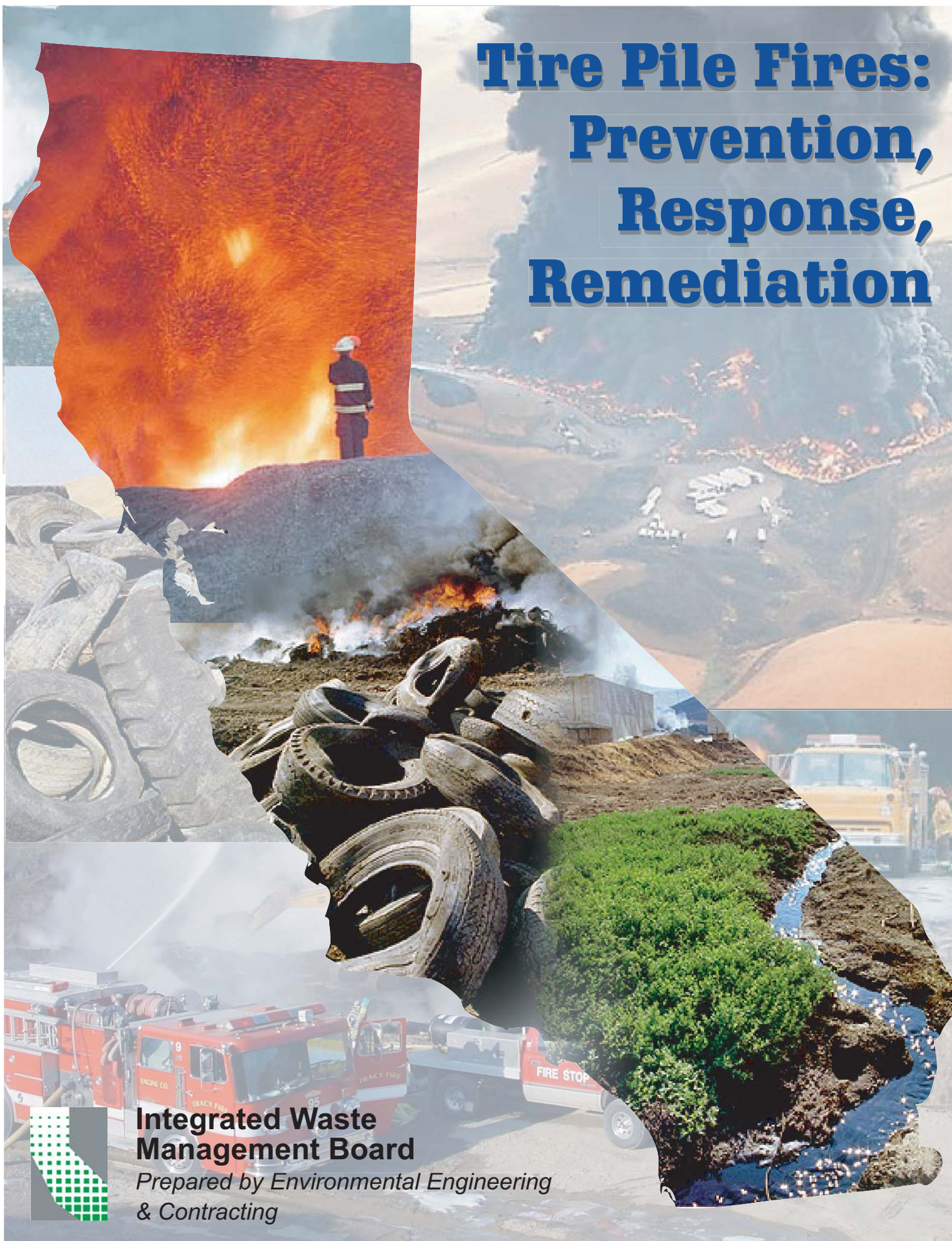


# Tire Pile Fires: Prevention, Response, Remediation



**Integrated Waste  
Management Board**  
*Prepared by Environmental Engineering  
& Contracting*



# **TIRE PILE FIRES**

## **PREVENTION, RESPONSE, REMEDIATION**

**September 23, 2002**

**Prepared By:  
Environmental Engineering and Contracting, Inc.  
505 Parkcenter Drive  
Santa Ana California 92705  
(714) 667-2300**

## TABLE OF CONTENTS

Abbreviations and Acronyms .....	iv
1.0 Introduction.....	1-1

### **Section A – History, Legislation, and Enforcement**

2.0 Brief History of Tires.....	2-1
2.1 History of Vulcanization and Tires.....	2-1
2.1.1 Natural Rubber.....	2-1
2.1.2 Synthetic Rubber.....	2-1
2.1.3 Bias Ply Versus Steel Belt .....	2-2
2.2 Tire Industry and Background.....	2-2
2.2.1 Chemical Compounds of Tires – Historic .....	2-2
2.2.2 Chemical Compounds of Tires – Current .....	2-2
3.0 Statutes and Enforcement in California .....	3-1
3.1 Current Statute .....	3-1
3.1.1 Collection and Disposal/Reuse .....	3-1
3.1.2 Abatement of Existing Tire Piles.....	3-1
3.1.3 Recycling/Reuse .....	3-2
3.1.4 Funding.....	3-2
3.2 Current Code and Regulatory Compliance for Storage/Disposal Facilities .....	3-2
3.2.1 Federal.....	3-2
3.2.2 State.....	3-2
3.2.2.1 California Code of Regulations .....	3-2
3.2.2.2 California Public Resources Code .....	3-4
3.2.3 Local .....	3-5
3.3 Enforcement.....	3-5
3.3.1 Enforcement Agencies.....	3-5
3.3.2 Enforcement Mechanisms.....	3-5

### **Section B – Fire Prevention for Tire Piles**

4.0 Prevention by Alternative Use/Marketing .....	4-1
4.1 Tire Recycling/Reuse Markets.....	4-1
4.1.1 Reuse Options .....	4-1
4.1.2 Energy Options .....	4-3
4.1.3 Barriers to Reuse/Recycling .....	4-3
4.2 Tire Disposal Options .....	4-4
5.0 Fire Prevention at Existing Tire Pile Sites.....	5-1
5.1 Permitted Site Characterization and Evaluation .....	5-1
5.1.1 Review and Storage Site Design Requirements.....	5-2
5.1.2 Site Security and Fire Department Access.....	5-2
5.1.3 Water Supply Requirements .....	5-3
5.1.4 Identify Sensitive Receptors in Surrounding Communities.....	5-3
5.2 Unpermitted Site Characterization and Evaluation.....	5-4
5.2.1 Identify Tire Pile Locations .....	5-4

5.2.2	Identify Responsible Parties .....	5-4
5.3	Site Assessment .....	5-4
5.3.1	Assessment and Mapping of Tire Pile Characteristics .....	5-5
5.3.2	Site Specific Characteristics/Unusual Circumstances .....	5-5
5.3.3	Topography, Geology, and Climate.....	5-5
5.4	Develop Site Contingency Plan (Pre-incident Planning).....	5-6
5.4.1	Resources .....	5-6
5.4.2	Topography.....	5-6
5.4.3	Notification.....	5-6
5.4.4	Pyrolytic Oil.....	5-7

**Section C – Tire Fire Response**

6.0	Education of Firefighters/Planning.....	6-1
6.1	Education .....	6-1
6.1.1	Training Programs .....	6-1
6.1.1.1	Firefighters.....	6-2
6.1.1.2	Site Operators.....	6-3
6.1.2	Fire Fighting Techniques .....	6-3
6.1.2.1	Exposures.....	6-4
6.1.2.2	Containment.....	6-4
6.1.2.3	Extinguishment .....	6-4
6.1.3	Health and Environmental Concerns .....	6-6
6.1.4	Non-Standard Firefighting Equipment .....	6-6
6.2	Preplanning .....	6-8
6.2.1	Develop Pre-Incident Plan .....	6-8
6.2.2	Identification of State and Local Emergency Response Teams.....	6-11
6.2.3	Identification of Local and or Regional Response Contractors.....	6-11
6.3	Health and Safety.....	6-12
6.3.1	Site Safety Plan.....	6-13
6.3.2	Evaluation of Dangers to Life Safety.....	6-13
6.3.3	Threat to Surrounding Communities .....	6-14
6.3.4	Recognize Fire as a HAZMAT Response.....	6-14
6.3.5	Establishment of HAZMAT Procedures.....	6-14
6.3.6	Identify Toxic Exposure Hazards .....	6-15
6.3.7	Personal Protective Gear.....	6-15
6.3.8	Establishment of Control Zones.....	6-15
6.3.9	Decontamination Procedures .....	6-16
7.0	Command and Control.....	7-1
7.1	Access Fire.....	7-1
7.1.1	Burn Suppression.....	7-2
7.1.2	Spread Control .....	7-2
7.2	Recognize Unusual Activities/Site Practices .....	7-2
7.3	Establish Unified Command.....	7-3
7.4	Establish Effective Communication .....	7-3
7.5	Coordinate Public Agencies and Private Contractors.....	7-4
7.6	Recognize Contact Notification Procedures .....	7-5
7.7	Mobilize Resources.....	7-6
7.8	Public Relations and Information .....	7-6
7.8.1	Responding to Public and Press.....	7-6

7.8.2	Develop an Information Distribution System.....	7-6
8.0	Implement Action Plan.....	8-1
8.1	Develop Standard Operating Guidelines.....	8-1
8.2	Tire Fire Dynamics (Stages of Combustion).....	8-2
8.2.1	Ignition and Propagation Stage.....	8-2
8.2.2	Free Burning: Compression Stage.....	8-2
8.2.3	Free Burning: Equilibrium and Pyrolysis Stage.....	8-3
8.2.4	Smoldering Stage.....	8-3
8.3	Firefighting Tactics/Strategies.....	8-3
8.3.1	Rural.....	8-5
8.3.2	Urban.....	8-5
9.0	Environmental Concerns.....	9-1
9.1	Pyrolytic Oil, Ash, Smoke, and Water.....	9-1
9.1.1	Pyrolytic Oil.....	9-1
9.1.2	Ash.....	9-2
9.1.3	Smoke.....	9-3
9.1.4	Water.....	9-5
9.2	Environmental Monitoring.....	9-5
9.2.1	Air Sampling.....	9-5
9.2.2	Sampling Run-off Water.....	9-7
9.3	Run-off Control.....	9-7
9.4	Immediate Remediation Needs.....	9-8
9.5	Other Site Characterization Activities.....	9-8

## **Section D – Post Fire Assessment and Remediation**

10.0	Site Assessment and Related Activities.....	10-1
10.1	Site Assessment.....	10-1
10.2	Identify the Chemicals of Concern.....	10-1
10.3	Soil Sampling.....	10-3
10.4	Water Sampling.....	10-4
10.5	Air Sampling.....	10-5
10.6	Quality Assurance/Quality Control.....	10-5
10.7	Health and Safety Plan.....	10-6
10.8	Site Monitoring.....	10-6
10.9	Medical Monitoring.....	10-6
10.10	Public Notification.....	10-8
11.0	Possible Site Remediation Options.....	11-1
11.1	Remediation Options.....	11-1
11.2	Prevention of Contaminant Migration.....	11-1
11.3	Evaluate Disposal Options.....	11-2
11.4	Decontamination Equipment.....	11-2
11.5	Long Term Monitoring and Operation and Maintenance.....	11-3
12.0	Documentation and Reports.....	12-1
12.1	Liability Issues Documentation.....	12-1
12.2	Final Report – Lessons Learned.....	12-1
13.0	Bibliography.....	13-1



## ABBREVIATIONS AND ACRONYMS

AB	California State Assembly Bill
ADC	Alternative daily cover
ASTM	ASTM International, formerly American Society for Testing & Materials
BTU	British thermal unit
Cal-EPA	California Environmental Protection Agency
CAM-17	California assessment metals, list of 17 metals from Title 22 CCR
CCR	California Code of Regulations
CFR	Code of Federal Regulations
CGI	Combustible gas indicator
CIWMB	California Integrated Waste Management Board
CO	Carbon monoxide
COC	Chemicals of concern
CRZ	Contaminant reduction zone
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FID	Flame ionizing detector
FOSC	EPA Federal On-Scene Coordinator
GC	Gas chromatograph
GCMS	Gas chromatograph/mass spectrometer
GPM	Gallons per minute
HAZWOPER	Hazardous waste operations and emergency response
HSP	Health and safety plan
ICP	Inductively coupled plasma
ICS	Incident command system
IDLH	Immediately dangerous to life and health
IIO	Incident information officer
LEL	Lower explosive limit
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Safety and Health
N.O.R.	Not otherwise regulated
O <sub>2</sub>	Oxygen
O&M	Operation and maintenance
OSHA	Occupational Safety & Health Administration, U.S. Department of Labor
OSWER	Office of Solid Waste and Emergency Response
OVA	Organic vapor analyzer
PAH	Polynuclear aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PID	Photo ionizing detector
PIO	Public information officer
PPE	Personal protective equipment
PPM	Parts per million
PRC	California Public Resources Code
QA/QC	Quality assurance/quality control
QMP	Quality management plan
RAC	Rubberized asphalt concrete
RMA	Rubber modified asphalt
RP	Responsible party
SAP	Sampling and analysis plan
SOP	Standard operating procedure
SBR	Styrene butadiene rubber
SSHO	Site safety and health officer
STLC	Soluble threshold limit concentration
SVOC	Semi-volatile organic compound

## **Abbreviations and Acronyms (continued)**

TDF	Tire-derived fuel
TLV	Threshold limit value
TTLC	Total threshold limit concentration
TWA	Time-weighted average
UC	Unified command
UFC	Uniform Fire Code
USFA	United States Fire Administration
VOC	Volatile organic compound

## 1.0 INTRODUCTION

In October 2001, the California Integrated Waste Management Board convened a workshop to discuss the most up-to-date emergency response measures designed to protect the environment and human health before, during and after a tire pile fire. Environmental Engineering and Contracting, Inc. was selected to convene this workshop and prepare a report which would serve as a guidance document for managing tire fires and to provide the California Integrated Waste Management Board (CIWMB) with a summary of existing data concerning the health and environmental impacts of tire pile fires. The workshop consisted of ten invited guest's representing the fire service, government, Environmental Protection Agency, and consultants. Each expert has significant experience managing various aspects of tire pile fires, their prevention, and/or environmental and health and safety effects resulting from the tire fires. The workshop, held at the offices of the California-Environmental Protection Agency in Sacramento California, was designed to allow a free exchange of information and experience in fire prevention, tire fire response, fire fighting tactics, health and safety, environmental issues, and remediation.

This report is divided into four sections. Section A of this report contains a discussion of the history of rubber; legislation regarding used tires in California; and enforcement actions related to waste tire piles. Section B contains a discussion on Fire Prevention, ranging from tire recycling option to fire prevention at existing tire pile sites. Section C includes a discussion of Tire Fire Response, including education, fire fighting techniques, pre-planning, command and control; health and safety precautions, and environmental concerns. Section D addresses post fire assessment and remediation at tire pile fire sites.

Each section is designed to be stand-alone document, allowing professionals in one field (for instance fire fighting) to review the section pertaining to their profession (Tire Fire Response) without missing crucial information. Therefore, those persons reading the entire document, may find certain topics repetitive, however, attempts have been made to minimize this as much as possible.

The information contained in this document is based upon the collective experiences of professionals from a variety of fields, and includes information taken directly from previous documents prepared on this topic.



## Acknowledgement

The insight, experiences and contributions of the participants of the workshop is greatly appreciated. The participants included (in alphabetical order):

Michael Blumenthal Vice President Rubber Manufactures Association 1400 K Street, NW Washington, DC 20005	Ms. Martha Gildart Supervising Waste Management Engineer California Integrated Waste Management Board 1001 I Street Sacramento, California 95812
Susan Boraston SP Environmental Services 1305 Whispering Pines Drive Scotts Valley, California 95066	Waddell Hill Deputy Fire Marshal Pierce County Fire Protection District 201 S. "J" Street Tacoma, Washington 98405
James Coulson Retired Manager of Operations Office of the Fire Marshal Toronto, Ontario	Mr. Dan Shane Federal On-Scene Coordinator United States Environmental Protection Agency 75 Hawthorne Street San Francisco, CA 94105-3901
Vernon Elarth URS Corporation Crown Corporate Center 2870 Gateway Oaks Drive, Suite 300 Sacramento, CA 95833	Rodney Slaughter Dragon Fly Communications 528 Oak Mill Court Chico, California 95926
John Fellingner Senior Staff Consultant TechLaw Inc. 1617 JFK Boulevard, Suite 1705 Philadelphia, PA 19103	Mr. Todd Thalhamer Waste Management Engineer California Integrated Waste Management Board 1001 I Street Sacramento, California 95812

This document also relied heavily upon documents and guidelines prepared by other agencies and organizations. Readers are encouraged to review these publications for additional insight and information pertaining to the prevention of fires, firefighting techniques, and environmental awareness and sampling. A complete list of these publications is included in the Bibliography to this report. Special thanks would like to be given to the authors of several publications that were heavily utilized in the preparation of this document. These documents include:

Rings of Fire - Fire Prevention and Fire Suppression of Scrap Tire Piles  
California Office of State Fire Marshall (COSFM), 1995 .

Guidelines for the Prevention and Management of Scrap Tire Fires.  
Scrap Tire Management Council, 1992.

Scrap and Shredded Tire Fires, (Report 093)  
United States Fire Administration. December 1998.

This document contains guidelines which do not necessarily represent the policies of the California Integrated Waste Management Board, its staff or members, or members of the workshop.

Questions or comments regarding this report can be directed to the CIWMB or Mr. Mark Zeko, Environmental Engineering and Contracting, Inc., (714) 667-2300.

## SECTION A – HISTORY, LEGISLATION, AND ENFORCEMENT

Since early vulcanization processes allowed the use of natural rubber to be formed into tires, piles of scrap or waste tires have been accumulating. Section A presents a brief history of tires and the tire industry along with statutes, codes and regulations associated with the storage and/or disposal of waste or scrap tires.



## 2.0 BRIEF HISTORY OF TIRES

### 2.1 History of Vulcanization and Tires

The vulcanization process, which transforms natural rubber into a substance with the stability and durability to be useful for tires, was first discovered in approximately 1839 by Charles Goodyear. Rubber tires were first invented in the late 1800s for bicycles, but competent air-filled rubber tires were not developed until the early 1900s.

#### 2.1.1 Natural Rubber

Prior to the invention of vulcanized rubber by Charles Goodyear in 1839, natural rubber had few industrial uses. South American natives had been using natural rubber for centuries to make items such as water resistant shoes, coats, etc. However, products made from natural or India rubber, as it was known, melted in hot weather, froze and cracked in cold, and adhered to everything they touched. Many inventors in the early 1800s experimented with ways to increase the stability and durability of rubber. In 1830, Charles Goodyear began experimenting with raw rubber to turn it into a useable product. Over the next nine years, Goodyear spent much of his time working with rubber. By 1839, he had a product the consistency of gum, which he had hardened by mixing the rubber with sulfur and treating it with an acid gas. When Goodyear's gummy substance accidentally landed on a hot stove, he discovered it had reached the consistency he had been trying to achieve, and the vulcanization process had been discovered (Olcutt, 2001).

Rubber was first used to make tires in Belfast, Ireland in 1888, by John Dunlop. Dunlop used a thin rubber sheet covered with fabric to make air-filled tires for his son's bicycle. In 1889, Dunlop's tire concept was sold to Harvey du Cross, Jr., the founder of the Dunlop Rubber Company. The first air-filled tires for cars were made by André Michelin in 1895, for a 350-mile auto race from Paris to Bordeaux. However, numerous flat tires during the race caused the air-filled tire to be thought of as a failure for automobiles.

In 1911, the Hardman Tire & Rubber Company became the first to produce a combination tire and tube. An air filled inner tube was surrounded by a hardened rubber tube that was reinforced with fabric, creating the first usable air-filled tire for automobiles. A patent for the first tubeless tire, which used a two-piece arrangement similar to the Hardman company design, was granted in 1903, but it wasn't until 1954 that the first automobile with tubeless tires was offered on the market. In 1908, Frank Seiberling, founder of the Goodyear Tire and Rubber Company, built a machine that cut grooves in the hard tire surface for traction. In 1910, the B.F. Goodrich Company added carbon to the rubber to reduce wear. By 1920, the life expectancy of an automobile tire was 13,000 miles (Encyclopedia.com, 2002).

#### 2.1.2 Synthetic Rubber

Contact was cut off with rubber producers in Asia and South America at the beginning of World War II. The lack of natural rubber forced tire companies to develop a petroleum-based synthetic rubber. The Goodyear Tire and Rubber Company began making synthetic tires in 1937 and patented a man-made substance called Chemigum. By 1950, man-made rubber made up half of all tires produced. Today, over 60 percent of a tire is synthetic (Encyclopedia.com, 2002).

Synthetic rubber is made from derivatives of petroleum, coal, oil, natural gas, and acetylene. Synthetic rubber is comprised of copolymers, which can be altered to achieve specific properties that make the product better suited for different uses. The synthetic rubber generally used for tires is called styrene-butadiene rubber (SBR), which is one of the earliest synthetic rubbers and whose properties are close to those of natural rubber (Columbia, 2000). Synthetic rubber ages and weathers better than natural rubber,

is more resistant to chemicals such as oil, solvents, oxygen, and ozone, and remains resilient over a wider temperature range than natural rubber. However, synthetic rubber tends to allow greater heat buildup from flexing and is less resistant to tearing when heated.

### 2.1.3 Bias Ply Versus Steel Belt

The single change in the tire manufacturing industry that has had the greatest impact on the current waste tire pile issue was the transition from bias ply to steel belted tires. Commercial tires were originally constructed in a bias ply configuration. In a bias ply tire, the cords in a single ply run across the tire in a crisscross pattern to provide strength. Modern tires, however, are constructed with a steel belt (radial-ply belted) or a rigid belt of synthetic fabric (bias-ply belted) to provide strength (Encyclopedia.com, 2002). Belted tires provide longer wear than bias ply tires. The significance of this change to the scrap tire industry is that steel belted tires cannot be retreaded and are generally discarded after use instead of recycled (CIWMB, 2002b). Additionally, the steel in discarded tires is a source of heavy metals that are released during a tire pile fire.

## **2.2 Tire Industry and Background**

### 2.2.1 Chemical Compounds of Tires – Historic

The earliest tires were made by vulcanizing natural rubber, to harden and stabilize the natural rubber. The vulcanization process basically consisted of adding sulfur to natural rubber, treating it with acid, and heating the product. Natural rubber essentially consists of a hydrocarbon compound called isoprene. This natural rubber was often mixed with fillers, pigments, antioxidants, vulcanizing agents, etc. Rubber was reinforced with fabric beginning in the late 1800s.

### 2.2.2 Chemical Compounds of Tires – Current

Modern tires consist of three major components: the body, tread and sidewalls, and beads. The body is comprised of multiple layers of rubberized fabric, which is generally made of rayon, nylon, or polyester. Chemically treated rubber comprises the sidewalls and tread. The beads are two steel hoops that hold the tire to the wheel rim (Columbia, 2000).

Today, a tire's chemical composition typically includes: natural and synthetic rubber polymers, oil fillers, sulfur and sulfur compounds, phenolic resin, clay, aromatic, naphthenic, and paraffinic oil, fabric, petroleum waxes, pigments such as zinc oxide and titanium dioxide, carbon black, fatty acids, inert materials and fiber made from steel, nylon, polyester or rayon (USEPA, 2000b). These compounds are listed in the table below.

**TABLE 2-1**  
Typical Tire Composition

Natural and synthetic rubber polymers	Petroleum waxes
Pigments such as zinc oxide and titanium dioxide	Oil fillers
Sulfur and sulfur compounds	Carbon black
Phenolic resin	Fatty acids
Steel, nylon, polyester or rayon fibers	Inert materials
Aromatic, naphthenic, and paraffinic oils	Clay
Fabric	

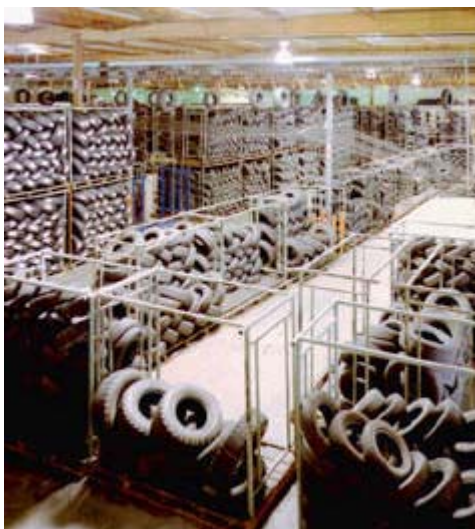
Source: USEPA, 2000b

## 3.0 STATUTES AND ENFORCEMENT IN CALIFORNIA

### 3.1 Current Statute

According to the California Integrated Waste Management Board (CIWMB, 2002a), approximately 31 million reusable and waste tires are generated annually in the State of California. Of these, it is estimated that approximately 20 million are reused or recycled (retreading, recycling, or combustion). The remaining 11 million are either shredded and disposed of in a permitted solid waste facility, disposed of as whole waste tires in a permitted scrap tire facility, or disposed of illegally in waste piles throughout the state. Currently about 3 million waste tires are stockpiled in disposal facilities throughout the state. There are currently three statutes for collection, disposal, recycling, and management of waste tires in California, as listed below:

- Title 14 California Code of Regulations (CCR), Chapter 3, Article 5.5, entitled “Waste Tire Storage and Disposal Standards”
- The California Tire Recycling Act of 1989 (AB 1843)
- California Public Resources Code (Chapters 7, 16, and 17)



#### 3.1.1 Collection and Disposal/Reuse

Article 5.5 of Title 14 CCR contains the California State regulations associated with waste tire storage and disposal. The California Public Resources Code grants the CIWMB the authority to create and enforce the laws regarding tire piles in the State of California. Specific requirements of the California State laws and codes are provided in Section 3.2.2 below.

#### 3.1.2 Abatement of Existing Tire Piles

Pursuant to Section 42821 of the California Public Resources Code, a major waste tire facility permit requires that a detailed plan and implementation schedule be submitted for “the elimination or substantial reduction of existing tire piles...” The CIWMB or local designated agency is responsible for enforcement of the tire abatement plan.

### 3.1.3 Recycling/Reuse

The CIWMB is charged with managing tire recycling efforts in the State of California. Chapter 17 of the PRC contains the provisions of the California Tire Recycling Act. Chapter 7 of the PRC outlines the Retreaded Tire Program. The California Tire Recycling Act comprises a funding mechanism to provide the means necessary to both enforce current codes, and subsidize and otherwise encourage tire recycling research efforts by both government and private industry. The Retreaded Tire Program is one such effort, in which market evaluations are performed for retreaded tires and certain State vehicles are obligated to use retreaded tires.

### 3.1.4 Funding

In 1989, California Assembly Bill 1843, also known as the California Tire Recycling Act, created the California Tire Recycling Management Fund and established a \$0.25 per tire fee to be collected from each purchaser (CIWMB, 1999). This bill also launched the permitting program for major waste tire facilities, gave the CIWMB the authority to impose fines for non-compliance, and required the CIWMB to adopt regulations regarding shredded tire storage at landfills (CIWMB, 1999). In 2000, California Senate Bill 876 increased funding to \$1.00 per tire through the year 2006, after which the fee will be reduced to \$0.75 per tire (PRC 42885). The fee was increased and extended in order to create an emergency reserve fund and provide funds for tire pile cleanup, a tire hauler manifest system, and tire disposal enforcement (CIWMB, 2001).

## **3.2 Current Code and Regulatory Compliance for Storage/Disposal Facilities**

### 3.2.1 Federal

There are no Federal regulations pertaining to storage and disposal of waste tires. The legislative responsibility lies with each individual state. However, the EPA does have numerous programs and initiatives in place to help reduce the millions of scrap tires across the nation. Also, the National Fire Protection Association (NFPA) issues standards and codes pertaining to the indoor storage of tires (NFPA, 1989).

### 3.2.2 State

#### *3.2.2.1 California Code of Regulations*

Article 5.5 of Title 14 of the California Code of Regulations (CCR) contains the California State regulations associated with waste tire storage and disposal. Title 14 incorporates the storage requirements in the Uniform Fire Code and the National Fire Protection Association (1989) Code 231D. The statutes in Title 14 CCR apply to any solid waste facility storing 500 or more waste tires, any major or minor waste tire facility storing tires indoors or outdoors, and any solid waste facility that disposes tires by burying (14 CCR Section 17350). The statute comprises the following sections:

*Fire Prevention Measures* (Section 17351) - This section mandates that certain measures are taken at each qualifying facility to minimize the risk of fire. The four measures identified in the statute include:

1. Maintaining communication equipment at all staffed facilities to ensure that an attendant can immediately notify the appropriate fire authority in the event of a fire;
2. Maintaining adequate fire control equipment in working order at the facility, including one dry chemical fire extinguisher, one 2.5-gallon water extinguisher, one 10-foot long pike pole, one round point shovel, and one square point shovel;
3. Maintaining an adequate water supply for use by the local fire authority in the event of a fire, capable of delivering either 1,000 gallons per minute (gpm) for three hours at facilities with under



10,000 waste tires, or 2,000 gpm for three hours at facilities with greater than 10,000 waste tires; and

4. Granting the local fire authority the power to develop different standards for fire control equipment and water supply than are stated in Section 17351, if the local fire authority determines these changes are necessary to meet the intent of the written standards for fire control and protection of life and property, and the CIWMB approves the alternative requirements.

*Facility Access and Security* (Section 17352) - This section mandates that certain measures be implemented at each qualifying facility to provide access to emergency vehicles, maintain security from unauthorized persons, and provide signage with a minimum amount of information. The three measures identified in the statute include:

1. Maintaining a sign at the facility entrance that gives the name of the operator, states whether tires are received from any source other than the operator, and gives the operating hours and site rules;
2. Having an attendant on duty during business hours if the facility receives tires from a source other than the site operator; and
3. Maintaining an access road to the facility for emergency and vector control vehicle use, and strictly controlling unauthorized access to the facility.

*Vector Control Measures* (Section 17353) - This section establishes measures to minimize vector habitats within tire piles. All tires shall be stored in a manner that prevents breeding and habitation of mosquitoes, rodents, snakes, etc. This can be done by covering piles with an impermeable barrier other than soil to keep precipitation from accumulating, and/or using vector treatment methods that are approved by the local vector control authority or the local health department.

*Storage of Waste Tires* (Section 17354) - This section provides guidelines for the size and configuration of tire piles. The six guidelines mandate that:

1. An individual tire storage unit will not exceed an area of 5,000 square feet, with a volume of no more than 50,000 cubic feet and a height of no more than 10 feet. If the tire pile is located within 20 feet of any property line, the tire storage unit shall not exceed 6 feet in height. No tire pile is allowed within 10 feet of any property line. Table 3-1 is provided below showing the minimum allowed distance between waste tires and structures (fire lane widths) located on- or off-site (14 CCR Section 17354);

**TABLE 3-1**  
Representative Exposure Separation (Fire Lane) Distances (Ft.)

Length of Exposed Face (Ft.)	Tire Storage Pile Height (Ft.)		
	6	8	10
25	50	56	62
100	84	100	116
150	99	117	135
200	111	130	149
250	118	140	162

Source: 14 CCR

2. Waste tires shall be separated from vegetation or any other flammable material by at least 40 feet. Fire lanes must be maintained at a minimum width based on Table 3-1 (14 CCR Section 17354). These fire lanes must be unobstructed at all times and kept free of flammable materials or vegetation;
3. The local fire authority has the power to develop different standards for fire control equipment and water supply than are stated in Section 17354, if the local fire authority determines these changes are necessary to meet the intent of the written standards for fire control and protection of life and property. Any changes must be reported to the CIWMB within 30 days;
4. Surface water drainage must be diverted away from or around any waste tire storage units;
5. Waste tires may not be stored on grades that will interfere with fire fighting equipment or personnel, unless a written exception is granted by the local fire authority; and
6. New waste tire storage facilities may not be sited a) in an area that may be subjected to flooding during a 100-year storm, unless it can be demonstrated to the CIWMB that tires would not migrate or be transported offsite, and b) in an area with physical features or grades that will interfere with fire fighting efforts.

*Storage and Disposal of Waste Tires at Solid Waste Facilities* (Section 17355) - This section states that after January 1, 1993, waste tires may not be disposed of in landfills or other solid waste disposal facilities, unless they are permanently reduced by shredding or some other approved method. This requirement does not apply to waste tires commingled with municipal waste at less than one-half percent by weight, waste tires in household loads that cannot easily be separated, or oversized waste tires (17.5 x 24 or larger) received prior to January 1, 1994.

*Indoor Storage* (Section 17356) - According to this section, waste tires stored indoors should meet conditions set forth in “The Standard for Storage of Rubber Tires,” National Fire Protection Association, NFPA 231D-1989 edition, unless the local fire authority determines that different requirements are necessary to meet the intent of the above referenced fire control standard. Storage requirements in Article 5.5 do not apply to waste tires stored in fully enclosed, moveable containers that are kept closed and locked except during loading or unloading.

### 3.2.2.2 California Public Resources Code

The California Public Resources Code provides the CIWMB the framework and authority to create and enforce laws regarding tire piles. The applicable sections of the California Public Resources Code are listed below:

CHAPTER 7. RETREADED TIRE PROGRAM	
Article 1. Definitions .....	<a href="#">42400-42401</a>
Article 2. Retreaded Tire Program.....	<a href="#">42410-42416</a>
CHAPTER 16. WASTE TIRES	
Article 1. Definitions .....	<a href="#">42800-42808</a>
Article 2. General Provisions.....	<a href="#">42810-42814</a>
Article 3. Major Waste Tire Facility Permits.....	<a href="#">42820-42825</a>
Article 4. Minor Waste Tire Facility Permits.....	<a href="#">42830-42835</a>
Article 5. Renewal, Suspension, or Revocation.....	<a href="#">42840-42849</a>
Article 6. Administrative Enforcement.....	<a href="#">42850-42855</a>
CHAPTER 17. CALIFORNIA TIRE RECYCLING ACT	
Article 1. Findings .....	<a href="#">42860-42861</a>
Article 2. Storage at Landfills.....	<a href="#">42865-42867</a>
Article 3. Tire Recycling.....	<a href="#">42870-42875</a>
Article 4. Administration .....	<a href="#">42880-42883</a>

Article 5. Financial Provisions.....	<a href="#">42885-42889.4</a>
Article 6. Use of Recycled Tire Products by State Agencies.....	<a href="#">42890-42895</a>

### 3.2.3 Local

Title 14, Chapter 3, Article 5.5 allows the local fire authority having jurisdiction over a particular facility to require measures different than those listed in the statute to meet the intent of the laws. Any local fire requirements that differ from those found in Title 14 must be reported to the CIWMB within 30 days and must be approved by the CIWMB at the time of issuance or renewal of the permit. Also, the types of vector control treatments used in accordance with Section 17353 must be approved by the local health departments or other appropriate agencies.

## **3.3 Enforcement**

### 3.3.1 Enforcement Agencies

The primary agency charged with enforcing regulations and codes associated with waste tire piles is the CIWMB. The authority and framework for enforcement is set forth in the California Public Resources Code. The responsibility of enforcement also falls on local fire agencies and local health departments, or any designee of the CIWMB. State regulations contain provisions for local fire agencies to require site-specific measures that differ from those specified in the regulations, as long as they fulfill the spirit of the laws in terms of protection of life and property and are approved by the CIWMB. Local health departments are primarily involved in approving vector control treatments.

### 3.3.2 Enforcement Mechanisms

The primary enforcement mechanisms available to the CIWMB are the permitting system and the system of monetary fines, both of which are set forth in Chapter 16, Section 42850-42855 of the California Public Resources Code. Permits are required to store waste tires at a facility. Violations of state regulations or provisions of the major or minor waste tire facility permits result in civil actions such as suspension/revocation of a permit, a monetary fine, or imprisonment, as amount specified in Article 6 of Chapter 16 of the PRC. According to the PRC, a negligent violation of state laws can result in a fine of between \$500 and \$5,000 for each occurrence or for each day of a continuing violation. An intentional violation can result in a fine of up to \$10,000 per occurrence or per day of a continuing violation, imprisonment in the County jail for up to one year, or both fine and imprisonment.

## SECTION B – FIRE PREVENTION FOR TIRE PILES

It is often said that an ounce of prevention is worth a pound of cure. That old adage is also true when it comes to tire pile fires. Section B presents a discussion on alternative disposal methods (recycling and reusing) for scrap and waste tires, fire prevention measures for permitted and unpermitted tire disposal and/or storage facilities, and the process and value of preparing a fire contingency or pre-incident plan for each facility.



## 4.0 PREVENTION BY ALTERNATIVE USE/MARKETING

Tire pile fires can be prevented simply by not creating waste or scrap tire piles in the first place. This section discusses alternatives to scrap piles and their viability.

In California, the CIWMB has been given the responsibility by the PRC and the California Tire Recycling Act of managing the approximately 31 million waste tires that are generated annually throughout the state. The CIWMB estimates that approximately 20 million of these waste tires (65%) are currently being diverted away from tire piles toward an alternative end, such as recycling, reuse, or combustion (CIWMB, 2001). The CIWMB attempts to minimize the number of waste tires that are disposed of at landfills or scrap tire piles by continually encouraging the development of new markets for used tires. Programs that encourage new markets for waste tires include:

- Business development assistance to California enterprises;
- Research to expand the uses and recyclability of tires;
- Assistance to local governments in managing waste tires;
- Regulation of waste tire facilities and waste tire haulers to help ensure the protection of public health, safety, and the environment;
- Public education;
- The Tire Grant Program;
- The Recycling Market Development Zones Loan Program;
- Research Contracts; and
- Tire Recycling Conferences.

Funding for these programs is provided by the California Tire Recycling Management Fund, which currently receives revenue from a fee of \$1.00 per tire assessed on new tires. The California Tire Recycling Management Fund and the Tire Recycling Program were created by the California Tire Recycling Act of 1989, in an effort to reduce the number of stockpiled waste tires. Since the Tire Recycling Act was passed, the number of waste tires that have been diverted away from landfills has increased from an estimated 9.2 million to 20.1 million (CIWMB, 2001).

### 4.1 Tire Recycling/Reuse Markets

The CIWMB publishes a Waste Tire Marketing Guide (the Guide) as a resource to all businesses, recyclers, rubber product manufacturers, or anyone interested in recycling or reuse of waste tires in California. The Guide provides contact information for organizations that share the goal of the CIWMB to minimize scrap tire piles and waste tires, or are in the market for used tires to recycle. Many states have their own programs to encourage recycling or destruction of waste tires. This subsection describes many of the recycling options that are currently available. Hopefully, as technology progresses and as awareness increases the number and availability of recycling or reuse options will increase.

#### 4.1.1 Reuse Options

Many options and markets have been developed for reusing waste tires, in industries ranging from agriculture to civil engineering to sports. Some of the reuse markets are discussed in this section. However, the CIWMB and other agencies across the nation are continually encouraging the development of new markets.

Numerous value-added rubber products are made from crumb rubber (made by finely shredding rubber after removing the steel cords) or rubber in other forms from waste tires. Some examples are listed in Table 4-1 below.

**TABLE 4-1**  
Examples of Reuse Products

Athletic mats	Running tracks
Playground chips	Carpet padding
Toys	Airplane shock absorbers
Stock Feeders	Fences
Dock Bumpers	Boots
Door mats	Gloves
Hockey pucks	Soles for sandals
Mud flaps	Speed bumps
Roofing materials	Soaker hoses

Source: COSFM, 1995

Perhaps the most direct reuse of waste tires is retreading, in which the old tread is peeled from the casing, the casing is buffed, and a new tread is applied to the old casing. The old tread can then be reused in another application, and the retreaded tire put back into active service (COSFM, 1995). According to the CIWMB, retreading generally applies only to heavy truck tires, since passenger car tires are not designed for retreading (CIWMB, 2002b). However, the United States Fire Administration (USFA) and Federal Emergency Management Agency (FEMA) report that as of December 1998, approximately 38 million passenger car tires and truck tires were retreaded (USFA, 1998).

Several significant applications have been identified and developed in the civil engineering field. These applications include artificial reefs, breakwaters, retaining walls, and crash barriers, to name a few. Some of the more notable markets are listed below:

Rubberized Asphalt Concrete (RAC) or Rubber Modified Asphalt (RMA) – Crumb rubber is mixed with standard road paving materials to create RAC or RMA. Crumb rubber from as many as 800 to 1,200 waste tires is used per mile of a two-lane, 3-inch lift roadway (COSFM, 1995).

Alternative Daily Cover (ADC) – The CIWMB has approved the use of shredded tires as an ADC at municipal solid waste landfill sites in the State of California. California law (27 CCR Section 20614) requires that daily cover be used to cover “the active face at least at the end of each operating day in order to control vectors, fire, odor, blowing litter, and scavenging.” Currently only two municipal landfills in California use ADC, but the use of ADCs represents a potentially significant market for waste tires (CIWMB, 2002b).

Loose Fill – Using shredded tires as fill for low-lying areas or trenches provides good drainage. The shredded tires are generally covered with a thin soil layer (CIWMB, 2002).

Slope Stabilization – Use of shredded tires on inclines can reduce the risk of mud and landslides (CIWMB, 2002b).

Levee Slurry Walls – Still in the experimental stages, chipped (1-2 inch pieces) tires can be added to a slurry mixture to form a levee wall (CIWMB, 2002b).

Landfill Leachate Collection Systems – Shredded tires can be used as filter material in landfill leachate collection systems, allowing leachate to drain to a sump for transfer to a treatment system (CIWMB, 2002b).

Baled Tires – Baled waste tires can be used in fencing, retaining walls, or berms (CIWMB, 2002b).

Additionally, a significant number of waste tires in California are exported to foreign countries. In 1999, an estimated 1.5 million tires were exported for recyclable uses (CIWMB, 2002b).

#### 4.1.2 Energy Options

The largest market for reuse of waste tires both in the nation and in California is the use of tires as a fuel supplement in pulp and paper mills, cement kilns, and coal co-generation facilities. According to the CIWMB, nearly 39 percent of all waste tires generated in California in 1999 were used as fuel. Tire Derived Fuel, or Tire Diverted Fuel (TDF), is a high quality fuel that can produce up to 15,000 British Thermal Units (BTU) per pound of tire material (COSFM, 1995), as shown in Table 4-2. Additionally, tires generally create less ash and sulfur than some types of coal, and when mixed with coal burn completely, minimizing chemical emissions to the atmosphere.

**TABLE 4-2**  
Comparison of Heating Values

Fuel	BTU/Pound
Scrap Tires	15,000
Lignite Coal	7,000
Bituminous Coal	12,000
Petroleum Coke	13,500
No.6 Fuel Oil	18,000
Municipal Solid Waste	3,500
Newspaper	7,400
Sawdust	7,800

Source: COSFM, 1995

Three cement kilns in California used 4.1 million tires as supplemental fuel. Tires were used because they have higher heat energy by weight and they reduce emissions of certain regulated pollutants. Additionally, the steel belts in many tires produce minor amounts of iron ore, which is used in the cement making process (CIWMB, 2002b). Coal co-generation plants can burn shredded tires with the coal to produce energy. The CIWMB funded emissions tests at two coal co-generation plants in northern California. The results of these emissions tests revealed that these two coal co-generation plants could use 1-2 million tires per year (CIWMB, 2002b).

#### 4.1.3 Barriers to Reuse/Recycling

The CIWMB and other agencies across the nation are continually encouraging the development of new markets. This includes not only identifying new applications for recycled or crushed rubber, but also identifying and attempting to eliminate barriers to recycling.

One such barrier is the byproducts of burning tires. However, markets have been identified for many of the combustion products. Table 4-3 below shows some of the uses for the major combustion byproducts. For example, calcium from the quick lime used as a filter in the stack scrubbers at the Modesto Energy Plant in Modesto, California, absorbs sulfur from flue gases, forming calcium sulfate, or gypsum (COSFM, 1995).



**TABLE 4-3**  
Examples of Combustion Byproduct Markets

<b>Byproduct</b>	<b>Use/Market</b>
Calcium sulfate (gypsum)	Agricultural additive for clay soils
Zinc oxide (from fly ash)	Smelting, fertilizer and feed companies
Iron oxide (from furnace)	Cement production

Source: COSFM, 1995

The major barriers to recycling, however, are the cost and technological challenges related to pyrolysis, devulcanization, and gasification. In these areas, technological challenges must be met and processes must become more cost effective before additional markets can be developed.

**Pyrolysis** – Pyrolysis, the process of thermally decomposing organic substances into less complex molecules (USFA, 1998), can be applied to waste tires to generate oil, gas, carbon black, and steel. However, the cost of building tire pyrolysis plants is quite high, and the revenue from the sale of the pyrolysis products currently does not cover the cost of production (CIWMB, 2002b).

**Devulcanization** – Tires are originally created by combining sulfur and heat with natural rubber in a process called vulcanization. Reversing this process, or devulcanization, can break down old tires into a feedstock that can then be used to make new tires. However, the cost of this process currently limits its viability as an option (CIWMB, 2002b). Also, the current technology cannot completely remove the sulfur from the rubber, rendering the final product useless in bonding processes in which chemical bonding with other polymers is necessary, such as producing plastics.

**Gasification** – Gasification is the process of mixing pure oxygen with heavy oil from liquefaction of waste tires under great temperature and pressure to produce a gas. This gas can be used with steam turbines to produce electrical energy. Although Texaco Oil is experimenting with this technology, the gasification process is a long way from being a viable and available alternative use for waste tires (CIWMB, 2002a).

It is expected that in the foreseeable future there may be viable markets for the products of pyrolysis, devulcanization, and for gasification.

## **4.2 Tire Disposal Options**

Effective disposal options are continually being sought for the hundreds of millions of tires that are discarded each year. Currently there are no federal laws or regulations specifically governing scrap tires. At the State level, 48 states currently have some law or regulation regarding disposal and management of scrap tires. While each state has its own program, some common features include licensing or registration requirements for scrap tire haulers, processors and some end users; manifests for scrap tire shipments; limitations on who may handle scrap tires; financial assurance requirements for scrap tire handlers; and market development activities.

Although responsible means for disposal, such as recycling, reuse and energy-recovery have become more common, the tire dumps of the last forty years continue to present environmental and safety hazards that will continue into the foreseeable future. Scrap tires are not desirable in standard landfills because, when buried, the tires tend to trap air and “float”, which interferes with future landfill reclamation operations. As permitted landfill space diminishes, it is necessary to limit the types of accepted material to those better suited to future reclamation. However, this creates additional need for suitable scrap tire storage and disposal facilities.

Aside from recycling or reuse options, tire disposal options involve alternative methods of storing waste tires at scrap tire facilities. Several of these storage options are described below.

**Barrel Stacks** – Whole tires stacked on top of one another. Typically this is used for graded or reusable tires. These graded tires may be resold, retreaded, or exported to foreign dealers.

**Laced Stacks** – Whole tires stacked in an overlapping or herring bone pattern. This “laced” stacking takes advantage of space, exposes less surface area of the tires to a fire, and may be used as a retaining wall for randomly stacked tires.

**Random Stacks** – Tires are simply tossed into piles. This method requires little effort or handling by a site operator but also requires the most storage space. Randomly stacked tires are a greater fire risk because they expose more tire surface area and create greater volumes of air between tires than other stacking methods.

**Bundling/Bailing** – Up to 18 whole scrap tires can be compressed from approximately 11 feet into approximately 30-inch bundles. This process clearly reduces the space required to store tires and reduces interior spaces decreasing potential wildlife and insect habitats. However, studies have shown that even after 6-months of compression, when the bundling is released the tires spring back to their original shape. In a fire, the steel bundling wires are broken by high temperatures and stress from the bundled tires. As the tires quickly return to their original size and shape, oxygen and fire are drawn into the interior space of the tires, which fuels the fire.

**Shredding** – In this process tires are ripped and shredded into smaller pieces by a shredding machine. One pass through a shredding machine yields ‘single pass’ or ‘chunk’ tire material. If this material is run through the shredding machine several times, 2” Tire Derived Fuel (TDF) is produced. This 2” TDF is used in cement kilns and paper factories. Shredding reduces tire volume, eliminates interior air space, and prevents water collection and breeding of mosquitoes and other wildlife. Shredded and ‘chunk’ tire piles also tend to be less intense and create less smoke than whole tire pile fires since shredded tire piles tend to burn at the surface.

## 5.0 FIRE PREVENTION AT EXISTING TIRE PILE SITES

The prevention of a fire should be the primary defense against any fire. This is particularly true with scrap tire piles. Prevention of tire fires is paramount because of the potential size, environmental impact, duration, and cost of a major fire. A successful fire prevention program begins with the development of a rapport between the fire prevention officer and the scrap tire owners or operators. Additionally developing a working relationship with other agencies including the local County Health Departments, local planning commission for Air and Water Quality Control Boards are key to a successful fire prevention program.

Pre-incident fire plans are often used by local authorities to develop plans and policies regarding tire storage site maintenance. This section of the report presents site conditions and preventive measures that all scrap tire facilities should utilize as a baseline. Specifically, this section will present site characterization criteria to enable development of a site contingency plan or pre-incident plan. Additionally, because of the threat of arson, a key component to tire fire prevention presented in this section is site security. The most successful fire suppression effort begins with advanced planning.



### 5.1 Permitted Site Characterization and Evaluation

Article 5.5 of Title 14 CCR contains the California State regulations associated with waste storage and disposal. The statutes of Title 14 CCR apply to any solid waste facility storing at least 500 waste tires, any major or minor waste facility storing tires indoors or outdoors, and any solid waste facility that disposes tires by burying. Section 17351 of Fire Prevention Measures outlines certain measures to be implemented at a permitted facility. Each tire storage site will have different characteristics and individual cases will require special considerations. In the following sections, a summary of the common elements of fire prevention at tire storage sites is presented.

### 5.1.1 Review and Storage Site Design Requirements

Due to the lack of extensive research on waste tire storage, differences among recognized standards and guidelines have occurred. The CIWMB developed comprehensive technical standards for waste tire piles in Title 14, Division 7, Chapter 5, the Natural Resource Code. The intent of the Code is to reduce the risk to the public and environment from the tire storage and tire fires. Title 14 was developed through research of similar regulations nationwide as well as incorporating the more restrictive provisions of the Uniform Fire Code and NFPA 231D. However some differences exist between the two codes. For example, the Uniform Fire Code restricts the size of the tire pile to no more than 5,000 square feet of continuous surface area and not to exceed a total volume of 50,000 cubic feet or exceed a height of 10 feet above grade. Conversely, NFPA 231D restricts the storage of waste tires to no more than 250 feet in length or width and no more than 20 feet in height. As can be seen, the NFPA 231D is less restrictive in terms of storage requirements. In this case the more restrictive Uniform Fire Code was adopted as part of Title 14 of the Natural Resource Code. A summary of the tire storage requirements according to Title 14 CCR and the Uniform Fire Code is presented below.

#### Tire Storage Requirements – Title 14

- Individual tire storage units shall not exceed 5,000 square feet.
- Individual tire storage units shall not exceed a volume of 50,000 square feet.
- Individual tire storage units shall not exceed a height of 10 feet.
- The edges of a 10-foot high tire storage unit shall not be closer than 50 feet to the perimeter fence.
- If a tire storage unit is located within 20 feet of the property boundary, the tire storage unit shall not exceed a height of 6 feet.
- No tire storage should occur within 10 feet of the property boundary.
- All interior fire breaks should be at least 60 feet wide.
- All access areas and setbacks between tire storage and the property boundary should be free of all vegetation.

#### Additional Tire Storage Requirements – Uniform Fire Code

- The area extending 200 feet from the outside perimeter of the tire storage unit should be free of all vegetation (i.e. trees, plants, etc), buildings, vehicles, and other flammable materials.
- Waste tires should not be stored on wetlands, floodplains, ravines, canyons, or other steeply graded surfaces.
- New waste tire storage facilities may not be sited on a 100-year flood plain or in an area containing physical features or grades that would interfere with fire fighting efforts.
- No open air burning should be allowed within 1,000 feet of a tire pile, and no welding or other heat-generating devices are allowed within 200 feet of the tire pile.
- Lightning rods should be appropriately placed on the facility.
- Smoking is only allowed in designated areas and well clear of the tire pile.

### 5.1.2 Site Security and Fire Department Access

A summary of site security and fire department access requirements is presented below.

#### Site Security

- The perimeter of the site should be surrounded by a chain-linked fence at least 10 feet high with intruder controls on top.

- Signage displaying hours of operation, name of operator, regulations, and whether tires are received from any source other than the operator, should be posted at the facility entrance.
- A qualified security attendant or site manager should be on site at all times when the facility is open.
- The site should be adequately secured to prevent access when the facility is closed. After hours security and/or patrols will help reduce the threat of arson. Guard dogs have been efficiently used at some sites.

### Fire Department Access

- Access roads and/or firebreaks shall be spaced at distances no greater than 150 feet through the tire pile.
- Access roads should be at least 60 feet wide.
- Facility entrance gates should have a minimum width clearance of 20 feet and be designed with a rapid entry feature to allow quick access by emergency personnel.
- Access roads should be designed to handle the weight, width, and height tolerances for fire fighting equipment; including 14-foot vertical clearance and turning radii of not less than 45 feet. Dead-end roads should be designed with a turn around at the terminus.
- All access roads should be adequately maintained, including debris removal, road grading, etc.

### 5.1.3 Water Supply Requirements

Maintaining an adequate water supply source for use by the local fire authority in the event of a tire fire is a critical component of site operation. Title 14 requires that a facility containing less than 10,000 tires have a water supply capable of delivering 1,000 gpm for a minimum of 3 hours. For tire storage facilities containing more than 10,000 tires, a water supply capable of delivering at least 2,000 gpm for three hours is required. If there is a stream, lake or other water body nearby, connections to utilize this water supply should be incorporated as part of the design plan.

Additionally, the facility is required to have properly maintained fire control equipment including at a minimum; one dry chemical fire extinguisher, one 2.5-gallon water extinguisher, one 10-foot long pike pole, and one round-end and one square-end shovel.

### 5.1.4 Identify Sensitive Receptors in Surrounding Communities

Tire fires are extremely dangerous to the environment and surrounding communities. Tire fires can release toxins into the air, soil, surface water, and groundwater. Public health should always be the first concern. Sensitive receptors including residential areas, schools, hospitals, etc., should be identified as part of the pre-incident plan. Additionally, tire storage also poses a potential threat to public health by fostering a habitat for mosquitoes, rodents, and snakes. Once a tire fire becomes fully involved, quick decisions need to be made by the fire authority to protect human health and protect the environment. Quick decisions regarding containment of released contaminants will pay dividends down the road.

Rubber tires are made of very combustible compounds, including carbon, oil, benzene, toluene, rubber, and sulfur. The EPA does not consider scrap tires as a hazardous waste. However, once ignited, the tire product breaks down into hazardous compounds including gases, heavy metals, and oil. The environmental impact of tire fires on the air can often be minimized by letting the fire free burn, which consumes most of the fuel. However, this is only a viable option in remote rural areas where smoke inhalation by sensitive receptors is not a critical concern. Generally, of greater concern, is the large volume of run-off oil (pyrolytic oil) produced by such fires. Pyrolytic oil should be contained and recovered to minimize the environmental impact to soil and water.

To protect human health in the surrounding community, air quality should be the first concern. Sensitive receptors include the elderly, children, and those with respiratory health problems. Monitoring of the smoke plume by appropriately trained technicians on site and at down wind receptors should be accomplished. Health concerns of the smoke from the tire fire focuses on the high levels of volatile organic compounds, including benzene, toluene, and xylene. Polynuclear aromatic hydrocarbons, dioxins, dibenzofurans are also a concern. These chemicals are suspected or known carcinogens. Evacuation of civilians, as a life safety consideration, should be considered as the highest priority by the fire commander. Incident management should not bypass evacuation considerations. Areas for evacuation should be a component to the pre-incident plan. The most direct health concern from the smoke of a tire fire is to the fire fighters working in the immediate area of the fire. The local media can be utilized to assist with communication and evacuation efforts in order to minimize the effects to the public from the smoke of a tire fire. Additionally, a pre-incident plan with emergency response provisions is critical to maintain proper control of the tire fire event.

## **5.2 Un-permitted Site Characterization and Evaluation**

Unpermitted sites are tire piles that have been dumped on a property with or without the knowledge of the property owner. The sites are generally hidden and unknown to enforcing agencies. Tire piles can often be hidden as brush and shrubs grow up around and through the tires thus adding an additional fuel source to this potentially dangerous condition. There is no control of indigenous wildlife in the vicinity of the tire piles adding to the threat of disease. Further, access to these sites is often very limited, thus enhancing fire-fighting challenges. The most critical issue associated with unpermitted sites is the absence of knowledge that these sites exist and where they are located. At a minimum, knowledge of these sites is critical for the management of the fire and for the safety of the fire fighters and sensitive receptors that may inhabit the area.

### **5.2.1 Identify Tire Pile Locations**

To the extent possible, the exact location and size of the tire pile should be determined. This is often very difficult because many sites are located in remote areas or have accumulated because of illegal dumping. Often, available historic and current aerial photographs can be utilized to identify the location of an undocumented tire pile. Additionally, area reconnaissance of jurisdictional areas on a regular maintenance schedule will aid in the identification and location of undocumented tire piles. Once identified, maps of the area should be obtained or developed and a pre-incident plan should be developed. The composition of the pile should also be documented which will assist in the development of a fire fighting strategy.

### **5.2.2 Identify Responsible Parties**

Once an unpermitted or undocumented tire dump is identified, every effort should be made to identify the property owner to investigate the origin of the tire dumping. In many cases the property owner may be unaware of such dumping. However, once identified a cooperative management strategy should be developed with all parties.

## **5.3 Site Assessment**

The most effective fire management plan is fire prevention. Assessment of a site is the first step in developing an effective pre-incident management plan. Effective fire suppression efforts begin with a complete and thorough knowledge of the site. There are a number of variables in a tire fire emergency, which can be identified by collecting data before the emergency. This data will enhance the ability to make wise and prudent decisions to prevent a fire, and/or to best fight a fire if one should occur. During

the collection of site assessment data it is important to remember that you cannot collect too much information. The data that is collected will form the foundation of the pre-incident plan.

### 5.3.1 Assessment and Mapping of Tire Pile Characteristics

The exact location and size of the facility needs to be determined. Additionally, knowledge of the site history should be obtained if possible. Knowledge of the site history and other site operations can provide critical information regarding potential risks and hazards that should be considered in the development of a pre-incident plan. Maps of the site should be developed and updated regularly. Ingress and egress for fire fighting equipment and personnel should be included. This information should be kept onsite in an easily accessible location, and also placed on file with the local fire department.

Estimating the size of the tire pile is an important component in the site assessment process. The number and size of the tire pile can be estimated mathematically. Additionally, the number of tires in chip tire piles can also be estimated.

The composition of the pile should be considered as part of the pre-incident plan because important differences exist that could affect the fire fighting strategy. For example, fire-fighting strategies vary between shredded tires and whole tires. Additionally, the presence of plastic, metal, refuse, hazardous waste, and vegetation will affect the tire fire management strategy.

### 5.3.2 Site Specific Characteristics/Unusual Circumstances

Site-specific characteristics and any unique site conditions should be identified as part of the site assessment. For example, the location of any utilities on or near the site should be located so fire fighters can shut off power to electrical or gas lines which could exasperate a dangerous condition. Schools, homes, crops, and transportation routes near the site should be identified and characterized as “high risk” exposures and should be handled accordingly in the pre-incident plan. The conditions of the road for ingress and egress should be investigated and evaluated in terms of maintenance, access, susceptibility to flooding, etc.

### 5.3.3 Topography, Geology, and Climate

Knowledge of the local topography, geology, and climate will provide important insight in the development of a pre-incident plan. A topographic map is useful in determining areas where run-off may flow. This information is useful in developing a run-off containment plan, which may include dikes, containment areas, and surface impoundments.

Geologic information should also be collected during the site assessment. Soil type, texture, and structure may affect the approach and/or management of the fire. For example, the introduction of fluids in fire fighting will have varying affects on the environment based on the soil type. A sandy soil will be more permeable and allow infiltration of toxic chemicals into the subsurface more readily than low permeability clay.

Data associated with the local climatic conditions should also be collected as part of the site assessment. Knowledge of the average wind direction and speed will be useful in determining the approach to the tire fire. The approach to the tire pile should always be from upwind of the fire. The average humidity and rainfall affects the dryness of local vegetation and should be noted.



## 5.4 Develop Site Contingency Plan (Pre-incident Planning)

Development of site contingency plans or pre-incident planning is critical to minimize the potentially devastating affects of tire fires. Pre-incident fire plans can be used by local authorities to develop policies regarding tire storage and maintenance. The objective of a pre-incident plan is to identify special considerations and hazards at a particular site so that the responding fire-fighting unit is prepared to handle the emergency. Pre-incident plans should include the agency's standard operating procedures and specify exactly how procedures are to be utilized. All tire and rubber storage facilities should be considered high-risk storage facilities and as such a pre-incident fire management plan should be developed.

Specifically, the pre-incident plan should include; resource materials including maps of the area, information on the soil conditions, water supply sources, emergency contacts, etc. Additionally, anticipated field assignments, anticipated control sectors, and organizational charts should be included within the pre-incident plan.

The local fire departments should initiate the pre-incident planning process by recognizing scrap-tire operations as potential hazardous material/fire incidents not simply refuse or trash fires. The challenge of tire pile fires requires formal written plans to minimize the impact on the community and the environment.

### 5.4.1 Resources

A list of resources, vendors, suppliers and all services required should be developed so that these resources can be deployed during an emergency without delay. Contracts for on-call services should be implemented. The resources list should always be kept current and updated regularly (not exceeding annually). Examples of commonly needed resources are presented below.

- Construction and wood supply companies;
- Equipment repair and maintenance contractors;
- Fill dirt and gravel contractors;
- Canteen or food service providers;
- Public and private universities – departments of ecology, geology, environmental engineering, etc.;
- Foam/chemical additives manufactures;
- Oil reclamation and clean-up companies; and
- Aerial photography and Infrared reconnaissance.

### 5.4.2 Topography

Topographic maps should be obtained from the area and updated as necessary to reflect changes. These maps will depict low topographic depressions and surface flow features that are critical components to the pre-incident plan. Direction of surface flow data will be used to develop a run-off containment plan. The topographic maps should incorporate other features such as access roads, interior lanes or passes, hydrants, water supply sources, etc.

### 5.4.3 Notification

A component of the pre-incident plan should be the development of an up-to-date emergency contact list of applicable local, state, and federal agencies or organizations with the expertise and responsibility in

management of environmental disasters. This list should include; agency affiliation, contact name, phone number, facsimile number, address, and/or other emergency contact mechanisms. Agency involvement will vary from place to place. Each fire department will have to research their respective governing structure. Involved agencies should participate in creating and be familiar with the pre-incident plan.

Examples of some agencies that could be involved include the following:

- State and Local Police;
- Public Works agency;
- State Department of Emergency Management;
- Regional Offices of the Federal Emergency Management Agency (FEMA);
- Regional, State or Federal Environmental Protection Agency (EPA);
- State Division of Natural Resources or State Forestry Agency;
- State Fire Marshals office; and
- Finance, Purchasing and Budget agencies.

Within the pre-incident plan, the various government agencies should be assigned to the appropriate sectors in the command system. This provides a smoother transition as the respective experts arrive at the scene of the fire.

#### 5.4.4 Pyrolytic Oil

Pyrolytic oil is a product of pyrolyzed tires, which is the thermal decomposition of tires in the presence of low oxygen. When tires are subjected to high temperatures with a low oxygen supply, tires melt releasing pyrolytic oil. Each passenger tire contains approximately 2.5 gallons of oil. Management of this waste during the course of the tire fire is critically important. By way of example if only half of the tires at the Hagersfield Ontario fire were liquefied in this manner, approximately 14 million gallons of toxic oil would have been generated and could have leached into the soil of nearby farmlands. By comparison, the Exxon-Valdez incident spilled an estimated 11 million gallons of oil into the sea. As can be seen by this example, handling pyrolytic oil generation is critical for the protection of the environment. During the preparation of the pre-incident plan a detailed and specific contingency plan should be developed for pyrolytic oil generation containment.



## SECTION C – TIRE FIRE RESPONSE

Should a tire pile fire occur, planning and preparedness will prove invaluable in protecting lives and the environment. Section C includes dialogue on educating firefighters about the challenges, preplanning, and health and safety issues specific to tire pile fires; establishing command and control of a tire fire incident; implementing an action plan; and the environmental concerns particular to tire pile fires.



## 6.0 EDUCATION OF FIREFIGHTERS/PLANNING

Education of firefighters and pre-incident planning of tire pile fires is essential for a response to be successful. Several well-written documents have been previously prepared on these topics. Significant portions of this section were prepared utilizing information and/or direct experts from the following publications:

- Guidelines for the Prevention and Management of Scrap Tire Fires, prepared by the Scrap Tire Management Council,
- Scrap and Shredded Tire Fires – Special Report, prepared by the United States Fire Administration, and
- Report on Tire Fires, prepared by the USFA, August 1998.



### 6.1 Education

Knowledge of what to expect in a tire pile fire will result in effective management decisions in an emergency situation. This section will present a discussion of training programs for firefighters and site operators; fire fighting techniques involved in tire fires; health and environmental concerns; and equipment standards for tire fires.

#### 6.1.1 Training Programs

Tire pile fires, like all hazardous materials (HAZMAT) responses, require advanced planning, and effective strategies and approaches. Concerns associated with tire pile fires include the threats to site operators, emergency responders, local inhabitants, and the environment caused by exposure to toxic materials and products of combustion. Emergency response personnel must protect themselves and others (and the environment to the extent possible) from these toxic threats.

Secondary to these concerns are the challenges of extinguishing the tire fire itself. Tire fires generally have a heavy fuel load, as well as ample oxygen to sustain the fire once it begins. Large tire pile fires tend to be located in remote areas, and gain considerable headway before adequate responders arrive onsite. Therefore, site operators and firefighters must develop effective strategies to address both the toxic effects and extinguishment challenges presented by these fires.

A brief description of tire fire training programs for firefighters and site operators is presented in the sections below.

#### 6.1.1.1 Firefighters

Currently, no nationally available courses that have been developed specifically for tire fires. It is beyond the scope of this report to adequately address firefighting training procedures. However, there are a number of training courses that deal with hazardous materials fires that can be applied to the challenges presented by tire fires. The U.S. Fire Administration's (USFA's) National Fire Academy has a number of courses available including:

- Hazardous Materials Incident Analysis;
- Incident Command System;
- Recognizing and Identifying Hazardous Materials;
- Initial Response to Hazardous Materials: Basic Concepts;
- Initial Response to Hazardous Materials: Concept Implementation;
- Incident Safety Officer;
- Basic Life Support/Hazardous Materials Response;
- Command and Control of Fire Department Operations at Target Hazards;
- Hazardous Materials Operating Site Practices; and
- Hazardous Materials Incident Management.

Training programs should be developed and implemented in accordance with NFPA guidelines and codes and OSHA directives for hazardous waste and emergency response standards described in 29 CFR 1910.120 and 29 CFR 1926.65, paragraph (q): *emergency response to hazardous substance releases*. In addition, very useful training information is included in publications such as the United States Fire Administration special report on scrap and shredded tire fires.

At a minimum, training programs should include the following elements:

- Emergency Response;
- Hazards at Different Stages of Combustion;
- Exposures;
- Containment;
- Extinguishment; and
- Overhaul.

Firefighters should be knowledgeable of site-specific pre-incident plans. Regularly scheduled drills for emergency response should also be conducted to review site-specific emergency plans. Effective training will enhance decision-making efforts and aid the firefighter with the information needed to handle a tire fire emergency.



### 6.1.1.2 Site Operators

Site operators provide the first line of defense at a tire pile site since they are usually onsite at the onset of a fire before emergency responders arrive. Site operators should be trained in tire fire prevention and initial response tactics for tire pile fires. This training should provide site operators a basic understanding of fire prevention measures, firefighting techniques, toxic effects of a tire fire, and the environmental issues that arise out of a tire pile fire. In addition, the owner/operator of the facility must be familiar with state and local Fire Department and Health and Safety Department codes. With sufficient training and knowledge, the staff at the facility has the ability to respond to a fire emergency in a prompt, positive, and effectively manage the emergency until fire fighters arrive on site.

Listed below are several fire prevention practices that each tire pile facility should adopt, to minimize the breakout of a large tire pile fire.

- Conduct a Fire Safety Audit;
- Appointment and Organization of Supervisory Staff;
- Develop Emergency Procedures;
- Fire Drill Procedures and Training;
- Maintenance of Building Facilities and Fire Protection Equipment;
- Alternate Measures for Temporary Shutdown of Fire Protection Equipment or Systems;
- Control of Fire Hazards;
- Fire Department Access for Fire Fighting and Related Fire Suppression Information;
- Preparing Schematic Diagrams and Site Plans; and
- Posting Emergency Procedures and Emergency Phone Numbers.

### 6.1.2 Fire Fighting Techniques

In general, the approach to fighting a tire pile fire is the same as fighting most other fires. The general approach includes the following:

- Rescue/Evacuation;
- Exposure Protection;
- Confinement;
- Extinguishment; and
- Overhaul.

This section of the report describes techniques for fighting tire fire piles, as described in the United States Fire Administration Scrap and Shredded Tire Fire Special Report (1998). In many fires, the exposure, confinement, and extinguishment phases can occur almost simultaneously with good tactics of hose line placement. However, with tire fires, each phase of the fire must be completed before the next phase can begin. Until the exposure of unburned tires is removed, the fire cannot be contained, and until it is contained, it cannot be extinguished. Extinguishment must be complete before overhaul can begin because of the tendency for tires to retain heat and re-ignite.

Tire fires rarely involve life-threatening rescue efforts, but many require evacuation of residential areas in the vicinity. The speed and direction of the wind will dictate the extent of evacuation, and conditions may change during the course of the tire fire, which may warrant a change in the evacuation plan. Evacuation efforts can often be delegated to police or other agencies.

### 6.1.2.1 Exposures

Experience of emergency responders to previous large tire pile fires has shown that fire exposure problems (e.g. unburned tires) may be the most important and difficult challenge to address during a fire incident. The exposure priority of burning tire products is usually accomplished by surrounding and/or isolating unburned tire piles. If the exposure can be eliminated, then the fire department has protected the exposure and contained the scope of the incident.

Minimizing the spread of a tire fire to unburned tires has many challenges including the following:

- Most tire piles are not adequately separated;
- Fire apparatus and heavy equipment access roads may be inadequate;
- Tire pile separation requires heavy equipment that may take substantial time to get on site and in operation;
- Even with large amounts of water, it is difficult to keep deep-seated tire fires from re-igniting and spreading from within the pile; and
- In the first 30 minutes of the fire, the fire spreads quickly, at a rate of approximately two square feet every five minutes.

All of the challenges can be managed through the development of an effective pre-incident plan. In many of the case studies, fire departments attempted to use water to confine and extinguish the fires with “surround-and-drown” tactics because the heavy equipment needed to move unburned tires was not immediately available.

Therefore, the initial stages of the fire are best spent on exposure control and containment of run-off oil and water. Water is best used to keep unburned tires from burning rather than to extinguish the burning tires.

### 6.1.2.2 Containment

Once adequate separation is obtained with excavators and bulldozers, an earthen berm should be built around the burning tire pile. The earthen berms should be at least one half the height of the tire pile, provided that the angle of repose of the pile is not such that material from the top can tumble out of the confining berm. With the berm complete, the tire fire can be considered contained and extinguishment can become the main focus.

A berm can also be used where adequate separation is not possible; NFPA recommends berms 1 1/2 times the tire pile height. However, because heavy equipment and loads of earth must be moved into position to build berms, it is difficult to accomplish this if adequate separation is not available during a fire.

### 6.1.2.3 Extinguishment

According to the United States Fire Administration special report on scrap and shredded tire fires (USFA, 1998), there are several strategic considerations and tactical options with tire fire extinguishments. There are many issues that need to be considered during a tire fire event to manage the emergency. The primary goal is to protect human health. In the event of an emergency, the pre-incident plan should be implemented. Depending on the site-specific pre-incident plan, the following firefighting techniques should be considered:

*Letting the Tire Fire Burn:* This technique has been used to minimize hazardous water runoff and groundwater contamination. Allowing the fire to burn minimizes the impact on air pollution because the free-burning tire fire is in equilibrium and pyrolysis phase and will consume most of the fuel. Free



burning therefore reduces toxic and carcinogenic combustion emissions such as benzo(a)pyrene and benzene, as well as toluene, chrysene, zinc oxide, titanium dioxide, carbon monoxide, sulfur dioxide, and hydrogen sulfide.

*Burying the Burning Tires:* This technique consists of extinguishing the fire by smothering it with dirt. This method of extinguishment can be an effective means of managing major tire fires, however, once smothered, the fire may continue to smolder for weeks or months and generate a continuous source of pyrolytic oil. It is also possible for the smoldering tire fire to periodically break out into open flames creating an unpredictable and hazardous environment for emergency personnel. Additionally, due to oil residues, this method can result in significant soil and water contamination.

*Use of Water:* Water is generally utilized to fight Class A fires which include absorbent materials such as wood, paper, and cloth. By contrast, tires and shredded tires do not absorb water, but instead repel it. Experience at tire piles has shown that master water streams produce much greater runoff without significantly improving fire knock-down. Instead, fog streams may be more effective for dousing separated burning product piles (USFA, 1998). At tire fire sites where water extinguishment has been successful, excavation equipment was used first to separate the burning materials into small manageable piles. The fire was doused with hand-lines, and a front-end loader was used to move the material to be submerged or buried to complete the overhaul. It is important to keep heavy equipment cool and wet due to the extreme heat of a tire pile fire.



Other successful methods utilizing water include submerging burning rubber in water filled construction bins or ponds. It should be noted that after the material has cooled, the residual water must be tested for contaminants and, if necessary, shipped off site for hazardous disposal. Overhaul operations can commence after the water has been safely removed from the containers.

*Accelerants:* In some instances accelerants may be utilized to enhance the fire and maximize the combustion of toxic byproducts.

*Foam Fire Suppressants:*

Foam suppressants are most effective in extinguishing small tire fires. Heavy machinery is used to disseminate a larger tire pile into a smaller manageable fire. In this technique water is used to cool the

fire, and then foam is used to douse the fire. Foam is particularly useful in suppressing oil fires that are common with tire fires (COSFM, 1995).

### **Class A Foam/Wetting Agents**

Class A foam is used to insulate unburned fuel. Class A wetting agents are designed to reduce surface tension to improve water penetration. These products have limited use and controversial effectiveness in tire fires. Like water, their best use is perhaps preventing ignition of unburned tires (Horriagan, 1999).

### **Class B Foam**

According to the United States Fire Administration (USFA) special report on scrap and shredded tire fires (1998), the use of Class B Foam was not effective in extinguishing the fire in the ignition and propagation phases. Class B foams can be used to prevent ignition of run-off oil, and to control any run-off fires.

## 6.1.3 Health and Environmental Concerns

Pyrolytic oil, ash, and smoke are byproducts of a tire pile fire, and present a significant risk to the environment and the responders to a tire pile fire. The two main environmental concerns associated with pyrolytic oil, ash, and smoke are health affects to response personnel and impacts to the environment. Health and Environmental Concerns from tire pile fires are discussed in more detail in Section 9.0.

## 6.1.4 Non-Standard Firefighting Equipment

Because a tire pile fire is very different from a typical structure fire, non-standard fire fighting equipment is necessary to effectively combat the fire. This non-standard fire fighting equipment includes a variety of heavy equipment and HAZMAT trained equipment operators. Because tire pile fires typically meet the requirements for activation of state Environmental Protection Agency (EPA) assistance, the state EPA will usually provide contractors familiar with hazardous waste cleanup, and who have expertise and knowledge of excavation equipment. Heavy equipment can be also procured through a variety of means including county, state, and commercial suppliers. Counties often have heavy equipment in their highway departments including; excavators, bulldozers, front loaders, dump trucks, etc. At the state level, the California Department of Forestry (CDF) has heavy equipment with operators already trained in firefighting techniques. If these resources are not available, commercial suppliers can be contracted to provide necessary equipment and operators. It is the responsibility of the local fire authority to select the most appropriate route to procure heavy equipment and operators and to have an appropriate training plan in place to utilize these resources.

Four types of equipment are usually needed on tire fires. With these specialized machines, the operation can be more efficient and effective. These four types of equipment are described in the USFA Scrap and Shredded Tire Fire Special Report, dated December 1998, and included for reference below.

**1) Excavator.** A track-mounted excavator is necessary for separating burning tire piles to allow extinguishment. This is sometimes referred to as a track hoe. The excavator is also available with wheels, but track models are better suited to maneuver through the muddy terrain that will result from a tire-fire incident.

Excavators are rated by weight, the length of the bucket reach, and breakout power. Breakout power is the power of the machine to pull the bucket into undisturbed soil. Shorter reach and a heavier boom improve breakout power. However, for tire fires the important factor is the length of bucket reach. Fire departments should look for machines with the longest reach available that can still be transported on a flatbed trailer without disassembly. This is approximately a 23-ton machine with a reach of 30 feet. Larger excavators require disassembly for transport and reassembly on site.

The track-mounted excavator is a vehicle with a wide base that is stable without support jacks. It is important that this machinery remain mobile so it can move out of the way of burning oil flare-ups or pile collapse if needed. The excavator can rotate 360 degrees on a turntable. It has a fully enclosed cab, in which the operator is situated five to six feet above the ground. That position, combined with the long reach, provides the operator with sufficient safety to operate on tire fires. Although the cab of the machine is enclosed, operators should wear hard hats, appropriate protective clothing, and breathing apparatus if necessary. Excavators are usually equipped with a roof escape hatch should the machine overturn or the side door become blocked during tire fire operations. A fire-fighting crew with charged hose lines should always be available for rescue.

The most common attachment to the excavator is the digging bucket, which can be used on tires. Another is the grapple, which is hydraulically operated and opens or closes so the tires can be gripped and lifted. While the grapple may work well for whole tires, it is not as effective for tire shreds or burned tire scraps.

The ideal attachment is a bucket used for digging combined with a mechanical thumb attachment. The thumb is a mechanical lever that is hydraulically operated and can close over the bucket as the thumb of the hand closes over cupped fingers. With the mechanical thumb open, the bucket can be used for digging. With the thumb closed over bulky material, it works similarly to a grapple.

**2) Bulldozers.** Bulldozers are also utilized to separate unburned tires from burning tires to prevent exposure fires, to build berms around the burning tires for containment, to dig and grade run-off oil containment ponds, and to construct access roads or repair roads for heavy equipment. As tires burn, the radial steel wire cords become personnel trip hazards that can also wrap around mechanical equipment drive shafts and damage machinery. A bulldozer can maintain clear passable roadways for other vehicles at these incidents.

The burned tires separated from the pile by the excavator will need to be pushed to the extinguishment area; the bulldozer is the best machine for this task. It can dig the submergence pond in which to soak tires for complete extinguishment.

The key factors in selecting a bulldozer are weight and horsepower. A dozer cannot push more than it weighs and has to have sufficient engine horsepower. The bulldozer selected for tire fires should be one of the larger units weighing 30 tons or more with a minimum of 230 horsepower. Dozers are designed specifically to push heavy loads with proportional weight when equipped with aggressive tracks called grouser cleats.

Dozers should not be confused with tracked front-end loaders. The loaders have the weight distributed to provide ballast for the bucket when raised in the air. There is some compromise for front-end loaders that makes them less efficient for pushing heavy weights than are bulldozers.

One manufacturer makes a high-sprocket dozer that is distinguished from oval-track machines by the triangle-shaped track. The high-sprocket machine offers an advantage for tire fire applications because the hydraulic oil and drive sprocket are higher off the ground, minimizing exposure to flames and entanglement of steel tire cords.

**3) Front End Loaders.** The third type of heavy equipment that will be needed is the front-end loader. The loader is a track-mounted machine that looks similar to a dozer. A loader has a front bucket that can scoop up a load, raise it, and dump the load into a truck or other container. The loader is needed to load the extinguished tires into trucks for hauling. The loader can also be used to scoop dirt and dump it on tires to bury them until they cool.

In the Washington, Pennsylvania fire, large refuse containers were loaded with tires using a front-end loader, and then hauled away. In Frankfort, Kentucky, tires were pulled out of a cave, extinguished with water, and buried until cool using a front-end loader, minimizing the chance of re-ignition of the tires.

While the front-end loader cannot push as well as a dozer, it could substitute for one if a multi-purpose bucket was used. This bucket has a hydraulically operated bucket extension that converts the open-ended bull push plow used exclusively for pushing into a bucket (closed on the ends) used for lifting and loading. This multi-purpose bucket allows for both pushing and loading.

The front-end loader needs to be a large machine with the weight of 21 tons or more and 160 to 220 horsepower. The bucket should have a capacity of approximately three cubic yards.

Efficient use of these pieces of heavy equipment requires a skilled operator. It is generally not advisable to attempt to use fire department personnel to operate rented machines. Even if fire department members are experienced with these specific pieces of equipment, it is advisable to utilize their skills in safety officer assignments or coordinating with fire operations rather than the excavation equipment operation.

**4) Trucks.** Dump trucks to deliver dirt and stone for containment berms and access roads will be necessary. Dump trucks can also be used to remove totally extinguished burned tire product to other landfill or disposal sites.

If trash containers are used, as was the case for the Washington, Pennsylvania fire, trucks designed to roll back the container on rails and pull the loaded container onto the truck chassis are preferred. Container contractors generally have the trucks to deliver and pick up these containers. Water should be drained from the containers before being loaded on the truck.

Transportation of excavation equipment to the site will generally require the use of flatbed trailers. After off-loading, these tractors and trailers should be sent back to their equipment yard or parked away from the fire so they do not interfere in tactical operations, or impede site access.

## 6.2 Preplanning

Preplanning is essential in effective tire fire management. At a minimum, all local fire-fighting authorities should develop pre-incident plans, site safety plans, identify Federal, State, and local Emergency Response Teams, and identify local and/or regional response contractors. Additional guidelines can be referenced using NFPA guidelines and codes, OSHA directives for hazardous waste and emergency response standards described in 29 CFR 1910.120 and 29 CFR 1926.65, paragraph (q): *emergency response to hazardous substance releases*, the United States Fire Administration Special Report on Scrap and Shredded Tire Fires (USFA, 1998), and the Rings of Fire report on fire prevention and fire suppression of scrap tire piles (COSFM, 1995).

### 6.2.1 Develop Pre-Incident Plan

Pre-incident planning is described in detail in a document prepared by the Scrap Tire Management Council (Scrap Tire Management Council, 1992). Excerpts of this document pertaining to pre-incident planning are presented in this section, with only slight modifications.

Pre-incident plans are developed to identify the special considerations and hazards of a particular site or property so that responding units will know what to expect and how to proceed during initial operations. Pre-plans must accommodate the agency's standard operating procedures and specify exactly how those procedures are to be applied should a

fire break out at a given location. All scrap tire and rubber products storage facilities should be considered high-risk storage sites and pre-planned accordingly, regardless of the site location.

Included within the pre-incident plan is information and resource material useful to the incident commander. In the case of a tire fire, these resources would include maps of the area, information on the hydrographic conditions of the soil, water supply contingency plans, emergency contacts and a variety of other important considerations.

Also included in the pre-incident plan, should be anticipated assignments for mutual aid companies and organizational charts specifying the anticipated control sectors. The means of maintaining fire ground and incident management strategies (Incident Command System), should be anticipated and included in the pre-incident plans.

This section discusses the following common elements of tire fires that need to be considered and included in the pre-incident plans.

- The anticipated establishment of a functional incident management system, to include command and control of all responders and workers.
- The early recognition of tire fires as potential hazardous materials (HAZMAT) incidents, with considerations given to treating them as such.
- Information regarding the site's location, layout, size and composition. Also information regarding access and egress routes, the physical infrastructure of the roads and other "access" considerations.
- Information management plans, to include resource request tracking forms, video recording of incident progression, and financial reimbursement requests.
- Access to local, state and federal agencies or organizations with environmental and/or emergency management responsibilities (Section 6.2.2).
- Access to local and regional contractors with specialized equipment (Section 6.2.3).

Each of these elements of a pre-incident plan is further discussed in the following paragraphs.

### ***Incident Management Planning***

All fire incidents should be managed within the guidelines of an incident command system. A complete description of the components and structure of the various command systems is beyond the scope of this document, but is available through the Fire Service Incident Management System Consortium and the National Fire Protection Association.

A system of personnel accountability and appropriate lines of authority must be established and utilized from the earliest stages and continued throughout the duration of the incident. This is particularly important considering the number of fire fighters and other personnel operating at large tire fires.

Mutual aid departments and outside agencies should be included in the pre-incident planning process. All departments and personnel operating at the fire should be familiar with the fire ground control and accountability systems. Drills should be conducted to ensure that all personnel are familiar with their individual roles and responsibilities on the fire ground.

***Recognition of Hazmat Potential***

The pre-incident plans should note that tire fires produce a variety of pollutants, and although not always toxic, should be regarded with a high index of suspicion. Since it is recommended that major tire fires be handled as hazardous materials incidents, the pre-incident plans should call for first-responder HAZMAT precautions and subsequent activation of department HAZMAT personnel and resources. Additional information on Hazmat Potential is described in Section 6.3.4.

***Site Location, Layout, Size and Composition***

The exact location and size of the tire storage yard or dump should be determined. This is often difficult and incompletely performed since many sites are located in remote areas or accumulate as the result of illegal dumping.

Maps of the site should be updated and made available in the pre-incident plan. Ingress and egress plans for apparatus and personnel should be included. The development of additional access points should be planned with the means of maintaining or expanding accesses provided. The possible locations for a command post and any usable on-site buildings may also be identified.

Topographical, aerial and soil composition maps should be obtained and updated to show hydrants and water supply sources, accesses, interior lanes or passages, and fuel load configurations.

Schools, homes, and transportation routes near the site should be identified as "high risk" exposures and considered in pre-incident planning should evacuation or pollution control become necessary.

The location of any utilities on or near the site should be identified so responders can quickly shut off power to electrical or gas lines and prevent the run-off of contaminated water into storm drains or plumbing systems.

The condition of roads and access routes should be considered in the pre-incident plans in order to avoid a common problem of first-arriving units becoming stuck in mud or unable to exit a narrow access. The fire department should identify how access can be made to remote sites. More information on access roads is contained in Section B – Fire Prevention for Tire Piles.

The composition of the tire pile should be considered since important differences exist in developing suppression strategies. Shredded or "chip" tire piles present different challenges than whole tires, as would the existence of plastics, metals, refuse or hazardous chemicals/waste. Additionally, the age of the pile and the local climate may affect the amount of rodent and insect infestation of the particular site.

***Information Management and Resource Request Tracking***

The amount of information, both written and oral, that is generated during a prolonged incident is overwhelming, and can cripple the command structure if it is not managed effectively. Therefore, an orderly system of information management should be designed as part of the pre-incident plans. A senior member of the command system should be designated as the Information and Resource Management (IRM) Officer.

All requests for major materials, supplies or resources should be coordinated by the incident IRM Officer. Similarly, all incoming resources and supplies should be reported to the IRM Officer. When another sector commander pulls a resource, notification should be immediately sent to the IRM Officer. In turn, the IRM Officer should make available a list of available supplies.

The management of this flow of requests and notification may be best handled by the use of carbon copy "tracking forms". The Information and Resource Management Officer should have copies of all tracking forms. Ideally this allows for rapid tracing of unfilled requests and missing materials. After the incident, a system of resource tracking will be critical for the reimbursement of the fire department(s) and all other concerned organizations by federal and state agencies.

Video taping of the incident should also be included in the pre-incident plans. This will allow for post-incident analysis as well as documentation of fire department activity. Videotaping of requests and meetings with government officials and private parties can only assist in assuring that promised resources are delivered.

### 6.2.2 Identification of State and Local Emergency Response Teams

State and Local Emergency Response Teams should be a component to pre-planning. In the event of a tire fire, local fire fighting efforts for communities may not have sufficient resources to handle such an emergency.

Pre-incident plans should contain up-to-date emergency contacts for all local, state, and federal agencies or organizations with expertise or responsibility in management of environmental disasters. The lists should include phone numbers, facsimile numbers, addresses, and radio frequencies, if applicable.

Since emergency management structures differ across state and county lines, each fire department will have to research its own government structure and laws to determine the appropriate agencies to involve. These agencies should participate in, or at least become familiar with, the pre-incident plans.

Examples of concerned agencies would be:

- State and local Police;
- Public Works agencies;
- State Department of Emergency Management;
- Regional offices of the Federal Emergency Management Agency (FEMA);
- Regional, State or Federal Environmental Protection Agency (EPA);
- State Division of Natural Resources or State Forestry Agency;
- State Fire Marshals office; and
- Finance, Purchasing and Budget agencies.

The pre-incident plans should assign the various government agencies to appropriate sectors in the command system. This will allow for smoother transition of sector control in areas such as "environmental management" or "resource management" when those respective experts arrive on scene.

### 6.2.3 Identification of Local and or Regional Response Contractors

Identification of local and or regional response contractors is a necessary component of pre-planning for a tire fire response. A current list of contractors should be maintained at all times. Utilization of these

contractors will enhance the response efforts in the event of a fire emergency. Having these contractors identified and coordinating their use in simulated drills with the local fire authority will provide the necessary training to manage the emergency and make informed decisions.

Contractors commonly utilized in a tire pile fire include:

- Providers of heavy equipment including but not limited to front-end loaders, track excavators or mid-size dozers;
- Construction and wood supply companies;
- Equipment repair and maintenance contractors;
- Fill dirt and gravel contractors;
- Canteen or food services providers;
- Sanitation or "Porta-John" companies;
- Public and private universities - departments of ecology, environmental engineering, etc.;
- Foam/chemical additives manufacturers;
- Oil reclamation and clean-up companies; and
- Aerial photography and Infrared reconnaissance sources (sometimes provided by State Police or a university).

Private contractors expected to participate in fire suppression activities, such as tractor operators, will need to be trained in the use of fire fighting personal protective clothing and gear, including self-contained breathing apparatus. Provisions should also be made for earth-moving equipment to accommodate SCBA cylinders or other such equipment in a way that will not restrict the operator.

The pre-incident plans should assign the various contractors to appropriate sectors in the command system. This will allow for more efficient operations in areas such as "maintenance" or "reconnaissance" when those respective contractors arrive on scene. The contractors identified in the pre-incident plans should participate in, or at least become familiar with, those plans.

### **6.3 Health and Safety**

This section of the report presents a summary of health and safety concerns with tire fires and will focus on chemical exposure hazards within this section. The following topics are discussed: evaluate dangers to life safety, the threat to the surrounding community, recognition of tire fires as a HAZMAT response, establishment of HAZMAT procedures, identification of toxic exposure hazards, personnel protective gear, the establishment of control zones, and decontamination procedures.





### 6.3.1 Site Safety Plan

All site work should be conducted in accordance with the protocols established in a Health and Safety Plan (HSP) designed specifically for conditions anticipated to be encountered at a Tire Fire Pile site. The purpose of the Health and Safety Plan is to provide detailed information regarding anticipated health and safety matters, and establish policies and procedures adequate to protect workers, the public, and environment from predicted site hazards. The information provided in this plan is based, in part, on best available information regarding the site. If unexpected health and safety issues arise during the course of the investigation, the plan should be modified to reflect these new conditions. A copy of this site HSP must be available on site at all times during site assessment activities.

While based on the minimum requirements of 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER), the HSP document is developed with the express purpose of implementing a high quality safety and health program. These HSP guidelines are a "living document" to be modified and updated as new regulations and other requirements are issued. The basic goals of the HSP are provided below.

- Define a clear chain of command for safety and health activities and/or issues.
- Define procedures to implement in the event of an emergency.
- Identify potential physical and chemical hazards at the site.
- Outline roles, responsibilities, and accountability for safety and health performance.
- Define expectations regarding safety and health.
- Define task and operational hazards/risks.
- Identify comprehensive hazard prevention and control methods.
- Outline recordkeeping requirements to track program progress.

### 6.3.2 Evaluation of Dangers to Life Safety

The first arriving units should determine whether any threats to their own safety exist. Personnel should keep a safe distance from any scene thought to be unsafe because of criminal trespassers or hostile

property owners. First responders also need to assess the dangers of live wires, HAZMAT or environmental exposures and other possible complications.

The incident commander should tour the site's perimeter (if possible) in order to view all angles of the fire, determine the location and rate of fire spread, amount of available fuel and the location of exposures. During this initial survey, a determination should be made whether any persons have been injured or if anyone at the site is in danger.

Nearby homes, commercial buildings or public places should be considered for evacuation depending on the amount and direction of the smoke plume. Any area likely to be contacted by direct smoke should be evacuated as a precaution. Consider closing roads or transportation routes affected by thick smoke (Scrap Tire Management Council, 1992).

### 6.3.3 Threat to Surrounding Communities

During the initial response to a tire pile fire, it is essential that the threat to the surrounding community be assessed quickly. The incident commander should consider evacuation of civilians, as a life safety consideration, as a highest priority. No strategy for managing the incident should by-pass evacuation considerations. Since burning tires are extremely difficult to extinguish, the incident commander should make early evacuations a high priority.

Areas identified for potential evacuation during the pre-incident planning process, including any area exposed to the smoke plume, or subject to such exposure from shifting winds, should be evacuated as a precaution. The staging locations for evacuees should be identified during the pre-incident planning process. The time needed to conduct the evacuations in an orderly manner should be considered and factored into calculations for transportation requirements.

Liaison with law enforcement and emergency preparedness organizations will be necessary to facilitate this activity. Medical and health care agencies should also be involved to assist the elderly, especially if the evacuation time is prolonged.

No evacuees should be allowed to return to the vicinity until environmental monitoring has been performed by the appropriate authorities and the area is deemed safe and habitable.

### 6.3.4 Recognize Fire as a HAZMAT Response

Due to the potential release of toxic chemicals, the first responders to the tire fire emergency should handle the fire as a HAZMAT incident. The approach to the incident should be in accordance with tactics common to a hazardous materials response. The initial approach to the fire should be upwind and/or upstream while taking into consideration the weather, wind direction, and the local topography. Activation of an incident command and control system should be implemented immediately to facilitate suppression efforts. All personnel should be trained with the best available technology, and the best available information to ensure safety to responding personnel, the community, and the environment.

### 6.3.5 Establishment of HAZMAT Procedures

Tire fires release chemicals into the air, soil, and potentially water tables, which are hazardous to both onsite personnel and downward receptors. Standard HAZMAT procedures are to be implemented immediately to ensure public safety, safety for emergency personnel, site operators, and the environment. Command and Control systems can size up the incident situation; establish safety procedures and tactics to firefighting personnel; enhance safety decisions for the evacuation of local residents; and enhance decisions for the containment of toxins and the protection of the local environment.

### 6.3.6 Identify Toxic Exposure Hazards

The combustion of waste tires result in the release of chemicals that are known or suspected carcinogens that can be absorbed through the skin, mucous membranes, or the respiratory system. Exposure hazards associated with tire fires can be introduced by a smoke plume (from the fire), water run off (from the water used to put out the fire), and soil contamination (from the oil and heavy metal products). Hazardous substance associated with tire pile fires are listed below:

*Pyrolytic Oil:* Pyrolytic Oil is free flowing oil that contains the following target compounds: Naphthalene, anthracene, benzene, thiazoles, amines, ethyl benzene, toluene, and various metals such as, cadmium, chromium, nickel and zinc.

*Ash:* Ash contains various heavy metals including lead, arsenic, and zinc.

*Smoke:* Smoke contains VOCs, SVOCs, PAHs, particulate metals, heavy metals, carbon monoxide, dioxins and furans, sulfur and nitrogen oxides, PCB's and acid gases (hydrochloric, and sulfuric).

A list of target compounds is provided in table 9-1 in section 9.1.3 of this report.

### 6.3.7 Personal Protective Gear

Tire fires are hazardous and require dermal and respiratory protection for all personnel responding to and working in the vicinity of the tire fire. The use of personal protective gear is mandatory for tire fires. The local Incident Command and Control System and the pre-incident emergency plan should describe what level of personal protective equipment (PPE) is required for each phase of the emergency event. The following is a list of standard PPE:

- Helmet;
- Turnout Coat;
- Turnout Pants;
- Nomex Hood;
- Latex Gloves (to be worn under firefighter gloves to provide secondary protection against absorption of chemicals through wet gloves);
- Firefighting Gloves;
- Boots;
- Self contained breathing apparatus (SCBA) and
- Tyvex Suits (optional: to provide secondary protection against absorption of chemicals through primary protective clothing)

Additionally, due to other potentially hazardous components, the pre-incident plan should include PPE guidelines, NFPA guidelines and codes, OSHA directives for hazardous waste and emergency response standards described in 29 CFR 1910.120 and 29 CFR 1926.65, paragraph (q): *emergency response to hazardous substance releases*, and the United States Fire Administration Special Report on Scrap and Shredded Tire Fires (1998).

### 6.3.8 Establishment of Control Zones

Tire pile fires, like any hazardous materials incidents, require that control zones be setup to minimize hazards to responding fire personnel, law enforcement, consultants, press, and the public. Control zones are those areas at a hazardous materials incident that are designated based upon safety and the degree of

hazards. The most frequently used terminology for these zones are the hot, warm, and cold zones. These zones are described in more detail below.

- **Hot Zone:** The hot zone is the area immediately surrounding the tire pile fire, and extending far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the exclusion zone or restricted zone in other documents.
- **Warm Zone:** The warm zone or support zone is the area where personnel and equipment decontamination and hot zone support take place. It includes control points for the access corridor and thus assists in reducing the spread of contamination. This zone is also referred to as the decontamination, contaminant reduction, or limited access zone in other documents.
- **Cold Zone:** The cold zone contains the command post and other support functions that are deemed necessary to control the incident. This zone is also referred to as the clean zone in other documents.

### 6.3.9 Decontamination Procedures

Decontamination, or contaminant reduction is the physical and/or chemical process of reducing and preventing the spread of contamination from persons and equipment used within the hot zone of the tire pile fire. Decontamination takes place within the “Warm Zone” or “decontamination area”.

The National Fire Protection Agency (NFPA, 1997) published an excellent reference describing decontamination procedures at tire pile fire sites. This description of decontamination procedures at tire pile fire sites is reprinted below.

**Decontamination Plan.** At every incident involving hazardous materials, there is a possibility that personnel, their equipment, and members of the general public will become contaminated. The contaminant poses a threat, not only to the persons contaminated, but also to other personnel who may subsequently come into contact with the contaminated personnel and equipment. The entire process of decontamination should be directed toward confinement of the contaminant within the hot zone and the decontamination corridor to maintain the safety and health of response personnel, the general public, and the environment. Sound judgment should be exercised and the potential effects of the decontamination process upon personnel should be considered when developing the decontamination plan.

Although decontamination is typically performed following exit from the hot zone, the determination of proper decontamination methods and procedures needs to be considered before the incident, as part of the overall pre-incident planning and hazard and risk evaluation process. No entry into the hot zone should be permitted until appropriate decontamination methods are determined and established based on the hazards present, except in those situations where a rescue may be possible and emergency decontamination is available.

Emergency response personnel should be familiar with the definitions of the following terminology:

- (a) Contaminant
- (b) Contamination
- (c) Decontamination (contamination reduction)

- (d) Decontamination corridor
- (e) Emergency decontamination
- (f) Exposure
- (g) Gross decontamination
- (h) Secondary contamination

**Decontamination.** Decontamination consists of reducing and preventing the spread of contamination from persons and equipment used at a hazardous materials incident by physical and/or chemical processes. Emergency response personnel should implement a thorough, technically sound decontamination procedure until it is determined or judged to be no longer necessary.

Emergency response personnel should have an established procedure to minimize contamination or contact, to limit migration of contaminants, and to properly dispose of contaminated materials. The primary objective of decontamination is to avoid becoming contaminated or contaminating other personnel or equipment outside of the hot zone. If contamination is suspected, decontamination of personnel, equipment, and apparatus should be performed.

Procedures for all phases of decontamination need to be developed and implemented to reduce the possibility of contamination to personnel and equipment. Initial procedures should be upgraded or downgraded as additional information is obtained concerning the type of hazardous materials involved, the degree of hazard, and the probability of exposure of response personnel. Assuming protective equipment is grossly contaminated, appropriate decontamination methods should be used for the chemicals encountered.

The decision to implement all or part of a decontamination procedure should be based upon a field analysis of the hazards and risks involved. This analysis generally consists of referring to technical reference sources to determine the general hazards, such as flammability and toxicity, and then to evaluate the relative risks. Decontamination procedures should be implemented upon arrival at the scene, should provide an adequate number of decontamination stations and personnel, and should continue until the incident commander determines that decontamination procedures are no longer required.

**Precautionary Decontamination.** There are occasions when an apparently normal alarm response turns into a hazardous materials incident. Frequently, most of the initial assignment crews will have already gone into the incident area and exposed themselves to the contamination threat. It is essential that all members so involved remove themselves from the area at once, call for decontamination capability, and stay together in one location. They must not wander around, climb on and off apparatus, and mix with other personnel since there is a potential for them to be contaminated or to spread the contamination. Fire fighters so exposed should be given gross decontamination as a precautionary measure. Knowledgeable hazardous materials personnel, such as the decontamination sector officer, in conjunction with the incident commander, should determine whether more definitive decontamination is necessary. Remember, the primary objective of decontamination is to avoid contaminating anyone or anything beyond the hot zone. When in doubt about contamination, decontaminate all involved personnel, equipment, and apparatus.

## **Decontamination Methods**

**Physical Methods.** Physical methods generally involve the physical removal of the contaminant from the contaminated person or object and containment of the contaminant for appropriate disposal. While these methods can reduce the contaminant's concentration, generally the containment remains chemically unchanged. Examples of physical decontamination methods include the following:

- (a) Absorption
- (b) Brushing and scraping
- (c) Isolation and disposal
- (d) Vacuuming
- (e) Washing

**Chemical Methods.** Chemical methods are used on equipment, not people, and generally involve decontamination by changing the contaminant through some type of chemical reaction in an effort to render the contaminant less harmful. In the case of etiologic contaminants, chemical methods are actually biologically "killing" the organism.

Examples of chemical methods include the following:

- (a) Adsorption
- (b) Chemical degradation
- (c) Disinfection or sterilization
- (d) Neutralization
- (e) Solidification

**Prevention Methods.** If contact with a contaminant can be controlled, the risk of exposure is reduced and the need for decontamination can be minimized. The following points should be considered to prevent contamination:

- (a) Stress work practices that minimize contact with hazardous substances.
- (b) Wear limited-use or disposable protective clothing and equipment, when appropriate.

**Decontaminating Personal Protective Equipment (PPE).** During doffing of personal protective equipment, the clothing should be removed in a manner such that the outside surfaces do not touch or make contact with the wearer. A log of personal protective equipment used during the incident should be maintained. Personnel wearing disposable personal protective equipment should proceed through the decontamination process setup in the decontamination area, and the disposable protective equipment should be containerized and identified for disposal in accordance with established procedures.

The physical and chemical compatibility of decontamination solutions needs to be determined before they are used. Any decontamination method that permeates, degrades, damages, or otherwise impairs the safe function of PPE should not be used unless there are plans to isolate and dispose of the PPE.

Water or other solutions for washing or rinsing may have to be confined, collected, containerized, and analyzed for proper treatment and disposal. Consult with

environmental and public health agencies or other appropriate reference sources and guidelines to determine the need for confinement and the appropriate disposal methods for collected decontamination fluids and personal protective equipment.

Decontamination methods vary in their effectiveness for removing different substances. The effectiveness of any decontamination method should be assessed throughout the decontamination operation. If decontamination does not appear to be effective, a different method should be selected and implemented. Before initiating decontamination, the following questions should be considered:

- (a) Can decontamination be conducted safely?
- (b) Are existing resources adequate and immediately available to perform decontamination of personnel and equipment?
- (c) If not, where can they be obtained, and how long will it take to get them?

Criteria that can be used for evaluating decontamination effectiveness during field operations include the following:

- (a) Contamination levels are reduced as personnel move through the decontamination corridor.
- (b) Contamination is confined to the hot zone and decontamination corridor.
- (c) Contamination is reduced to a level that is as low as reasonably achievable.

Methods that may be useful in assessing the effectiveness of decontamination include the following:

- (a) Visual observation (stains, discolorations, corrosive effects, etc.)
- (b) Monitoring devices (Devices such as photoionization detectors (PIDs), detector tubes, radiation monitors, and pH paper strips/meters can show that contamination levels are at least below the device's detection limit.)
- (c) Wipe sampling (Such sampling provides for after-the fact information on the effectiveness of decontamination. Once a wipe swab is taken, it is analyzed by chemical means, usually in a laboratory. Both protective clothing, equipment, and skin may be tested using wipe samples.)

**Large Item and Equipment Decontamination.** Large items of equipment, such as vehicles and trucks, should be subjected to decontamination by washes, high-pressure washes, steam, or special solutions. Water or other solutions used for washing or rinsing may have to be confined, collected, containerized, analyzed, and treated prior to disposal. Consult with environmental and public health agencies to determine the appropriate disposition. If a large number of vehicles need to be decontaminated, the following recommendations should be considered:

- (a) Establish a decontamination pad as a primary wash station. The pad may be a coarse gravel pad, concrete slab, or a pool liner. It may be necessary to collect these decontamination fluids, and the decontamination pad may be bermed or diked with a sump or some form of water recovery system.
- (b) Completely wash and rinse vehicles several times with detergent. Pay particular attention to wheel wells, radiators, engines, and chassis. Depending on the nature of the contaminant, it may be necessary to collect all runoff water from the initial gross rinse, particularly if there is contaminated mud and dirt on the underside of the chassis.

- (c) Vehicles should be inspected thoroughly by qualified personnel for possible mechanical or electrical damage. Areas of concern include air intakes, filters, cooling systems, and air-operated systems.
- (d) Empty completely and thoroughly wash any outside compartments that were opened. The equipment should be washed and rinsed prior to being replaced.
- (e) Equipment sprayed with acids should be flushed or washed as soon as possible with a neutralizing agent such as baking soda and then flushed again with rinse water.
- (f) If vehicles have been exposed to minimal contaminants such as smoke and vapors, they may be decontaminated on-site and then driven to an off-site car wash for a second, more thorough washing. Car washes may be suitable if the drainage area is fully contained and all runoff drains into a holding tank.
- (g) Verification of adequacy of decontamination, where necessary, may consist of samples collected from the cab and exterior surfaces that are analyzed in an off-site laboratory.

Personnel assigned to the decontamination team should wear an appropriate level of personal protective equipment (PPE) and may require decontamination themselves. Personal protective equipment can be upgraded or downgraded as additional information is obtained concerning the type of hazardous materials involved, the degree of hazard, and the probability of exposure of response personnel.

If personnel display any symptoms of heat exhaustion or possible exposure, appropriate emergency measures need to be implemented to doff PPE, while protecting the individual from contaminants and preventing the spread of any contaminants. These individuals should be transferred to the care of emergency medical services personnel who have completed training in accordance with applicable standards (e.g., NFPA 473, Standard for Competencies for EMS Personnel Responding to Hazardous Materials Incidents).

A debriefing should be held for those involved in decontamination as soon as practical. Exposed persons should be provided with as much information as possible about the delayed health effects of the hazardous materials involved in the incident. If necessary, follow-up examinations should be scheduled with medical personnel.

Exposure records should be maintained for future reference by the individual's personal physician and employer. This will help to provide early recognition and treatment of personnel with adverse physiological responses as a result of on scene activities.



## 7.0 COMMAND AND CONTROL

Tire pile fires, like all fire incidents, should be managed under an incident command system (ICS), further it is recommended that these incidents be handled as hazardous materials (HAZMAT) incidents. In order to establish and maintain command and control of all response efforts associated with a tire pile fire, a unified command (UC) should be established where all aspects of the incident can be calculated and communicated. Typically, tire fires involve active participation from multiple federal, state, and local agencies 24-hours a day for several days or even months. Effective communication is imperative. Following an established site-specific safety and emergency response plan, or pre-incident plan, is the best approach to ensure timely and efficient containment of tire pile fires. However if unavailable, the following sections give general overviews of an approach to the command and control of a tire pile fire.



### 7.1 Access Fire

Current operating requirements for tire storage and disposal facilities requires that tires be separated into piles designed to create natural fire breaks which limit the amount of available fuel and provide access to burning tire piles. If access to the tire pile is inadequate or unsafe, it may be necessary to create access roads to allow entry of heavy equipment to the tire piles in order to fight and control the spread of the fire.

A map of the tire pile facility and surrounding area must be created. The map should show the layout of the facility including all fire protection systems; utility lines that service the area; and descriptions and locations of specific types of equipment used in and around the tire pile facility. It is also necessary to show area roads, streams, wooded areas, neighboring buildings, and water supplies. A topographic map of the vicinity can be used in strategic pre-incident planning to provide valuable insight into potential firebreaks including roads and natural vegetation breaks as well as likely run-off paths and down-stream receptors.

Specific tactics for creating access to each tire pile fire will depend on the size of the tire pile, availability of a continual water supply source, personnel, and response equipment, and proximity to structures.

However, in general, the following considerations should be followed when creating access roads to tire piles to allow access of heavy equipment for both burn suppression and control of spreading.

### 7.1.1 Burn Suppression

Sufficient access must be available or created to allow fire suppression equipment access to burning tires as well as viable water or foam suppression supplies. It is often necessary to use heavy equipment including excavators, bulldozers, front-end loaders and dump trucks to create adequate access roads around and through large tire piles. In order to establish adequate roads for the heavy traffic, it may be necessary to use sand, stone and dirt on the roads. A list of local and regional contractors with equipment available for use should be maintained by fire departments so that the information is readily available when needed. Equipment may be procured from:

- Local and State Highway and Public Works Departments
- Excavation and Building Supply Contractors;
- Fire Equipment Suppliers;
- Hazardous Waste Contractors including Oil Recyclers;
- Portable Sanitation Contractors;
- Apparatus and Equipment Repair Contractors; and
- Fuel Vendors.

It is generally recommended that trained operators be contracted to operate the heavy equipment, allowing trained firefighters to focus on extinguishing the fire. Keep in mind that both the state and federal EPA should be notified in the event of a tire fire. If the fire is declared a hazardous materials incident, state and federal funds might be available to alleviate or reimburse heavy equipment expenditures. A contract with a fuel vendor is also necessary to provide on-site re-fueling of equipment.

### 7.1.2 Spread Control

Another aspect of tire fire response is controlling the spread of the fire. This may involve the use of natural or created firebreaks, wetting unburned surfaces or structures, and removal of unburned tires from the pile. If possible, unburned tires should be separated from the burning tires to prevent spreading and to limit the available fuel sources. This may require the use of contracted heavy equipment. Burning and unburned tires may be wetted, buried, or submerged to prevent spreading of the fire. It is also necessary to address oily runoff associated with tire pile fires. It is possible for the runoff to be burning or to ignite and carry fire from the original location. In general, foam suppressants are used to prevent and extinguish oily run-off fires, but are generally ineffective on tire fires.

## **7.2 Recognize Unusual Activities/Site Practices**

Another critical aspect of tire pile fire response is identifying any unique activities or practices at the site and determining potential hazards or benefits associated with each. It is necessary to identify sources of combustible or flammable products such as fueling stations, underground storage tanks, heavy machinery, buildings, or debris piles. Steps must be taken to prevent the fire from reaching these features.

Other features, such as ponds, pits, hills or ravines may prove beneficial to fire response. A pond may provide a source of water for pumping or a place to submerge burning tires, burning tires may be placed in a pit or shallow ravine and covered with soil, sand or gravel to extinguish the fire. Hills or dirt piles may be used to create berms to prevent the spread of the fire or to smother burning or smoldering tires. It is also prudent to identify previous land uses (i.e. gasoline station, landfill, chemical storage facility, etc.) and any associated concerns. In addition, identify any areas of contamination that might be affected by or

migrate with runoff. If at all possible, identify all current and historic areas, features, equipment and activities at a tire pile site before a fire starts or in the earliest response plans.

### **7.3 Establish Unified Command**

Since burning tires should be considered hazardous materials incidents, response efforts should be conducted under strict hazardous materials incident protocols. As part of this response, and in order to effectively control the chaos that inevitably accompanies a tire pile fire, it is necessary to establish a unified command (UC). The UC operates similarly to an ICS and incorporates far more than merely the fire suppression activities. The UC is set up to incorporate the fire response ICS, as well as all environmental and public relations aspects. Typically the U.S. EPA and the Fire ICS commander serve as the UC, with the EPA Federal On-Scene Coordinator (FOSC), a public information officer (PIO), and technical support personnel directly beneath the UC command. With a UC in place, proper decisions can be made for all aspects of the tire fire response and communicated effectively to the appropriate response personnel.

A clear chain-of-command should be identified and a command station should be established. This command station will become the center of all activities at the site. Personnel at the command center are responsible for safety coordination as well as monitoring and supervising all aspects of the response, including media and public relations. The technical support resources, such as a State Fire Marshall or State or local regulatory agency, provide valuable input at the command level. Typically the responding fire department assumes the role of Incident Command until a UC is established. This is often prudent since incident response protocols vary from county to county and state to state, and typically the responding fire department is familiar with the policies or laws that govern the response and are able to determine which agencies should be involved (USEPA, 2000a; USFA, 1998; and Scrap Tire Management Council, 1992).

### **7.4 Establish Effective Communication**

Tire pile fires often involve members of several fire departments; local, state and federal government agencies; volunteers; and media representatives. Therefore, establishing an effective means of communication is essential to the overall efficiency of the response efforts. This may best be handled by the UC designating specific communication personnel, such as a PIO for all media and public information, or the ICS commander or a site Safety Officer for communicating with onsite personnel. The ICS commander would manage the fire fighting operations, while the Safety Officer would be responsible for controlling site access, conducting site briefings, as well as interacting with all agencies and personnel responding to the incident to ensure compliance with applicable Occupational Safety & Health Administration (OSHA) and Environmental Protection Agency (EPA) safety regulations. (Keep in mind that all responders should also be monitored by their respective employers.) It is also necessary for the Safety Officer to document all people and agencies responding to the incident, and any injuries or medical services associated with the incident. The designated Safety Officer may also coordinate air monitoring, run-off containment, general site security and safety, and burned product overhaul and/or removal processes.

At a minimum, site briefings should be held daily and at each shift change. Site briefings should be used to inform all personnel of the conditions at the site, dangers, potential risks, site-specific safety procedures, and any other pertinent information relating to response efforts. It is also necessary to discuss what communication channels are to be utilized and it must be verified that all participating parties are equipped with some means of communicating with other members of the response team in accordance with fire department personnel accountability systems. It is also recommended that the use of

communication codes or abbreviations be avoided to prevent confusion (USEPA, 2000a; USFA, 1998; and Scrap Tire Management Council, 1992).

## **7.5 Coordinate Public Agencies and Private Contractors**

Some agencies that may become involved in responding to a tire fire include:

- Police;
- Environmental Protection Agencies;
- Federal, State and Local Emergency Response/Management Agencies or Departments;
- Local and State Highway and Public Works Departments;
- Federal, State and Local Fire Agencies, including the State Fire Marshall's Office;
- State Natural Resources Agencies; and
- Procurement and Finance Agencies.

Private contractors will also play a valuable role in providing much needed resources during a tire fire response. A list of public and private resource providers should be developed so that required equipment and supplies can be requested without delay in the event of a tire pile incident. Operators of heavy equipment and other contract personnel responding to a tire fire incident will need to be trained in the use of fire fighting personal protective equipment and be kept current with hazardous materials response training and protocols. It is recommended that this training take place in the pre-fire planning stages to prevent delays and/or risks at the time of a tire fire incident. Some resources and resource providers are listed in Table 7-1.

**Table 7-1**  
Potential Contract Resource Providers

<b>Resource</b>	<b>Resource Provider</b>
Heavy Equipment and Operators	Local and State Governments; Highway and Public Works Departments
Heavy Equipment and Operators; Fill Dirt and Gravel	Excavation and Building Supply Contractors
Large Bulldozers, Excavators and Operators	Excavation/Rigging Contractors
Heavy Equipment and Operators	Fire Equipment Suppliers
Collection and Containment Systems	Hazardous Waste Contractors Including Oil Recyclers
Portable Sanitation Services	Portable Sanitation Contractors
Mechanical Equipment Maintenance & Repairs	Apparatus and Equipment Repair Contractors
Rehabilitation Shelters; Busses for personnel transportation and evacuations	Transportation Agencies/School Systems
Staff from Engineering, Ecology, and Environmental Departments	Colleges & Universities
Food Services	Food Service Contract Suppliers
Foam, Sand, Gravel, Fill Dirt, Water, Communication Devices, Portable Fences/ Barriers/ Buildings, etc.	Various Contract Suppliers

Source: USFA, 1998

## 7.6 Recognize Contact Notification Procedures

In responding to a tire pile fire, it will be necessary to notify various agencies, contract suppliers, and possibly the general public within the immediate vicinity of the incident. Establishing notification procedures will help to alleviate unnecessary or duplicate efforts and improve the efficiency. Keep in mind that the Federal and State EPA response centers should be notified within 24 hours. If the incident is declared or classified as a hazardous materials incident, state and federal funds may become available to help alleviate the cost of resource procurement and extinguishment of a tire pile fire. It is also necessary to accurately provide tire pile fire information to the California Fire Incident Reporting System coordinated through the State Fire Marshall's Office. Some agencies that should be notified include:

- Police;
- Federal Environmental Protection Agency (must be notified with 24 hours);
- Federal, State and Local Emergency Response/Management Agencies or Departments;
- Regional office of the Federal Emergency Management Agency (FEMA);
- Local and State Highway and Public Works Departments;
- Federal, State and Local Fire Agencies, including the State Fire Marshall's Office;
- State Natural Resources Agencies;

- Procurement and Finance Agencies; and possibly
- Local Media, Political, and Social Representatives.

## **7.7 Mobilize Resources**

Efficient and prompt mobilization of resources is critical to the effectiveness of any tire pile fire. Prompt response is critical in urban tire fire settings to minimize damage to adjoining properties and to prevent or minimize the health effects on the population in the immediate vicinity as quickly as possible. This is also important in non-urbanized areas where resources may not be readily available and responding agencies may be located some distance away increasing the time a tire burns before measures are in place to adequately protect the population and the environment and respond to the tire fire incident.

## **7.8 Public Relations and Information**

General incident command or management systems typically include establishing a public information officer (PIO) or an incident information officer (IIO) to coordinate with the Incident Commander to collect and release information about the incident to organizations, agencies, and the news media. Often tire pile fires become major incidents worthy of extensive media coverage, which can negatively impact response efforts if not properly managed. A press staging area should be established to provide a safe place for media teams to cover the story and for the PIO/IIO to distribute information to the media.

### 7.8.1 Responding to Public and Press

Written press releases should be prepared and distributed and press briefings and escorted visits to the incident command area should be scheduled at regular intervals. It may be necessary to conduct formal credentialing and identification of press members to limit the number of non-responding personnel to the area. Efforts should be made to provide the news media information in a timely manner paying attention to publication and production deadlines. It is the responsibility of the PIO/IIO to respond to and dispel all rumors and to be truthful and honest in all release statements. The PIO/IIO should write statements providing factual accounts of the incident following taped or live interviews. At all times, tire fire responders should maintain a positive and professional demeanor, especially in the presence of the media and the public (USFA, 1998 and Scrap Tire Management Council, 1992).

### 7.8.2 Develop an Information Distribution System

An information distribution system, including frequent press releases and regularly scheduled press briefings, can significantly reduce the personnel required to operate the communication command center. Well-publicized “hot line” numbers should be established to provide a place for the public and the media to access site-specific information and to clarify evacuation instructions (if required). Incident information should be prepared in advance and released accordingly. Information pertaining to the status of environmental regulatory, code enforcement, and hazard abatement activities should be promptly distributed to the media. An interview should be coordinated with a local public official to assure the public the incident is being adequately handled and managed. The PIO/IIO should provide special incident briefings to the local public official prior to the interview (USFA, 1998 and Scrap Tire Management Council, 1992).

## 8.0 IMPLEMENT ACTION PLAN

Upon initial arrival at a tire fire incident, the responding fire officer should “size-up” the incident and begin to establish an Incident Command System (ICS). It is necessary to accurately communicate the initial findings to the dispatcher so that communication with necessary responders can be initiated as soon as possible. It should be determined as soon as possible if an incident management plan or pre-incident plan exists for the facility. If a pre-fire plan or incident management plan exists, begin implementation of the plan immediately. If no plans exist for the facility, initiate development of a response plan immediately, following the same basic tactics that would be applied to incidents potentially requiring hazmat responses.



### 8.1 Develop Standard Operating Guidelines

Early development of standard operating guidelines will help ensure a cohesive approach to a tire fire incident. When developing these standards the general priority of actions should be protection of human life; spread prevention and containment; extinguishment; and overhaul (COSFM, 1995). Once these standards are developed they should be used to brief all responders participating in response efforts. Each of the priority actions is briefly discussed below.

- **Protection of Human Life:** This involves determining the appropriate personal protective equipment (PPE) to be used by incident responders and to determine if the smoke plume warrants evacuation of nearby occupied structures. It is necessary to continually assess weather conditions and modify PPE requirements and evacuation zones in order to most effectively protect the public. To the extent feasible, fire-fighting tactics should be approached and managed from the upwind direction to minimize health affects to fire fighting personnel.
- **Spread Prevention and Containment:** It is critical in the early stages of a tire fire to take steps to minimize the fire from spreading to unburned tires, structures and other fuel sources. This may involve the use of heavy equipment to remove unburned tires and to create fire and/or windbreaks. Wetting agents and foams may be used to protect structures and other fuels sources and to prevent oily run-off from igniting. Berms may be created to contain the fire and direct

run-off to collection ponds. The use of proper containment measures prior to the introduction of large quantities of water will minimize run-off and the associated environmental impacts.

- **Extinguishment:** After the fire has been adequately contained and run-off collection measures are in place, extinguishing methods may be employed. This may include letting the fire burn; dousing/flooding; smothering; burial; and submerging tactics. It is best to follow a site-specific pre-incident response plan that was researched and designed for the specific needs and limitations of each facility prior to a fire crisis. The best extinguishment technique for a tire pile fire will vary based on specific strategic considerations at each site (i.e. rural vs. urban location; proximity to water bodies; depth and use of groundwater; etc.).
- **Overhaul:** After a tire fire has been extinguished, it is necessary to overhaul the burn area to prevent re-ignition. Tires must be completely extinguished and cooled, typically to below 200° F, prior to transporting. Tires may be cooled by burial in dirt or by submergence in water in either shallow ponds or in construction dumpsters filled with water. Proper overhaul of a burned tire pile ensures against re-ignition and further damage.

## **8.2 Tire Fire Dynamics (Stages of Combustion)**

Basic concepts of combustion involve the transition of a material from a solid to a liquid to a vapor. This is true with tires as it is with almost any combustible material. One distinguishing difference between wood fires and tire fires is in a tire's ability to absorb radiant heat and to then transfer that heat to the internal steel belts and bead wires found in most modern tires. The tire's ability to absorb heat makes them more difficult to ignite than wood fires, but this same quality makes tire fires more difficult to extinguish than wood fires. Tire fires typically progress through three stages: the Incipient or Ignition and Propagation Stage; the Free Burning Stage; and the Smoldering Stage. The Free Burning Stage can be further separated into the Compression Stage and the Equilibrium and Pyrolysis Stage (USFA, 1998 and Scrap Tire Management Council, 1992). Each of these stages is discussed below.

### 8.2.1 Ignition and Propagation Stage

Once a tire has ignited and a flame front has been developed, constant radiant heat flow will begin to affect the surrounding tires. It is generally accepted that tires will begin to decompose in the presence of radiant heat between 410 degrees Centigrade (°C) and 538°C. An initial burn rate of approximately 2 square feet every five minutes in the windward direction is generally accepted for tire pile fires. The rate accelerates 50 percent after the first ten minutes of burn time. During this stage the fire has little forward and downward pressure as the surrounding tires are absorbing most of the heat.

### 8.2.2 Free Burning: Compression Stage

The flattening and shredding of tires as they begin to lose their shape and flatten into strips characterizes the beginning of the compression stage. Open flaming and forward pressure is produced during this stage with increased amounts of heat and smoke. The heat contributes to the collapse of the tires building downward pressure.

At this point, in very large tire pile fires, the surrounding air cannot quickly absorb the heat from the fire. There is very little downward pressure since the tires are still mostly round and the fire is not deep-seated. The heat output is relatively low with incomplete and uneven combustion. With large, high-piled tire pile fires, inward collapse may begin within thirty minutes to one hour after initial ignition. With low-piled tire pile fires, much of the available fuel is consumed during the first hour and it may take several hours before the pile begins to collapse.



As a tire pile begins to collapse, a semi-solid mass of rubber, tire cords and steel is created and the open flame is slowed as the internal portions of the tire pile fire receives less air. At this point, equilibrium is starting to occur, which is the next stage of a tire fire.

### 8.2.3 Free Burning: Equilibrium and Pyrolysis Stage

A tire pile fire reaches equilibrium when the level of fuel conversion is approximately equal to the available amounts of heat, fuel, and oxygen. At this point the tire pile fire has low open surface flames with much of the fire deep-seated or internal. This results in very high internal temperatures (approximately 1,100°C) and slower and more complete fuel consumption.

Fire spread during this phase is influenced by the tire product configuration. Whole tire piles will tend to burn down into the middle of the pile because the shape of the tires allows heat and gas to rise vertically, bringing oxygen up with the cool air, through the pile from below. After whole tires have burned, the covering formed by the remaining steel cords effectively break-up water streams, producing steam before the water affects the burning tire pile. Fire tends to spread over the surface of shredded tire and crumb rubber piles. This results in a ceramic clay-like covering that deflects water and prevents water penetration from dousing the fire, allowing the internal fire to continue burning.

Pyrolysis is defined as a chemical change brought about by the introduction of heat. In tire pile fires this occurs when tires breakdown in the fire and release pyrolytic oil. Downward pressures then push this oil out of the fire. During a tire pile fire, the average passenger tire releases up to 2.0 gallons of pyrolytic oil.

### 8.2.4 Smoldering Stage

As tire pile fires burn during the smoldering stage, products of incomplete combustion are released. Of particular concern is pyrolytic oil, which will begin to pool and run-off and/or leach into the soil. It is possible for the heat from the tire pile fire to ignite the pyrolytic oil creating a secondary flowing oil fire. Other products of concern released during this stage of a tire pile fire include carbon monoxide, polynuclear aromatic hydrocarbons and volatile organic compounds. As the rate of propagation of the fire slows along the edges, the outer surfaces cool trapping intense heat internally. At this point it can be extremely hazardous to open up the fire, as emissions of fire gasses are released at a high rate and can flash up at high speeds as available oxygen increases.

## **8.3 Firefighting Tactics/Strategies**

It is generally accepted that separation and dousing, submersion and/or burial is the most effective and least environmentally damaging method of tire pile fire extinguishment. Direct application of water and/or foams generally does not effectively extinguish tire pile fires; creates large volumes of contaminated run-off that must be contained and treated or disposed of; and may actually dramatically increase associated environmental impacts. In general, water and foam use is best limited to preventing fire spread and oily run-off fires. The following table addresses possible firefighting tactics for each stage of a tire pile fire.

**Table 8-1**  
Fire-fighting Tactics According to Stage of Fire

<b>Stages of Tire Combustion</b>	<b>Typical Time (minutes)</b>	<b>Whole Tires</b>	<b>Shredded Tires / Crumb Rubber</b>	<b>Possible Action</b>
Ignition and Propagation Stage	0 – 30	Active tire burning of individual tires. Fire has not spread to the entire pile. Once spreading begins, the fire continues at rate of approximately 2 square feet every five minutes.	Tire shreds are readily ignited. Fire spreads along surface of pile quickly involved entire pile in fire.	In first 5 minutes, extinguishment may be possible using water, foams or wetting agents. Otherwise, focus efforts on separating remaining tires/products from the fire. Focus on down wind direction first.
Compression Stage	30 – 60	Top layer of tires collapse. Flaming is reduced as fire becomes deep-seated.	Burns like coal - hot center with clay-like ash crust .	Continue separation efforts; build containment berms and collection ponds for oil and run-off.
Equilibrium / Pyrolysis Stage and Smoldering Stage	60+	Fuel consumption = available heat, fuel and oxygen efficiently consuming most products. Downward pressures push pyrolytic oil from the burn; increasing run-off. As fire moves into smoldering stage, products not consumed in combustion are released.	Clay-like crust prevents water from penetrating to hot core.	Focus on Containing Fire Spread and Oily/Run-Off. Most favorable means of suppression involves separation of a small portion of burning debris; which is then extinguished by fog stream or submersion (roll-off bin filled with water or shallow pond). Another method involves allowing tire pile to burn to a manageable size. Oily run-off may be ignited - Class B Foam is effective in suppressing oily-run-off fires (used after containment is in place)

Sources: (USFA, 1998 and Scrap Tire Management Council, 1992)

### 8.3.1 Rural

Response efforts for rural tire pile fire incidents may be hindered by extended response times. Access to the location may be hindered by very remote locations or by lack of sufficient access roads for the equipment necessary to respond to a tire pile fire incident. Often viable sustained water sources, other suppression products, and trained responders are limited or unavailable in rural settings. It may take extra time for resources and equipment to reach the incident, including required personnel and environmental representatives. Also, rural residents are more likely to rely on well water, which may become affected by the constituents contained in run-off. It is important to be knowledgeable regarding the underlying geology and depth to groundwater in the vicinity of a tire pile fire, in order to better assess the potential for beneficial groundwater and/or well contamination associated with run-off from tire pile fire response efforts. Grass and brush fires are also important considerations for rural tire piles as they can ignite tire pile fires and tire pile fires may ignite grass/brush fires.

### 8.3.2 Urban

Urban tire pile fire response efforts may require initial response efforts to focus on protecting dense populations of people and structures. Access and maneuvering space may be limited. It cannot be assumed that adequate water supplies exist, even though fire hydrants and other municipal utilities are available in the area. Pre-planning may reveal that hydrant water supplies are inadequate for responding to tire pile incidents since they often require large quantities of water. In at least one instance, pre-planning efforts discovered that the water tower supplying water to hydrants near a tire pile facility was limited by a 300,000-gallon capacity and refilling the tower was slow and could not keep up with the demand. Also, urban facilities that are no longer in operation may have fire suppression systems in place, however the power supply and/or other utilities needed to operate the systems may have been turned off hindering initial response efforts, while the utility companies are contacted to restore service to the facilities. When possible, pre-planning efforts should be conducted to identify and fully evaluate incident response procedures for each tire pile facility before a crisis occurs, this clear plan will speed response efforts and help reduce the damage to structures and the environment historically caused by tire pile fires.

## 9.0 ENVIRONMENTAL CONCERNS

### 9.1 Pyrolytic Oil, Ash, Smoke, and Water

Pyrolytic oil, ash, and smoke are byproducts of a tire pile fire, and present a significant risk to the environment and the responders to a tire pile fire. The two main environmental concerns associated with pyrolytic oil, ash and smoke are health affects to response personnel and impacts to the environment itself.

#### 9.1.1 Pyrolytic Oil

Pyrolytic oil is generally formed during the equilibrium/pyrolysis combustion stage of a tire fire, in which fuel combustion and heat production equalizes, combustion produces enough heat to consume most of the combustion products, and downward pressure of the tire pile causes an increase of run-off oil flow (USFA, 1998). As tires burn, they can theoretically release 2.0 gallons of pyrolytic oil per tire, potentially creating an oil fire that helps to both fuel and spread the scrap tire pile fire (USEPA, 2000c). Previous tire pile fires have generated as much as 10-14 million gallons of pyrolytic oil (USEPA, 2000c).



Pyrolytic oil is basically a free-flowing tar that contains naphthalene, anthracene, benzene, thiazoles, amines, ethyl benzene, toluene, and various other petroleum hydrocarbons, as well as various metals such as cadmium, chromium, nickel, and zinc (Horrigan, 1999). Measures should be taken to protect all workers or personnel who may come in contact with the oil. Primary routes of exposure to workers are dermal contact and ingestion of contaminated soil and water (surface water and run-off water) (USFA, 1998).

Other environmental concerns associated with pyrolytic oil include contamination of soil and water, including surface water and groundwater. Pyrolytic oil is capable of traveling significant distances over land depending on local topography, migrating downward through soil into groundwater, and entering surface waterways. Oil can also flow underground through a permeable soil horizon or other preferential pathway. Therefore, soil, surface water and groundwater can all become contaminated by pyrolytic oil during a tire fire. Pyrolytic oil flows must be contained to minimize environmental impacts. This includes developing an understanding of the topography and hydrogeology of the area, so strategic actions can be taken to contain oil flows.

### 9.1.2 Ash

Ash is a byproduct of combustion, and represents a great hazard to responders. Ash typically contains heavy metals such as lead, arsenic and zinc, which are released from the tires in particulate form. The primary routes of exposure for ash include ingestion, dermal contact, and inhalation. Due to the airborne nature of ash, measures should be taken to protect not only responders and other workers within the exclusion zone, but consideration should also be given to any personnel in the support zone and the public.

Ash can contaminate the soil or equipment when it settles out of the sky. Environmental impacts of ash can also be exacerbated by response activities. For example, ash can be carried downstream with surface run-off of foam or other fire suppressant materials, and can enter streams or other surface waterways. Tracks and wheels of heavy equipment used to fight the tire fire can churn up the ground and either push or mix ash into the surficial soil. Again, care should be taken and a strategic plan should be put into place to contain run-off.

### 9.1.3 Smoke

The smoke generated by a tire pile fire contains numerous hazardous compounds that pose a significant potential health hazard to downwind receptors. Smoke does not only affect the on scene responders, but has the potential to travel great distances and affect the general population downwind of the tire pile fire.

Chemicals of concern typically found in smoke from a tire pile fire include: VOCs, SVOCs, PAHs, particulate materials, heavy metals, carbon monoxide, dioxins and furans, sulfur and nitrogen oxides, PCBs, and acid gases (hydrochloric, sulfuric) (USEPA, 2000c). A comprehensive study of the toxicity of smoke from tire pile fires was performed for the EPA by E.H. Pechan & Associates, Inc. (USEPA, 1997a). A list of 34 “target compounds” was developed by analyzing data from laboratory tire fire simulations, and analytical test data from nine major tire fires (Table 9-1). These target compounds were determined to present the greatest probability of inhalation health impacts (USEPA, 1997a).



**TABLE 9-1**  
Target Compounds

<b>Compound</b>	<b>Carcinogen (Yes/No)</b>
Acenaphthene	Yes
Acenaphthylene	Yes
Arsenic	Yes
Barium	No
Benz(a)anthracene	Yes
Benzene	Yes
Benzo(a)pyrene	Yes
Benzo(b)fluoranthene	Yes
Benzylchloride	Yes
Butadiene	Yes
Carbon monoxide	No
Carbon tetrachloride	Yes
Chloroform	Yes
Chromium	Yes
Chrysene	Yes
Coal tar pitch volatiles	Yes
Cumene	No
1,2-Dichloropropane	Yes
Dibenz(a,h)anthracene	Yes
Ethylene dichloride	Yes
Hexachloroethane	Yes
Hexane	No
Lead	Yes
Methylene chloride	Yes
Nickel	Yes
Phenol	Yes
Styrene	Yes
Sulfur dioxide	No
Sulfuric acid	No
Toluene	No
1,1,2-Trichloroethane	Yes
Trichloroethylene	Yes
Vanadium	No
o-Xylene	No

Source: USEPA, 1997a

The primary routes of exposure are inhalation, skin and eye contact, however smoke and particulates can also be ingested if they enter the mouth (Horrigan, 1999). Due to the highly toxic nature of tire pile fire smoke, unprotected contact with any visible smoke must be avoided and all personnel working within the smoke must wear appropriate respiratory, eye and skin protection.

#### 9.1.4 Water

Although not a direct combustion byproduct, water is an environmental concern resulting from a tire fire. A significant volume of water is generated while fighting a tire fire with water or foam. Because the water has been in contact with the oil, the ash, and the smoke produced by the fire, run-off water may contain any or all of the contaminants found in these byproducts. Therefore, run-off water should be treated as a potentially hazardous material, and response personnel should avoid unprotected contact. As with pyrolytic oil, the run-off water will flow downhill, potentially carrying contaminants, or possibly some oil or ash itself, some distance away. The initial fire response planning stages should include a run-off containment plan. If run-off water does reach a surface waterway, such as a nearby stream, immediate action should be taken to minimize the impact of contaminants to the downstream water.

## **9.2 Environmental Monitoring**

“Real-time” environmental monitoring and environmental sampling must be incorporated into the tire pile fire response plan to assess the impact to the environment of combustion byproducts, and most importantly, to protect the health and well-being of the responders and the general public.

### 9.2.1 Air Sampling

Air sampling is essential to the health and safety of all people in the vicinity of a tire pile fire, from the response personnel to the general public. Airborne combustion byproducts such as ash and smoke contain numerous hazardous chemicals, including VOCs, SVOCs, PAHs, particulates, heavy metals, CO, dioxins and furans, sulfur and nitrogen oxides, PCBs, and acid gases (USEPA, 2000c). Many of these chemicals are carcinogenic. It is imperative to conduct air monitoring for two primary reasons: 1) to quantify the exposures received by the responding personnel and general public, and 2) to collect hard data regarding the air quality of air carried offsite. A complete air-monitoring program involves the use of general air surveillance equipment and personal air monitoring devices, and a combination of direct read out instruments and analysis of collected air samples. Strict quality assurance/quality control (QA/QC) procedures must be followed during sample collection. A sampling and analysis plan should be developed to govern all sampling activities, including standard operating procedures for sample collection and QA/QC.

Real-time air monitoring is performed using a combination of direct read out instruments. A windsock or other device should be properly installed to monitor wind direction, if possible wind velocity should also be determined. Direct read out instruments are used in the field to provide instantaneous (real-time) qualification of specific chemicals or classes of chemicals in the air, and can help identify immediately dangerous to life and health (IDLH) conditions, flammable or oxygen-deficient atmospheres, and toxic levels of contaminants in the air (Horrigan, 1999). Some direct reading instruments are listed below:

- Organic vapor analyzer (OVA) [includes photoionizing detector (PID) and flame ionizing detector (FID)]
- Three- or four-gas meters (multiple parameters, including O<sub>2</sub>, CO, %LEL)
- Colorimetric tubes (e.g. Draeger tubes, measures a specific compound)
- Combustible Gas Indicator (CGI)
- Oxygen monitor



- Real time aerosol monitor
- Portable infrared spectrometer
- Windsock and/or anemometer (wind velocity device)

In addition to real-time air monitoring, air sampling must be performed to fully assess airborne contaminants. Air samples are collected using a variety of sampling media, collection techniques, and analytical methods, depending on the target compounds. Sample media generally fall into one of two categories: filters or containers. Filters can be of various sizes and trap particles as air passes through them. These are generally used in conjunction with a small pump, and run for a specific duration. The filter is then analyzed in a laboratory to assess the contaminants that have been trapped on the filter throughout the specific time period. Containers collect a volume of air at a single point in time. Two types of containers are plastic (i.e. Tedlar) bags and steel cylinders. The entire container is taken to a laboratory, where the air inside is analyzed for various chemicals.

Collection methodology is established by occupational health or environmental health agencies such as the National Institute for Occupational Safety and Health (NIOSH), the EPA, and OSHA. The methodology specified by the agency will describe the proper media, sampling time, collection techniques, etc. and analytical methods, and is developed for each specific target compound or group of compounds (Horrigan, 1999). Analytical methods differ greatly depending on the target contaminants, and are performed by a certified laboratory. Some example analytical methods and their applications are listed below (Horrigan, 1999):

- Gas Chromatography (GC) – PAHs, hydrocarbons, VOCs
- Inductively coupled argon plasma atomic emission spectroscopy (ICP) – Metals
- Gravimetry – Particulates
- Ion chromatography – Inorganic acids

Several of the sampling methods published by NIOSH are listed in the table below:

**TABLE 9-2**  
NIOSH Sampling Methods

<b>NIOSH Method</b>	<b>Target Compounds</b>
NIOSH 2549	Volatile Organic Compounds
NIOSH 1501	Aromatic Hydrocarbons
NIOSH 1003	Halogenated Hydrocarbons
NIOSH 1500	Hydrocarbons, Boiling Point 36°-136°
NIOSH 1024	1,3-Butadiene
NIOSH 5506/5515	Polynuclear Aromatic Hydrocarbons
NIOSH 7300	Metals
NIOSH 500	Particulates N.O.R. Respirable
NIOSH 600	Particulates N.O.R.
NIOSH 5000	Carbon Black
NIOSH 7903	Acid Gases

Source: NIOSH, 1984

Air samples should be collected at strategically placed air monitoring “stations” and samples collected at a specific frequency for maximum effectiveness. Air samples should be initially collected when and where air contamination is suspected, after which samples should be collected at regular, pre-determined intervals. Samples should be collected upon a change in conditions, such as a change in weather (i.e.

prevailing wind direction), change in the state of the fire, change in fire fighting methodology, etc. Sampling locations should be strategically placed to provide specific data, as shown in Table 9-3 below. All air sampling data should be immediately compared to the pre-established air contaminant exposure limits, or action levels (Horrigan, 1999). Results exceeding these levels can indicate the need for action such as increasing the level of PPE worn by responding personnel, moving the contaminant reduction zone (CRZ) or support zone equipment, or notifying the downwind public.

**TABLE 9-3**  
Rationale for Air Sampling Locations

<b>Sample Location</b>	<b>Target Data (Rationale)</b>
Upwind	Establish background levels
Support Zone	Confirm location of "safe" zone
Contaminant Reduction Zone (CRZ)	Ensure that the CRZ is not within contamination plume
Exclusion Zone	Confirm that appropriate PPE is worn
Downwind	Determine contaminant levels offsite

Source: Horrigan, 1999

A good air-monitoring program provides good quality data to enable well-informed decisions regarding the protection of human health. Additionally this data can be used to defend against false litigant claims by the public and provide data for fair treatment of legitimate claims. If samples are collected from established stations along the perimeter of the site at regular time intervals throughout the operation, it can be documented when and if chemicals did or did not travel offsite. It is also advisable to collect air samples at certain offsite locations in a suspected high-risk area, such as at a school or other public facility in a nearby downwind town.

### 9.2.2 Sampling Run-off Water

Run-off water should be sampled to assess the level and types of contaminants that are being carried offsite with the water. This is especially important in situations in which a significant amount of run-off water exists, or if public drinking water or publicly accessed surface water may be impacted (Horrigan, 1999). Strict QA/QC procedures should be used during any sample collection activity. A sampling and analysis plan should be developed as a framework to guide all sampling activities, including standard operating procedures (SOPs) for sample collection and QA/QC.

The sampling plan should be designated to obtain representative samples (run-off water, soil, surface water, and potentially groundwater) to characterize the impacted body. Additionally, background samples from unimpacted areas should also be collected for comparison. Run-off water samples should be analyzed for any compounds suspected to be present in the combustion byproducts (ash, smoke, or oil), the tires themselves, and any foams or other fire fighting extinguishment chemicals. Samples should be collected at regular intervals (e.g. biweekly) during the active phases of the fire (Horrigan, 1999). Sampling should be repeated each time run-off flow changes due to changes in fire suppression tactics, or changes in run-off direction or flow. Specific methods for collecting and analyzing water samples are set forth by the EPA for different chemicals (Horrigan, 1999).

### **9.3 Run-off Control**

Run-off control is imperative to protect the environment from contamination and the public from exposure to contaminants. A run-off control plan should be developed in the pre-planning stages prior to a fire. However, if a pre-plan does not exist, as in the case of a fire at a non-permitted or illegal site, a

run-off control plan should be developed very early on in the fire fighting process. The first step in developing a run-off control plan is to evaluate the local topography and site geology and estimate the relative amount of run-off that will be expected (COSFM, 1995). For example, run-off will follow local topography and migrate downhill, much like a stream or river. Also, if the site geology consists of unconsolidated sand, much of the water and pyrolytic oil may infiltrate into the subsurface, further contaminating soil and potentially groundwater. If the local geology consists of clay or bedrock, infiltration will likely be minimal and a significant amount of surface run-off can be expected. In either case the run-off must be contained to protect the water resource, whether above or below ground. Some run-off control methods include diking, ponds, dams, and absorbent booms (COSFM, 1995). The types of control mechanisms must be engineered on a site-specific basis.

#### **9.4 Immediate Remediation Needs**

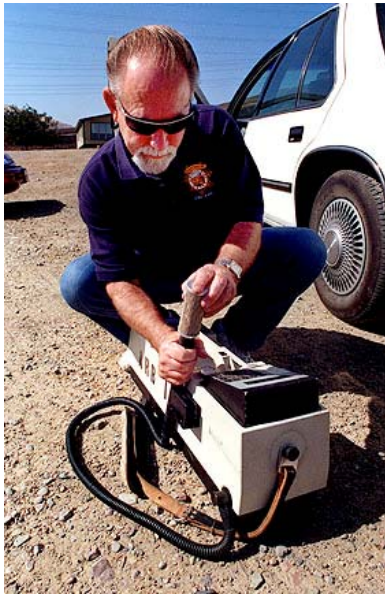
Although a great deal of site characterization and remediation of impacted soil, ground water, and surface water will occur in the post fire assessment stage, immediate remediation is critical to minimizing the environmental impacts of a tire pile fire. Following a fire, immediate remediation of pyrolytic oil, run-off or impacted water, ash, and soil can often greatly reduce the extent and cost of clean-up activities down the road. Contaminated surface water must be immediately remediated, if possible, before it carries contamination downstream to public waterways or drinking water supplies. Pooled oil or contaminated run-off water should be cleaned up as soon as possible to minimize the amount that enters the ground and possibly reaches a groundwater aquifer. Ash should be cleaned up, where possible, because excess ash can be blown or washed (by rain) offsite to public areas or into waterways. If feasible, excessively contaminated soil should be removed to minimize the potential for contaminants leaching into groundwater. Essentially, the more potentially contaminated materials that can be removed immediately following extinguishment of a tire pile fire, the less far-reaching the environmental impacts and the less time and money will be necessary to fully remediate the site.

#### **9.5 Other Site Characterization Activities**

Additional site characterization activities will generally be required at the site of an extinguished tire pile fire. These activities may include sampling/characterization and remediation of soil, groundwater, or surface water. The more completely the potential environmental impacts are anticipated and controlled in the pre-planning stage or in the fire fighting stage, the less clean-up work will ultimately be required.

## SECTION D – POST FIRE ASSESSMENT AND REMEDIATION

The extinguishment of the last flame is by no means the end of activities at a tire pile fire. Part D of this volume describes the post-fire activities. These post-fire activities include 1) site assessment; 2) site remediation; and 3) preparation of reports describing the fire fighting activities, health and safety concerns, environmental concerns, and lessons learned during the entire tire fire process.



## **10.0 SITE ASSESSMENT AND RELATED ACTIVITIES**

### **10.1 Site Assessment**

Site assessment activities are designed to identify impacts of the tire pile fire to the soil, air, surface water, and groundwater. To properly accomplish these tasks, it is necessary to understand the Chemicals of Concern (COC) that are generally present in tire pile fires, perform and document field activities and laboratory procedures using a strict Quality Assurance / Quality Control (QA/QC) program, protect onsite environmental personnel and others by preparation of an appropriate Health and Safety Plan, conduct onsite monitoring of site workers and site conditions, conduct post incident medical monitoring, and present assessment data to the public in an informative and understandable manner.

Prior to initiating any site assessment, a workplan should be developed describing the project objectives, identifying contaminants of concern, describing sample locations and sample methods and identifying appropriate laboratory analytical methods.

### **10.2 Identify the Chemicals of Concern**

Tire pile fires generally contain numerous COCs that vary depending upon the media (soil, water, air) that is affected.

Soil and ash at a tire fire site typically contains heavy metals, VOCs, and SVOCs that are released from the burning tires in particulate form. Ash and soil are combined because ash is commonly mixed with the soil by fire fighting equipment and fire fighting procedures. Generally, soil contains contaminants at a much lower concentration than those observed in ash samples. A list of contaminants typically found in soil and ash at tire pile fire sites is presented in Table 10-1. Also presented in Table 10-1, is the range of concentration of each contaminant based on experience at previous tire pile fire sites, and a comparison of those concentrations to the EPA's preliminary remediation goals, and total/soluble threshold limit concentrations.

**Table 10-1**  
Chemicals of Concern – Ash and Soil

<b>Compound</b>	<b>Range Found (ppm)</b>	<b>Residential Soil</b>	<b>Industrial Soil</b>	<b>Total/Soluble Threshold Limit Concentrations</b>
Petroleum Hydrocarbons	1,800-73,000	N/A	N/A	N/A
<i>VOCs</i>				
Ethylbenzene	14-530	230	230	N/A
Styrene	14-530	170	170	N/A
Toluene	14-530	520	520	N/A
Xylenes	14-530	210	210	N/A
<i>SVOCs</i>				
Naphthalene	29-125	56	190	N/A
2-methylnaphthalene	29-125	N/A	N/A	N/A
Anthracene	29-125	N/A	N/A	N/A
Pyrene	29-125	2,300	54,000	N/A
Benzoic acid	16	100,000	100,000	N/A
Methylnaphthalene	2.3	N/A	N/A	N/A
Para-isopropyl toluene	2	N/A	N/A	N/A
<i>Metals</i>				
Zinc (total)	880-156,000	23,000	100,000	5000
Zinc (soluble)	40 – 5,410	N/A	N/A	250
Cadmium (total)	>10x STLC	37	810	N/A
Cadmium (soluble)	N/A	N/A	N/A	1
Cr Cobalt (total)	>10x STLC	4,700	100,000	N/A
Cr Cobalt (soluble)	82	N/A	N/A	80
Lead (total)	>10x STLC	400	750	N/A
Lead (soluble)	37	N/A	N/A	5

Source: CIWMB, 1997

N/A = not applicable

VOCs = volatile organic compounds

SVOCs = semi-volatile organic compounds

Impacted surface and groundwater at a tire fire pile site may contain hazardous compounds such as heavy metals, VOCs, and SVOCs. A summary of contaminants frequently found in surface and/or groundwater at tire fire sites is presented in Table 10-2.

**Table 10-2**  
Typical Constituents Found at Concentrations Above Detection or Background Levels - Water

<i>Major Contaminants</i>	<i>Trace Contaminants</i>
Benzene	Polychlorinated bi-phenols (PCBs)
Ethylbenzene	Dioxins
Toluene	Furans
Xylenes	Phenanthrene
Phenols	Caprolactam
Ammonia	Benzonitrile
Zinc Oxide	Acetophenone
	Tolunitrile
	Phthalonitrile
	Benzothiazole
	Methyl Benzothiazole
	1-methyl naphthalene
	NDMA
	Fluorene
	Naphthalene
	Barium
	Chromium

Smoke generated by a tire pile fire contains hazardous compounds that pose a significant potential health hazard. Chemicals of concern typically found in smoke from a tire pile fire include: VOCs, SVOCs, PAHs, particulate materials, heavy metals, carbon monoxide, dioxins and furans, sulfur and nitrogen oxides, PCBs, and acid gases (hydrochloric, sulfuric) (USEPA, 2000c). Table 9-1 presents a list of contaminants frequently found in air samples collected at tire fire sites.

### 10.3 Soil Sampling

Soil sampling is conducted to determine the contaminant levels in the ash and underlying soil. The method of soil sample collection is most often determined by the soil type and the target depth of the sample. All sampling should be conducted in accordance with regulations set by the local oversight agency or federal guidelines, whichever is most stringent. Sampling should preferably be conducted only after a workplan for the proposed work has been prepared and approved by the oversight agency. At a minimum, sampling and its applicable QA/QC procedures should be conducted in accordance with U.S. EPA protocols such as those included in Quality Assurance/Quality Control Guidance for Removal Activities, Sampling, QA/QC Plan and Data Validation Procedures (Roy F. Weston, 1991).

Several sampling methods exist for the collection of near surface soil samples or samples from within exposed pits or trenches. One of the most common methods is the collection of samples using stainless steel or plastic scoops. This method can be used in most soil types, but is limited to samples within approximately one foot of the surface. Soil from the scoops is “packed” into stainless steel sample sleeves or laboratory grade sample containers. Soil must be “packed” into the container to minimize loss of VOC compounds by volatilization.

Deeper soil samples are typically collected utilizing one of many subsurface sampling techniques such as hand augers, hollow stem augers, and/or direct push methods. When using these drilling or direct push techniques, it is recommended to continuously collect soil samples for lithologic description in many if not all borings. The most common method to collect soil samples at depth is using a hollow-stem auger drill rig. The EPA documents “Subsurface Characterization and Monitoring Techniques – A Desk Reference Guide, Volume 1: Solids and Groundwater, Appendices A and B” describes a variety of subsurface soil sampling methods.

Soil, sediment, and rock encountered during drilling should be described and logged using the Unified Soil Classification System. Personnel performing the logging must be properly trained and work under the direct supervision of a California Registered Geologist.

Upon retrieval, soil samples must be sealed, labeled, and depending on the analytical tests performed, placed in a chilled (4°C) environment for transportation to a laboratory certified by the State of California for the appropriate analyses. Samples collected strictly for metals analyses only, do not require preservation by chilling. A Chain-of-Custody Record must be completed by the sampler and accompany the samples to the laboratory. Laboratory QA/QC for the soil and groundwater samples should include surrogates, method blanks, matrix spikes, and matrix spike duplicates for each analytical method. Soil samples from a tire pile site should be analyzed for the constituents discussed in Table 10-3.

**Table 10-3**  
Laboratory Analytical Methods for Soil Analyses

CAM-17 Metals	EPA Method 6010
Total Recoverable Petroleum Hydrocarbons	EPA Method 418.1
Volatile Organic, GCMS Analysis	EPA Method 8260
Semi-Volatile Organic, GCMS Analysis	EPA Method 8270
Dioxins and Furans	EPA Method 8280
Halogenated Volatile Organics (Potential compounds)	EPA Method 8010
*CAM-17 STLC Analyses (Soluble)	EPA Method 6010/7470

\*To be analyzed when individual TTLC result exceeds 10 times the STLC limit.

## 10.4 Water Sampling

Post-tire fire water sampling is conducted to determine contaminant levels in the surface water and groundwater at site. Surface water may include streams, ponds, rivers, or surface impoundments. Depending on the site location, groundwater may be a concern, especially if groundwater conditions are shallow and water in the site vicinity has a beneficial use. As with soil sampling, water sampling should be performed after a workplan for the proposed work has been approved by the lead agency. At a minimum, sampling and its applicable QA/QC procedures should be conducted in accordance with U.S. EPA protocols such as those included in Quality Assurance/Quality Control Guidance for Removal Activities, Sampling, QA/QC Plan and Data Validation Procedures (Roy F. Weston, 1991).

Several sampling methods are available for the collection of water samples. Surface water samples can be collected by filling a laboratory grade sample container from the designated water body. Collection of groundwater samples typically involves the installation of groundwater monitoring wells and then retrieving a sample with the use of a pump or bailer. An in-situ groundwater sampler can be utilized to collect groundwater samples without installation of a well. The in-situ sampler can be used as a screening tool to collect preliminary assessment data. The in-situ sampler does not allow for proper development necessary for collection of a representative water sample from the formation, however, it generally



provides a reasonable assessment of groundwater conditions. The advantage of this sampling method is that the data can be used to determine the proper placement of future groundwater monitoring wells, if needed.

If groundwater contamination is encountered, aquifer characterization will be necessary. Four basic questions must be answered to begin the aquifer characterization process, including: 1) how deep is water; 2) what direction is it flowing; 3) how much is flowing through the system; and 4) how fast is it flowing. Numerous methods are available for performing aquifer tests.

The most common groundwater sample method is to install groundwater-monitoring wells with a hollow-stem auger. EPA documents “Subsurface Characterization and Monitoring Techniques – A Desk Reference Guide, Volume 1: Solids and Groundwater, Appendices A and B” describes well installation methods and procedures.

Water samples collected in and around a tire pile site should be analyzed for the constituents shown in Table 10-4.

**Table 10-4**  
Laboratory Analytical Methods for Water Analyses

CAM-17 Metals	EPA Method 6010
Total Recoverable Petroleum Hydrocarbons	EPA Method 418.1
Total Petroleum Hydrocarbons	EPA Method 8015 modified diesel
Volatile Organic, GCMS Analysis	EPA Method 8260
Semi-Volatile Organic, GCMS Analysis	EPA Method 8270

## 10.5 Air Sampling

Post-fire air sampling should be conducted until airborne contaminants reach background conditions. This may take several days or weeks as off-gassing and residual pools of pyrolytic oil continue to smolder. At tire fire sites where tires have been buried, air sampling may continue for months, as the tires continue to smolder beneath the surface. As such, air sampling should be continued according to the methods discussed in Section 9.2.1 of this document.

## 10.6 Quality Assurance/Quality Control

To ensure that all data generated during a tire fire pile investigation is of suitable quality, the consultant must develop and maintain a quality assurance/quality control management program. All sampling plans developed for site assessment activities should document proper QA/QC procedures. The quality assurance program should include the following.

- Develop a Quality Management Plan (QMP) for site activities. The EPA has developed Standard Operating Procedures (SOP’s) for QA/QC Plans. Useful reference documents include “Quality Assurance/Quality Control Guidance for Removal Activities, Sampling QA/QC Plan and Data Validation Procedures (Roy F. Weston, 1991)” and EPA Region 9 Superfund Division Emergency Response Office Quality Management Plan, dated June 14, 2001”.
- Coordinating quality assurance efforts among all participating oversight agencies.
- Overseeing the planning, implementation and assessment of environmental quality assurance programs, and

- Overseeing the planning, generation, evaluation and reporting of data associated with quality indicators.

## 10.7 Health and Safety Plan

All site work should be conducted in accordance with the protocols established in a Health and Safety Plan (HSP) designed specifically for conditions anticipated to be encountered at a Tire Fire Pile site. The purpose of the HSP is to provide detailed information regarding anticipated health and safety matters, and to establish policies and procedures adequate to protect workers, the public, and environment from predicted site hazards. The information provided in this plan is based, in part, on best available information regarding the site. If unexpected health and safety issues arise during the course of the investigation, the plan should be modified to reflect these new conditions. A copy of this site HSP must be available on site at all times during site assessment activities.

While based on the minimum requirements of 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response (HAZWOPER), the HSP document is developed with the express purpose of implementing a high quality safety and health program. These HSP guidelines are a "living document" to be modified and updated as new regulations and other requirements are issued. The basic goal of the HSP is to provide the following information.

- Define a clear chain of command for safety and health activities and/or issues,
- Define procedures to implement in the event of an emergency,
- Identify potential physical and chemical hazards at the site,
- Outline roles, responsibilities, and accountability for safety and health performance,
- Well defined headquarters expectations regarding safety and health,
- Well defined task and operational hazards/risks,
- Comprehensive hazard prevention and control methods, and
- Recordkeeping requirements to track program progress.

## 10.8 Site Monitoring

Post fire site monitoring can take on a number of different approaches, depending on the media that has been affected. This monitoring may take one or more of several approaches including continuous collection and remediation of pyrolytic oil, monitoring of air for toxic contaminants, and the periodic sampling of groundwater to determine if contaminant migration is occurring. At buried and smoldering sites, post-fire monitoring may include aerial surveillance of the site using infrared photography to monitor current hot spots.

## 10.9 Medical Monitoring

Medical Surveillance of workers at hazardous waste sites is necessary to protect the health of the worker, establish fitness for duty, and ensure documentation of exposure to hazardous materials. The elements of the medical surveillance program contained in the site-specific HSP shall, at a minimum, address:

- Employees covered by the program;
- Frequency of medical exams/consultations;
- Content of medical exams/consultations;
- Information provided to the physician;
- Physician's written opinion; and

- Recordkeeping requirements.

The employee should receive a baseline or initial medical examination based on an activity hazard assessment prior to being assigned to a hazardous or potentially hazardous activity (e.g., exposure to toxic substances, repetitive motion, heat/cold stress). The examination should include, at a minimum, the items listed below.

- Complete medical and work history;
- Physical examination;
- Pulmonary function test;
- Eye examination;
- EKG;
- Audiogram;
- Urinalysis;
- Blood chemistry;
- Heavy metal screen (as appropriate);
- Radiological bioassay (as appropriate); and
- Evaluation of stresses related to repetitive motion.

It is beneficial to develop a table of hazardous substances expected at the work site, the target organs affected, the potential health effects, and the medical monitoring to be performed. Employees working on hazardous waste sites, which may include chemical, physical and/or radiological hazards, should be provided with medical examinations every 12 months, unless the physician believes a shorter or longer duration is appropriate.

The content of the examination is:

- Based on applicable state or federal laws and regulations;
- Determined by the physician;
- Designed to detect change from the baseline examination; and
- Designed to identify physiological changes.

Employee site-specific exposure data, parameters identified above, official dosimeter records, and a hazard assessment should be provided to the examining physician.

Follow-up examinations should be provided as soon as possible to the employee due to any of the following situations:

- Notification to the supervision, management, the Medical Program Administrator or physician that the employee has developed signs or symptoms indicating sensitivity or overexposure;
- Potential exposure above the permissible exposure limit or published exposure limit;
- Lost time illness of three working days or more;
- Any recordable injury to the employee; or
- Contamination incident.

In the case of injury or illness, the Site Safety and Health Officer (SSHO) or his/her designated alternate is responsible for notifying the Medical Program Administrator of the incident and the suspected substance involved. If the substance is unknown, it should be identified as such.

A licensed occupational medical provider will carry out the examination. The physician will determine the scope of the examination. The employee will not return to work until the physician certifies that the employee is fit to return to work, activity restrictions are identified, and documentation of fitness for duty is provided.

The employer should provide a termination medical examination when an employee is terminated or reassigned to an area or activity where the employee is not exposed to hazardous substances or radiological constituents. The termination examination content will be determined by the physician. If termination occurs within six months of a periodic examination, the physician may determine that an additional examination is not necessary. Documentation of the decision not to provide a termination examination, and its basis, should be provided in the medical file for the employee.

Limitation or other medical conditions identified during the medical surveillance program should be forwarded to the employee. The physician should provide a written opinion to the records indicating that the employee has been informed of the results of the exam and of any medical conditions that require further examination or treatment. In addition, the following specific records should be maintained:

- Name and Social Security number of employee;
- Physician's written opinion, recommended limitations and results of exam;
- Employee medical complaints related to exposure to hazardous substances;
- Information provided to the physician from the employer (not standard or appendices); and
- Engineering controls, work practices and personal protective equipment for employee protection.

Personnel medical records and exposure monitoring records should be maintained according to the requirements of 29 CFR 1910.120 (f)(8) and 29 CFR 1910.20. Access to medical records should be consistent with the requirements of 29 CFR 1910.20. The employer, to the extent permitted by law, will hold the employee medical records in confidence.

## **10.10 Public Notification**

During site assessment activities, lead agencies may require public notification of the proposed assessment activities. At a tire fire site, public notification would likely be limited to air quality requirements, unless surface water bodies have been impacted, or site assessment activities indicate that subsurface contamination has migrated offsite.

The site assessment report may also be distributed to public repositories to provide the findings of the investigation to the general public and/or interested parties. Upon completion of the site assessment process, a report describing the field methods, laboratory results, findings, and conclusions should be prepared. The report should be presented in a clear and concise format that can be understood by the general public, press, and government officials. Because the report is a compilation of all field activity, results of the investigation and recommendations, it is critical that the report is reviewed by all appropriate personnel prior to being released to the public. The report should also be reviewed and eventually distributed to interested parties by the Public Information Officer. If there is a significant interest in the findings of the report, it is recommended to conduct a community meeting to discuss the findings, results, and conclusions presented in the report.

## 11.0 POSSIBLE SITE REMEDIATION OPTIONS

After the fire is extinguished and the site assessment is complete, the site must be cleaned up. Site remediation is necessary to remove existing contamination and prevent the migration of contaminants at the site from further impacting soil, groundwater, and surface water bodies in the site vicinity.

### 11.1 Remediation Options

Remediation and/or stabilization of contaminated ash, soil, and residual pyrolytic oil is necessary to protect human health and the environment. Remediation options are fairly limited for a tire fire site. The following are typical remediation options to consider.

- Bury the waste materials including contaminated soil, ash, and oil onsite without any specific engineering design criteria.
- Consolidate and bury waste materials in an engineered landfill waste management cell. This option has been utilized at large tire fire sites such as the Panoche tire pile fire in California.
- Treat the waste materials using a solidification and stabilization processes such as cement fixation. This option is prohibitively expensive due to the high cost of separating large volumes of metal debris from the waste material. Additionally, petroleum wastes may inhibit the metal fixation process.
- Remove and transport the waste materials to an off-site process unit for treatment and recycling. Potential recyclers include scrap metal dealers, cement kilns and smelters. Experience at previous tire fire sites has shown that local and out-of-state recyclers have no interest in these materials; however, this could be a viable option with proper financial incentives.
- Remove and transport waste materials to an off-site hazardous waste disposal facility. This is generally considered infeasible due to the high cost of separating large volumes of non-hazardous waste (metal debris) from the hazardous waste (ash and soil). In addition, the transportation and disposal costs for such a high volume of waste material is generally prohibited at a large tire fire site.
- No action is always an option to consider at a fire site. Under this scenario, no remediation is implemented but the site is monitored on a regular schedule to evaluate what impacts, if any, would result from storm water runoff, groundwater migration, and other potential impacts to human health or the environment.
- Remediate contaminated soil onsite using natural or enhanced biological degradation.

### 11.2 Prevention of Contaminant Migration

Prevention begins at the pre-planning stage. Effective management of runoff during the tire fire emergency will minimize the need for post-fire remediation. If contaminants were introduced into the environment, a remediation plan should be initiated.

The primary goal for the selection of an effective site remediation plan is to prevent migration of contaminants within the pyrolytic oil and ash from spreading into un-impacted soil and groundwater beneath the site. Pyrolytic oil is capable of spreading through permeable soil horizons until the oil

reaches a natural subsurface barrier or enters a water body. During periods of precipitation, floating oil, dissolved hydrocarbons and metals can migrate along the surface and impact surface water bodies. Additionally, the introduction of water at the surface can also drive contaminants through the soil column and impact groundwater.

If a subsurface fire continues to generate pyrolytic oil, the oil should be captured and reclaimed through the use of interception trenches, containment basins, sumps, and various other containment and holding structures.

Runoff of contaminated water from a tire fire site should be captured through the use of storm water diversion systems and containment basins. Transport of contaminated sediments and ash by surface runoff can be minimized by implementing an aggressive hydroseeding campaign to stabilize the soil.

### **11.3 Evaluate Disposal Options**

Tires, metal, and other hazardous and non-hazardous debris from a tire fire burn site must be disposed of at a site approved by the CIWMB. As described previously in this report, significant quantities of pyrolytic oil are also generated during a tire fire pile. Previous experience at tire fire piles has indicated that the pyrolytic oil can be recycled at several types of reclamation plants. These plants include: 1) petroleum refinery for re-processing into a fuel oil product; 2) authorized oil recycler for blending into a supplemental fuel; 3) at tire manufacturer plants for use in making new tire products and; 4) an asphalt plant for use as an oil supplement in making asphalt products. Previous experience has shown that disposal of the oil at any of the above facilities would be at no cost to the state.

However, recycling of pyrolytic oil is discouraged in the State of California, because the California Environmental Protection Agency (Cal-EPA) classifies pyrolytic oil as a “hazardous waste” under California hazardous waste regulations. Instead, pyrolytic oil must be sent to an oil recycling facility. The cost of recycling pyrolytic oil is significant with a cost generally greater than \$1 per gallon. Discussions should be continued with the Department of Toxic Substances Control to allow for a variance or exclusion to the hazmat classification for materials generated during a tire pile fire, similar to those granted for petroleum producers

### **11.4 Decontamination Equipment**

Decontamination is the process that physically removes toxins, neutralizes them by chemical detoxification, or removes the contamination by a combination of physical and chemical means. It is important to decontaminate all equipment and personnel prior to the person and/or equipment leaving the site so that residual contamination is not transported offsite and potentially affecting others. Decontamination procedures include:

- Wiping
- Scraping
- Scrubbing
- Blowing
- Rinsing with flowing or pressurized water
- Washing with detergents or solvents
- Evaporating contaminants with steam jets

Physical contaminant removal methods are described below:

- Loose contaminants: such as dust and vapor that cling to personal protective equipment or become trapped in small openings. These can be removed by rinsing with water or another liquid to remove the contaminants. Removing materials that cling by static electricity can be made easier by coating the clothing or equipment with anti-static solutions.
- Adhering contaminants: Glues, cements, resins and muds have greater adhesive qualities and are more difficult to remove. Methods include scraping, brushing and wiping.
- Volatile liquids: These can be removed by evaporation and rinsing with water. Evaporation can be accelerated using steam jets. With any such process, however, workers must be protected from inhaling the toxins.

Physical removal of excessive contamination should be followed by rinsing with cleaning solutions and a water rinse, usually by one or more of the following methods:

- Use of chemical solvents. The use of chemical solvents is permissible if the solvents are compatible (safe) with the PPE or equipment being cleaned. Compatibility must be determined in advance of decontamination. Chemical decontamination solvents include ether, ketone, alcohol and polyethylene glycol. In some cases, halogenated solvents can be used, although these are toxic and are generally not compatible with PPE. Because of its potential hazards, chemical decontamination should be done under the supervision of an industrial hygienist or another qualified health professional.
- Use of surfactants. Washing with surfactants (detergents) boosts physical cleaning by reducing the contaminants ability to adhere to materials and by preventing them from sticking again. These agents include household detergents, some of which can be used with organic solvents.
- Neutralization. Acids can be neutralized with alkali materials, and vice versa. This process can generate enough heat to cause burns and should not be used on skin.
- Solidification/Freezing. Solidifying liquid or gummy toxins can make them easier to remove. Methods include soaking the moisture with ground clay or powdered lime; catalyzing them with appropriate chemicals; and freezing them with ice water or dry ice.
- Rinsing. This removes contamination through the processes of diluting, attracting and solubilizing contaminants.

## **11.5 Long Term Monitoring and Operation and Maintenance**

If the selected cleanup option is “no action” or site remediation is not complete, long term monitoring and operation and maintenance (O&M) of the site will be required. The purpose of the long term monitoring and O&M is to monitor environmental changes at the site, if any, and to prevent the release and further migration of hazardous materials into the environment. This long term monitoring and O&M will be the responsibility of the site owner or responsible party (RP) (CIWMB, 1997).

The following actions should be performed to limit potential exposures to populations, animals, and the environment:

- Place fences, warning signs, and implement site controls to prevent access.

- Construct drainage controls to prevent precipitation or run-on from entering or leaving the site to minimize the migration of hazardous substances offsite.
- Cap the contaminated soil with a relatively impermeable surface (clay, asphalt, cement, or bentonite) to reduce the migration of hazardous substances into the soil, groundwater, surface water, or air.
- Excavate and consolidate contaminated soil and place waste away from drainage or other areas to minimize the spread of contamination.

As a general rule of thumb, the RP should plan for semi-annual monitoring activities at the site. At a minimum, monitoring activities should include the following:

- Overall inspection to determine site conditions;
- Replacement of damaged fence and signage;
- Repair or the erosion rills;
- Placement of additional clay cover if erosion rills are significant; and
- Placement of additional grass seed; and
- Removal of trees, shrubs, or other deep rooting vegetation if they could compromise a engineered cap.

In addition to the semi-annual site inspections, the RP should inspect the site periodically after large storms or other significant events that may affect the stability of the site and in turn contaminant migration.

To prevent the unauthorized development, and restrict the land use to non-irrigated open space, a record of survey should be filed with the local jurisdiction.





## 12.0 DOCUMENTATION AND REPORTS

This final section describes documentation and preparation of reports. This is one of the most critical steps in the entire tire pile fire process, because the words chosen in the report will act as the “final word” on the activities that took place during the fire event. This report will be thoroughly reviewed and dissected by a variety of interested parties ranging from government officials to investigators representing private parties.

### 12.1 Liability Issues Documentation

Documentation of site activities, chronologies of events, and proper laboratory documentation, are all critically important during a tire fire. This information is not only necessary to assist the incident commanders and lead agency to determine if the response is effective, but also to be able to accurately present information to the press, public, and government agencies. A well documented chronology of events, combined with laboratory data, with properly completed chain-of-custody documentation (including sample date and time), is crucial to dissemination of the information to nearby residents and business owners who have been exposed to contaminants from the fire. In many instances, this data will alleviate fears of nearby residents who may be in the vicinity of a billowing smoke cloud, and provide the responding agencies authoritative and legally defensible data describing the exposure levels to residents, workers, and firefighters.

Documentation that should be included in the report includes: extinguishment methods used and the results associated with each, field notes, pictures, etc., air sampling data from offsite sources and downwind stations, and QA/QC (sampling) procedures. Additionally, soil and water quality data from both on and offsite locations should also be documented in the report.

### 12.2 Final Report – Lessons Learned

At the completion of fire-fighting efforts, the lead agency should prepare and publish a detailed report which at a minimum includes the following information: 1) Site Background; 2) Fire Cause and Tire Fire Dynamics; 3) Potential Threats; 4) Agency Response and Unified Command Structure; 5) Fire Suppression Tactics, 6) Health and Safety; 7) Environmental Sampling and Monitoring; and 8) Preliminary Site Assessment Results, if available.

The report should also contain a section that presents in an objective manner lessons learned during the tire fire event. The purpose of this review is to determine what approaches and tactics worked well, and which did not. At a minimum, the lessons learned analyses should include the following components of a tire fire response:

- Incident Command System/Unified Command;
- Federal, State, and Local Coordination;
- Fire Suppression Tactics;
- Public Relations;
- Health and Safety;
- Environmental Effects and Concerns;
- Regulations, Policy, and Research Needs; and
- Problems Associated with Multi-Agency Response and Coordination.

### 13.0 BIBLIOGRAPHY

- Adolfson Associates, 1994. Tire Fire Contingency Plan – Toxicology Aspects. September.
- California Air Resources Board, 2000. Memorandum, Filbin (Westley) Tire Fire Emergency Response. January 24.
- California Code of Regulations, 2002. Title 14, Chapter 3, Article 5.5. September 20.
- California Governor's Office of Emergency Services, Hazardous Materials Unit, 2002. California Hazardous Material Spill/Release Notification Guide, January.
- California Integrated Waste Management Board (CIWMB), No Date. Operational Concerns for Tire Fires.
- CIWMB, 1996. Market Status Report: Waste Tires. October.
- CIWMB, 1997. Construction Completion Report, Panoche Burn Site Remediation, Fresno County, California. December.
- CIWMB, 1999. California Waste Tire Program Evaluation and Recommendations Final Report, June 30.
- CIWMD, 2001. Five Year Plan for the Waste Tire Recycling Management Program (Fiscal Years 01/02-05/06). Report to the State Legislature. September.
- CIWMB, 2002a. Scrap Tire Management and Tire Fire. Available: <http://www.ciwmb.ca.gov/TireDisposal/Fires/>.
- CIWMB, 2002b. Waste Tire Marketing Guide. Available: <http://www.ciwmb.ca.gov/MktGuides/Tires/> (June 4, 2001)
- CIWMB, 2002c. Overview of Tire Management in California. <http://www.ciwmb.ca.gov/Tires/Overview.htm> (April 23, 2002)
- California Office of State Fire Marshall (COSFM), 1995 . Rings of Fire - Fire Prevention and Fire Suppression of Scrap Tire Piles.
- Canadian Chemical News, 1991. Analytical Chemistry in Hell: the 1990 Hagersville Tire Fire. September.
- Columbia Electronic Encyclopedia, 2000. Columbia University Press.
- Ecology & Environment, 1999. Memorandum, Ordod Landfill Tire Fire Air Surveillance Program and Safety Plan Review. February 16.

- Ecology & Environment, 2000. Westley Tire Fire, Final Report, Stanislaus County, California. December 11.
- Encyclopedia.com, 2002.
- Horrigan, L., 1999. Tire Fires: Toxic Exposure (Big Wheels Keep on Burning), April 29.
- IT Corporation, 1985. Ground Water Study, Rhinehart Tire Fire, Winchester, Virginia. June.
- National Fire Protection Association (NFPA), 1989. Standard and Code for Tires. (NFPA 231D).
- NFPA, 1997. Recommended Practice for Responding to Hazardous Materials Incidents (NFPA 471).
- National Institute for Occupational Safety and Health (NIOSH), 1984. Health Hazard Evaluation Report, Rhinehart Tire Fire, Winchester, Virginia, March.
- Olcutt, T., 2001. The History of the Tire and the Sad Life of Charles Goodyear. Available: <http://www.about.com>.
- Olsen, 2001.
- Roy F. Weston, 1991. Quality Assurance Work Plan, Tire Fire Sites, Catskill, New York, Tabernacle, New Jersey, and Mullica, New Jersey. December.
- Scrap Tire Management Council, 1992. Guidelines for the Prevention and Management of Scrap Tire Fires.
- Scrap Tire Management Council, 1999. Scrap Tire Characteristics.
- SP Environmental Services, 2001. Air Monitoring Report, Tracy Tire Fire Suppression Project, Tracy, California. January.
- United States Coast Guard, 1999. DRAFT Westley Tire Fire Site Safety Plan, Westley, California. September 29.
- United States Environmental Protection Agency (USEPA), 1984. Winchester Tire Fire, CERCLA Immediate Removal Project, Winchester, Fredrick County, Virginia. May.
- USEPA, 1993. Subsurface Characterization and Monitoring Techniques, A Desk Reference Guide. May.
- USEPA, 1997a. Air Emissions from Scrap Tire Combustion, (EPA-600/R-97-115). October.
- USEPA, 1997b. Panoche Tire Dump Fire, Fresno County, California. March.

USEPA, 2000a. DRAFT Westley Tire Fire, Stanislaus County, California. August.

USEPA, 2000b. Tire Fire Response, Westley Tire Fire, Lesson Learned.

USEPA, 2000c. Westley Tire Fire, OSC Readiness Training Workshop.

USEPA, 2001. Emergency Response Office Quality Management Plan. June 14.

United States Fire Administration (USFA), 1998. Scrap and Shredded Tire Fires, (Report 093).  
December



