CHAPTER IV

RISK PREVENTION AND PLANNING EMERGENCY RESPONSE TO EVENTS

This chapter focuses on pipeline failure prevention and response. It will discuss how prevention planning, preparation, developing and maintaining readiness, response implementation, and remedial actions can alter results from past pipeline failures and affect the expected risks and costs associated with future and present pipelines. The prevention, preparation, readiness, and remediation cycle is depicted in figure 28.

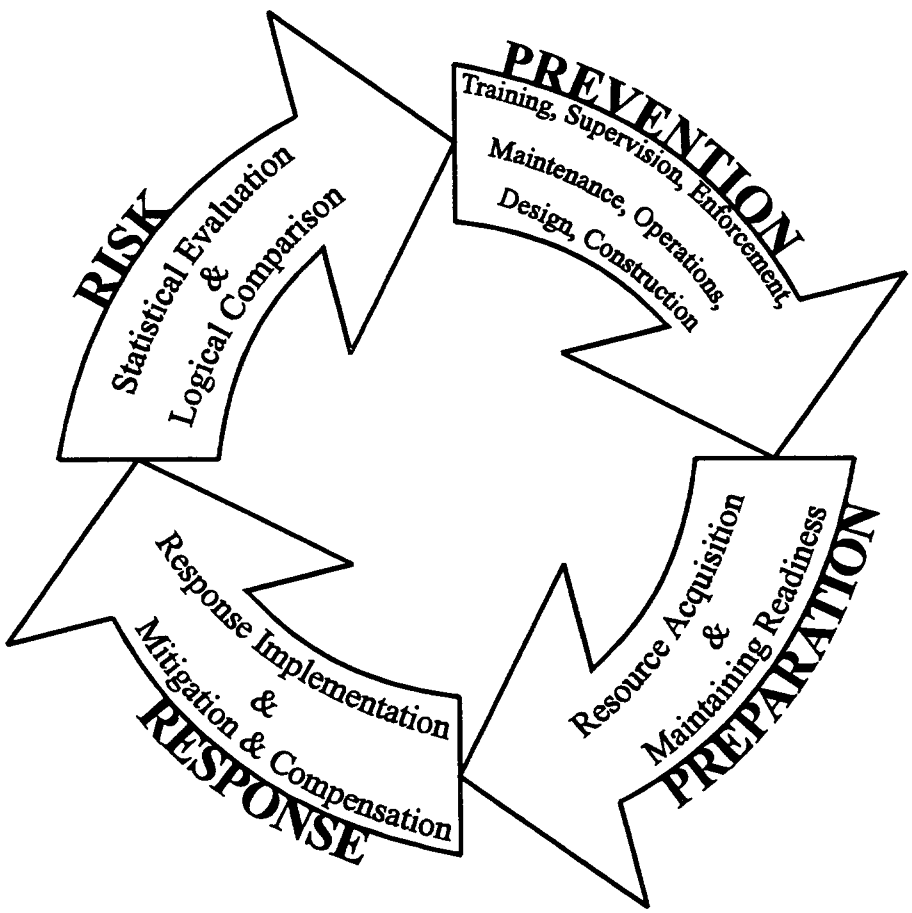

Figure 28: Risk-prevention-preparation-response cycle

Probability of Harm Concept

This analysis is based on a Probability of Harm equation and its relationship with cost. To begin the discussion we will look at the simple cost equation:

$$\text{cost}_T = P_{Harm} \times \text{cost}_I$$

where *Cost*$_T$ is the cost in time (T) and T can be per year, per life of a unit, etc.; P_{harm} is the probability that the event happens in time (T); and *Cost*$_I$ is the cost per event. *Cost* may be dollars or some other intrinsic value of worth. The probability is the likelihood of a total pipeline failure or a series of probabilities of smaller events (i.e., a pipeline rupture that results in an explosion and a fire). In the latter case the equation is expanded to:

$$\text{cost}_T = \sum_{i=1}^{n} (P_{Harm_i} \times \text{cost}_{I_i})$$

where n is the number of discrete sized events and the probability and costs are those associated with the incremental steps.

For example, assume that for a given activity the public is willing to accept a given unit of Cost_T. If a unit is placed where the cost of the potential event is small (i.e., in the desert), a higher probability of the event occurring is accepted. On the other hand, if the cost is high, a much lower probability of the event is acceptable, i.e., the safety level required on an activity in a populated area.

In some cases the real or intrinsic cost of a feature is so high that no risk is acceptable to the public (i.e., placing a hazardous/toxic materials pipeline through the city of New York's watershed regions).

The probability of harm from a pipeline-related incident is defined as the cumulative product of

- the probability that there is a pipeline accident, times

- the probability that there is a release of the pipeline product, times
- the probability of the released product reaching a damageable system, times
- the probability of the released product actually causing economic or environmental damage.

This equation is depicted in figure 29. A basic feature of this equation is that it identifies the different elements of the risk so they may be attacked individually to reduce overall risk to an acceptable level. In other cases it identifies areas which can be attacked and areas which are impossible or unfeasible to attack. For example, in areas with little or no response capability to contain or remove a spill, a greater emphasis should be placed on preventing accidents and spillage.

Also shown in figure 29 are the five tiers of action used to quantify and reduce the risk. The first of these is the "Statistical Evaluation and Logical Comparison" component. In this component, past statistics of events are evaluated to develop generalized risk statistics. These risk statistics are then evaluated with regard to the pipeline to allow for new technology and other factors such as age, size, operational control systems, pipe thickness, etc. which would alter the likelihood or magnitude of the event, spill, impact, and damage to the pipeline. For example, if 20-year-old eight-inch pipelines had a record of X spills of a certain size per year, this would become the expected failure level for these pipelines. Therefore, if a pipeline company was proposing to build a new eight-inch pipeline, they could use better materials, thicker walls, encasement, deeper burial, better supports, and better operations. By increasing these various prevention methods, the company would produce the potential of having a lower expected loss record than a historical one.

In evaluating these statistics it will generally be found that better information will exist for the probability of the accident and release than for the impact probability in columns C and D. Typical information relating to the probability of pipeline accidents and releases would be USDOT and Texas Rail Road Commission records, biennial Oil Spill Conference proceedings, the Oil Spill Intelligence Report and Golobs Oil Spill Bulletin.

			A		B		C		D
	P(harm) Likelihood of Harm Caused by a Spill/Leak	–	P(accident)	*	P(release)	*	P(reaching damageable environmental feature)	*	P(damage to feature)
1	Statistical Evaluation & Logical Comparison	...	Pipeline Safety Statistics		Pipeline Spill/Leak Statistics				Spill Cleanup Statistics & Reporting
2	Prevention Planning	...	Prevention Planning System Design RE: Accident system location relative to danger		Prevention Planning System Design RE: Release		Prevention Planning System Location Relative to Environment Vulnerability		Defensive Protection of Vulnerable Environment
3	Contingency Planning	...					Contingency Planning Response Planning		Contingency Planning Response Planning
4	Event Response	...					Response Implementation		Response Implementation
5	Remedial Actions	...							Damage Assessment Mitigation Compensation

Figure *29:* Pipeline probability of harm equation

Spill reports may provide information on clean-up activities and temporary or permanent damage to environmental features, but the information is not easy to obtain and is difficult to evaluate in an analytical manner. Nonetheless, subjective judgment with regard to potential impact coupled with documentation and classification of environmental systems concerning (1) vulnerability, (2) cleanability, and (3) value of living resources are extremely valuable.

The second row of information on figure 29 depicts the role of prevention planning in altering the various probabilities. Prevention planning is the dominant process in reducing each of the risk elements.

The prevention process or cycle is depicted graphically in figure 30. The first step in the process is to have a proper design and construction criteria which, when properly executed, will yield a well-designed and constructed pipeline.

The second step of the prevention cycle is *to* have effective maintenance and operating procedures including emergency response actions that are to be followed to ensure the pipeline is properly maintained and operated in a manner to avoid mechanical and operational failures.

The third step in the diagram shows proper training for various personnel to carry out the design, construction, maintenance, and operational criteria needed to operate the pipeline properly and safely. This training may be in the form of specialized direct training or by requiring licensing, registration, or certification as indicators of professional competence.

The fourth step in the prevention process is the task of supervising the first three steps to see that the pipeline operates as it should.

The final step recognizes the reality that enforcement, either internal or external, is necessary to assure compliance in each of the initial four steps of the prevention cycle. This enforcement may be in the form of plan review, construction certification, periodic maintenance and other inspections, policing of operations or examination and certification of training, and evaluation of supervision methods through environmental audits or other review processes.

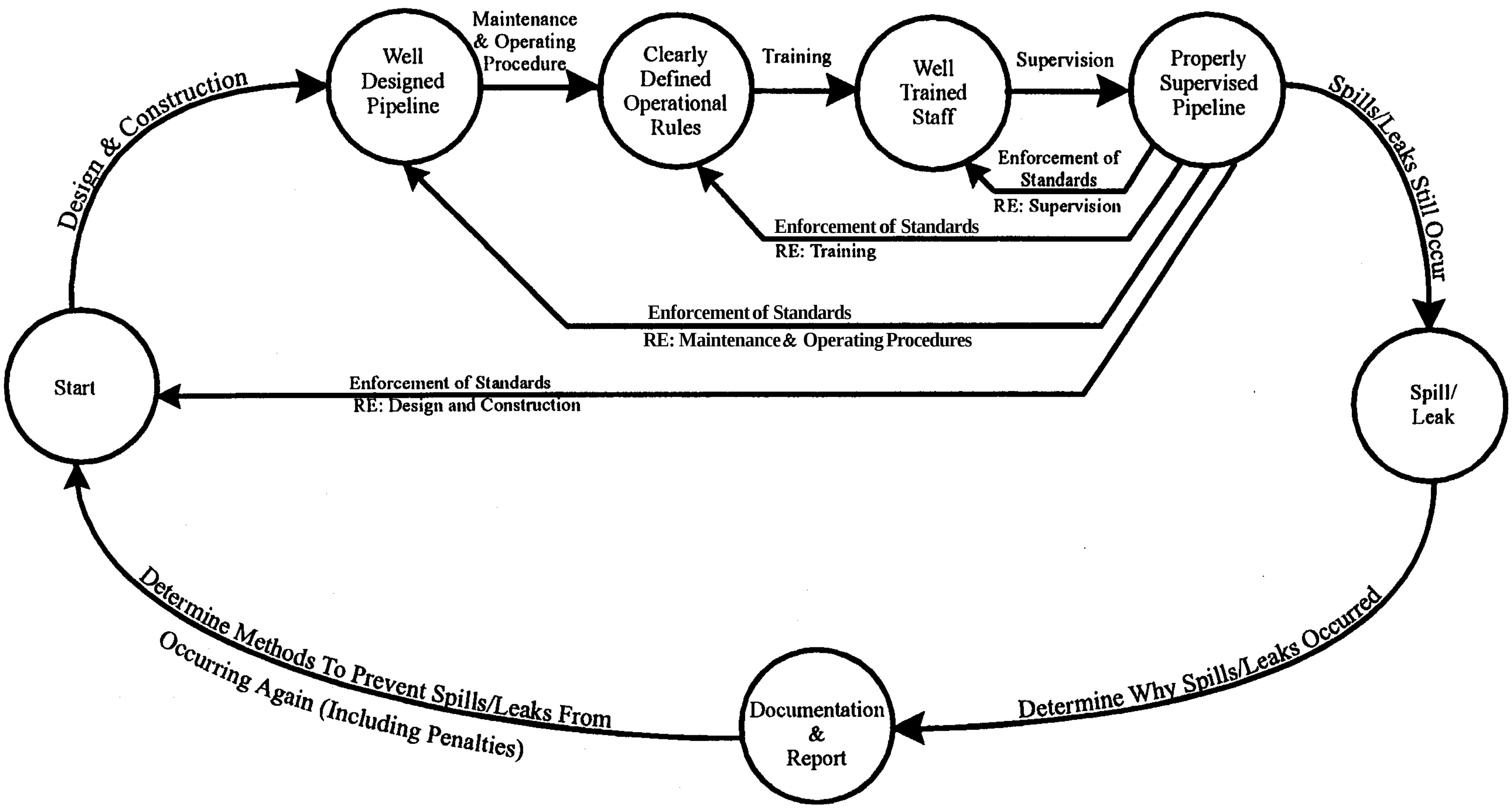

Figure 30: Pipeline system release prevention plan cycle

The bottom half of the cycle deals with the fact that "prevention" is not perfect. This half of the cycle focuses on determining where the top half went wrong and how to make corrections to the system to avoid repetition of the Same type of the bad event.

The Probability of Harm diagram, figure 29, relates to figure 30. In element A2 of figure 29, for example, prevention planning is used to avoid an accident which may lead to pipeline failure. This can be accomplished by installing better monitoring systems, constructing better supports, providing deeper burial, better locations for the pipelines, etc.

The second probability component, the Probability of Release, is limited by prevention (element B2) whereby the chance of loss is reduced by providing control and shutdown systems, appropriately positioned valves based on flow and exposure, thicker pipe, sumps, and other design features in a pipeline.

The third prevention step (element C2) involves keeping a released material fiom reaching a sensitive environment or economic system. Solutions entail relocating the pipeline a greater distance from a sensitive environment, providing adequate containment around tanks andor tank farms, building dams and special structures in a creek, and so forth. The basic concept fiom radiation protection of time, distance, and shielding is appropriate: time to permit response, distance to minimize likelihood of contact, and shielding with booms, barriers, dams, etc. to prevent the spilled material from getting to the vulnerable system.

The final prevention step (element D2) involves preventing damage from the spilled material by protection barriers (for protection as opposed to containment) including dams, booms, etc.; provision for flooding of marsh area or beaches; provision for removing fish, mariculture organisms or livestock; and provision for dispersing the spill from the surface into the water column so it moves with the current. These activities can be likened to the evacuation and property protection activities which take place prior to a hurricane.

The concept of prevention and prevention auditing is discussed in more detail in the Prevention section of this report.

Recognizing that prevention is not always successful, the Probability of Harm concept focus now shifts to preparation/contingency planning to deal with the event that a pipeline spill does occur. It should be noted that the preparation, develop and maintain readiness, and response implementation phases assist in limiting only the last two elements of the probability equation.

In the Probability of Harm Equation concept, effective contingency planning can reduce the likelihood of spilled pipeline contents reaching an endangered target (element C3) by providing for containment and removal of the pipeline contents en route fiom the spill to the impact zone or by dispersing the contents into the water and transferring the impact fiom a coastal boundary impact to a water mass impact.

The plan can also be effective in removing the spilled pipeline contents fiom the first environmental system impacted and thus preventing it fiom reaching another, perhaps more sensitive, system. This is particularly true in beach clean-up where the main goal is to stabilize and remove the contaminants fiom the ecosystem rather than reclaim the impacted beach.

Contingency planning can also result in reducing the harm upon impact by providing for defensive protection of endangered systems (interacts with prevention) such as removing and stockpiling beach sand, harvesting and transplanting marine life, etc., and the use of proper clean-up methods which minimize harm to the environment (e.g., fast response on beaches to minimize sand removal, marsh clean-up which doesn't disturb root systems yet removes smothering oil deposits, etc.)

The Event Response phase (row 4) deals with the response implementation of the contingency plan and response plan (e.g., the clean up of a spill).

The final phase in the process is the Remedial Action (row 5). This phase applies only to the last element in the risk equation (element D5). In this component the damage is assessed and an attempt carried forward to restore, mitigate or compensate the people, businesses, and/or the environment that has been damaged by the released material.

Restoration involves restocking of lakes, revegetation of marshes, oil farming, fertilizing and replanting damaged pastures, cleaning rock faces and sea walls, etc.

Other mitigation may include providing feed to replace pasture land out of service, providing jobs to fishermen out work because of the spill, and so forth.

Compensation to cover damages in lost income to individuals and businesses may be necessary to mitigate economic loss.

Prevention Concepts

As previously mentioned, the concepts of design, construction, maintenance, and operations of pipelines; training and supervision of pipeline personnel; and enforcement of pipeline requirements are key concepts in the prevention of pipeline failure. The type and extent of the preventive measures to be incorporated into these concepts will depend upon the type of risk and the risk ranking associated with the proposed or existing pipeline locations.

Design

A vital element in the prevention picture is the design of the pipeline structure. The design element involves the type and strength of the material, the pipe wall thickness, pipe diameter, section lengths, protective covers, location, monitoring devices, and so forth.

Any area that has a natural disaster risk ranking of moderate to high should have additional preventive measures incorporated into the design. The extent of these measures may vary depending on the uniqueness of the surrounding environment and the economic feasibility (see the cost function in the Probability of Harm Equation). The best prevention step is to route the pipeline system so that it does not cross a moderate to high risk zone. This may mean adjusting the route a few miles or several hundred miles. In some cases it may not be feasible or possible to avoid a particular risk zone; however, it may be possible to limit the amount of line crossing the zone. For example, in 1980 an extension to the existing All American Pipeline was to run through McCamey, Texas (near El Paso), to near Texas City, Texas, on the Gulf coast. This pipeline was proposed to run through the important and endangered Edwards underground aquifer recharge area, a zone of fractured limestone easily penetrated by an oil spill. A subsequent study and decision rerouted the pipeline to the north to avoid this environmental feature. Had it been built, the pipeline would have followed the northern alignment.

Another step to be reviewed in the design aspect of prevention is the amount of stress the pipeline can withstand. Outside of the type of material selected for the pipe, the pipe wall thickness is where its strength is derived. Although it is beyond the scope of this study to develop an alternate design or mathematical model for calculating required pipe wall thickness, researchers suggest that reasonable design safety factors be incorporated to allow for natural disaster events. Natural events with rankings fiom moderate to high would have one safety factor while those with low to none would have no safety factor, depending upon the surrounding environment.

As previously mentioned, protective covers are an important design prevention method. These methods may include earth cover, concrete coatings, concrete slabs, pipe casing, water depth, subsea covering, corrosion-resistant coatings, etc. The amount and type of protection will vary depending upon the risk. For example, a four-inch (100 mm) concrete slab may be effective for tornado zones but ineffective for subsidence zones.

Construction

The construction aspect of prevention is simply making sure that the pipeline is constructed the way it was designed. This means that the construction must be performed by qualified personnel and properly supervised. It is a good idea to have the engineers that designed the system also inspect it during and after construction. For example, Boeing engineers inspect their airplanes during and after construction to insure that design specifications are met. This sometimes slows down the process but allows for superior quality.

Operations

Operations are one of the most important aspects in prevention and in reducing the extent of release. This is the stage where observability and controllability are maximized. Since human interaction is the key defense in operations, an intense and thorough **training** program is essential (*see* Training in **this** section).

The operations stage in prevention, **as** discussed in **this** report, is divided into two sections:

1. Before spill/leak operations, and
2. After spill/leak operations.

Perhaps the most useful factor in the **first** section is lead time. **Lead** time is the period of time during which the operator knows of the coming event and can prepare for it. The amount of lead time for natural disaster events ranges fiom years to **no** lead time at all. Some typical lead times for natural disaster events are listed in table **7.**

Table 7: Lead times for selected natural disaster events

Natural Disaster Event	Lead Time
Subsidence	years
Hurricane	weeks, days, hours
Tornado	minutes
Flood	days, hours
Earthquake	little or none
Forest Fire	hours, minutes
Extreme Weather Temperatures	days, hours

For lead times that allow action to be taken, an established set of procedures needs to be developed in order to **minimize** the risk of a spill/leak. These procedures need to address the following questions.

1. Can the pipeline be shut down or the threatened section be closed off?
2. Can the section be emptied or filled with a non-hazardous or less hazardous material (i.e., water, air, nitrogen, etc.)?
3. If 1 or 2 is no, what eminent danger response activities need to be initiated?

In the event that the lead time does not allow for prevention measures to be taken, or if the answers to questions 1 and 2 are no, the operation shifts to "after the spill/leak" operations. There is a fine line between operations of the pipeline itself after the spill/leak and the subsequent contingency and response plans to deal with the incident. In this section, those actions taken by the pipeline operator personnel to shut down the pipeline and to minimize the release are still considered operation activities. After this stage contingency and response plans come into effect.

Maintenance

Maintenance aspects of prevention are not unique for natural disasters; however, they are important. Improper performance in maintenance can greatly influence the likelihood of a pipeline failure. Scheduled maintenance checks should be conducted on a routine basis and be consistent with regulatory requirements and industry standards as a minimum.

Training

Training of all personnel involved in the design, construction, maintenance, operations, and supervision is essential to prevent releases and to deal with them effectively when they occur. The training should cover information relevant to each worker's job function and responsibilities, as well as key aspects relevant to all pipeline personnel. Employees that have not been trained to a level commensurate with their function and responsibility should not engage in pipeline activity.

A good training program encompasses classroom instruction and hands-on practice. For the purpose of pipeline failure resulting from natural disasters, pipeline personnel should be taught where the risk zones are located, what the events are capable of doing to the pipelines, and what the procedures are for reducing the risk of pipeline releases resulting fiom these events. Particularly important information, such as shutdown procedures, should be provided in writing.

All personnel should complete refresher training, at least annually, to reemphasize the initial training and to update personnel on any new requirements, policies, procedures, or techniques. A record of training should be maintained in each employee's personnel file to confirm that every person assigned to a task has had adequate training for that task and that every employee's training is up-to-date.

Supervision

The supervision concept in prevention does not focus on natural disaster aspects; instead, it focuses on assuring that all aspects of all the other prevention concepts are met appropriately. In order for supervision to be effective it must do the following.

1. Assure trained personnel occupy positions and that credentials are verified.
2. Assure adequate manning levels exist for each operation.
3. Assure personnel are awake, alert, and performing as expected.
4. Assure design of pipeline system meets acceptable standards.
5. Assure construction of pipeline system meets acceptable standards.
6. Assure preventive maintenance programs are in place and properly operating.
7. Assure maintenance problems which occur are promptly corrected and that the source of recurring problems is found and corrected.
8. Assure that proper reports are prepared, read, and used to overview a quality maintenance program.
9. Assure that proper operational manuals and documents are prepared and kept up to date.
10. Assure that actual operations conform to operational plans and that deviations are reported and explained.

11. Assure a program of operational failures is clearly reported and procedures to correct failures carried out.
12. Assure that employees acquire internal and external training to maintain and upgrade skills to be able to conform to maintenance and operational method improvement.
13. Assure that maintenance and operational methods are continually upgraded to conform to industry, government, and common sense standards.
14. Assure that tests, simulated events and other procedures are used to verify the status of training and readiness for each component of the activity

Enforcement

Enforcement concepts are the legal measures for assuring that standards and requirements in prevention are being met appropriately. Although the aspects of enforcement are usually carried out by regulatory agencies, the pipeline corporation can and should have its own enforcement. This can be accomplished through "in-house audits." Traditionally environmental auditing focused on compliance with government regulations and liability for existing environmental liabilities. However, what is typically left out in these types of audits is a focus on preventing future events and liabilities. As part of the enforcement picture, in-house audits should incorporate prevention auditing. Prevention auditing should be consistent with a risk-based environmental management program in which pipeline personnel (specifically the operators and supervisors) look at how to reduce risks without being told how to do it by regulatory agencies. In other words, if the pipeline company wants to make changes to reduce risks, it can proceed the way the company decides is best and most cost-effective before being told a specific way to proceed by a regulatory agency.

Enforcement will involve the following:

1. design and review approval;
2. construction methods review and approval;

3. site inspections of facilities;
4. review of personnel education and experience qualifications;
5. written, oral, or physical testing of personnel;
6. review of records;
7. self-reporting of records;
8. accident and spill reporting;
9. sampling of contents of effluents;
10. physical testing of system components;
11. accreditation of training facilities;
12. accident/spill investigation;
13. operational deviation reports;
14. radar and aerial surveillance;
15. compliance activity; and
16. simulate emergencies with monitored responses.

These prevention concepts applied to several categories of pipelines are shown in tables 8 through 13.

Table 8: Prevention concepts applied to natural gas/LPG pipelines

STRUCTURE TYPE: Natural Gas/Liquid Petroleum Gas Pipeline

DESIGN CONCEPTS:

- Corrosion Protection
- Materials
- Control System
- Strength
- Valves
- Monitoring System
- Size and Pressure
- Pumping System
- Routing
- Pipewall Thickness

CONSTRUCTION CONCEPTS:

- Strength of Materials and Welds
- Proper Testing
- River/Stream Crossing
- Road Crossing
- Proper Materials
- Burial
- Coating
- Signs
- Proper Pumps and Valves
- Routing

MAINTENANCE CONCEPTS:

- Pump and Valve Maintenance
- Supports and Bridging
- Maintain Cover
- Test Monitoring Systems
- External and Internal Corrosion
- Coating
- Inspection

OPERATION CONCEPTS:

- Control Pressure
- Material Balance Determination
- Leak/Spill Detection
- Control Flowrate
- Route Selection
- Monitor Flowrate
- Monitor Pressure
- Proper Valve Operation
- Record Keeping
- communications
- Testing
- Monitor Valves

TRAINING CONCEPTS:

- Personal Safety
- Spill Response/Management
- Control
- Pipeline Design
- Maintenance
- Environmental Training
- Emergency Response Techniques
- Record Keeping
- Construction

Table 9: Prevention concepts applied to crude oil/gas gathering systems

STRUCTURE TYPE: Crude Oil/Gas Gathering System

DESIGN CONCEPTS:

- Materials
- Control System
- Valves
- Monitoring System
- Pumping System
- Routing
- Corrosion Protection

CONSTRUCTION CONCEPTS:

- Strength of Materials and Welds
- Proper Testing
- Routing
- Proper Material
- Proper Valves and Pumps

MAINTENANCE CONCEPTS:

- Pigging/Cleaning
- Supports and Bridging
- Test Monitoring System
- External and Internal Corrosion
- Inspection
- Pump and Valve Maintenance

OPERATION CONCEPTS:

- Control Pressure
- Material Balance Determination
- Leak/Spill Detection
- Communication
- Control Flowrate
- Monitor Valves
- Monitor Pressure
- Proper Valve Operation
- Record Keeping
- Route Selection
- Monitor flowrate
- Testing

TRAINING CONCEPTS:

- Personal Safety
- Spill Response
- Record Keeping
- Operations
- Maintenance
- Environmental Training
- Emergency Response Techniques
- Control
- Construction

Table 10: Prevention concepts applied to hazardous/toxic substance pipelines

STRUCTURE TYPE: Hazardous/Toxic Substance Pipelines

DESIGN CONCEPTS:

- Corrosion Protection
- Materials
- Control System
- Strength
- Valves
- Monitoring System
- Size and Pressure
- Pumping System
- Routing
- Thickness

CONSTRUCTION CONCEPTS:

- Strength of Materials and Welds
- Proper Testing
- River/Stream Crossing
- Road Crossing
- Proper Materials
- Burial
- Coating
- Signs
- Proper Pumps and Valves
- Routing

MAINTENANCE CONCEPTS:

- Pigging/Cleaning
- Supports and Bridging
- Maintain Cover
- Test Monitoring Systems
- External and Internal Corrosion
- Coating
- Inspections
- Pump and Valve Maintenance

OPERATION CONCEPTS:

- Control Pressure
- Material Balance Determination
- Leak/Spill Detection
- Control Flowrate
- Route Selection
- Monitor Flowrate
- Monitor Pressure
- Proper Valve Operation
- Record Keeping
- Communications
- Testing
- Monitor Valves

TRAINING CONCEPTS:

- Personal Safety
- Spill Response/Management
- Control
- Pipeline Design
- Maintenance
- Placarding
- Environmental Training
- Emergency Response Techniques
- Record Keeping
- Construction
- Toxicity/HAZWOP
- Pump operations

Table 11: Prevention concepts applied to major crude oil/product pipelines

STRUCTURE TYPE: Major Crude Oil/Product Pipeline

DESIGN CONCEPTS:
- Corrosion Protection
- Materials
- Control System
- Strength
- Valves
- Monitoring System
- Size and Pressure
- Pumping System
- Routing
- Thickness

CONSTRUCTION CONCEPTS:
- Strength of Materials and Welds
- Proper Testing
- River/Stream Crossing
- Road Crossing
- Proper Materials
- Burial
- Coating
- Signs
- Proper Pumps and Valves

MAINTENANCE CONCEPTS:
- Pigging/Cleaning
- Supports and Bridging
- Maintain Cover
- Test Monitoring Systems
- External and Internal Corrosion
- Coating
- Inspection
- Pump and Valve Maintenance

OPERATION CONCEPTS:
- Control Pressure
- Material Balance Determination
- Leak/Spill Detection
- Procedures for Switching Materials
- Route Selection
- Monitor Flowrate
- Testing
- Monitor Pressure
- Proper Valve Operation
- Record Keeping
- Communications
- Control Flowrate
- Monitor Valves

TRAINING CONCEPTS:
- Personal Safety
- Spill Response/Management
- Transfer Procedures
- Pipeline Design
- Maintenance
- Environmental Training
- Emergency Response Techniques
- Record Keeping
- Construction
- Control

Table 12: Prevention concepts applied to offshore loading port

STRUCTURE TYPE: Offshore Loading Port

DESIGN CONCEPTS:

- Piping Systems
- Control Systems
- Manifold Systems
- Pier Design
- Pumping Systems
- Hose Handling
- Spill Containment Systems

CONSTRUCTION CONCEPTS

- Strength of Materials and Welds
- Proper Testing of Complete Structure
- Proper Containment Systems
- Proper Location
- Components and Drainage

MAINTENANCE CONCEPTS:

- Test and Replace Hoses
- Maintain and Test Controls and Pumps
- Maintain Spill Containment

OPERATION CONCEPTS:

- Transfer Procedures
- Communication
- Safety and Environmental
- Leak/Spill Detection
- Hose, Flange, and Pump Processes
- Record Keeping
- Water Management
- Record Keeping

TRAINING CONCEPTS:

- Transfer Procedures
- Marine Fire Fighting
- Oil/Water Separation
- Environmental Training
- Construction
- operations
- Hose and Pump Operations
- Record Keeping
- Oil Spill Response
- Personel Safety
- Design
- Maintenance
- Control

Table 13: Prevention concepts applied to offshore oil and gas production lines

STRUCTURE TYPE: Offshore Oil and Gas Production Lines

DESIGN CONCEPTS:

- Materials
- Pumping System
- Strength
- Valves
- Monitoring System
- Subsea covering
- Size and Pressure
- Control System
- Thickness
- Corrosion Protection
- Tides/Currents

CONSTRUCTION CONCEPTS:

- Strength of Materials and Welds
- Proper Testing
- Tides/Currents
- Signs/Buoys
- Coatings
- Proper Materials
- Anchoring
- Actual Subsea Cover Applied

MAINTENANCE CONCEPTS:

- Pigging/Cleaning
- Supports
- Inspection
- Pump and Valve Maintenance
- External Corrosion
- Coating
- Test Monitoring Systems

OPERATION CONCEPTS:

- Control Pressure
- Material Balance Determination
- Record Keeping
- Test Monitoring System
- Monitor Pressure
- Leak/Spill Detection
- Proper Valve Operations

TRAINING CONCEPTS:

- Personal Safety
- Oil Spill Response
- Record Keeping
- Pipeline Design
- Maintenance
- Control
- Environmental Training
- Marine Firefighting
- Oil/Water Separations
- Construction
- operations
- Spill Management

Integrated Planning and Response Mechanism

The integrated contingency planning and response mechanism explains the importance of contingency planning and response activities. The mechanism is shown in figure 31 and reinforced by later figures in this section.

The first three steps entitled "The Problem" or "Risk," "Risk Assessment," and "Prevention" are simplifications of the steps shown in figure 29.

The concept then builds on the potential response environment, which includes the location of the potential risk, the type of hazardous material at risk, the properties of the material, the behavior of the material on the ground, on the water, or on groundwater systems, and in the atmosphere. Included in the above are the likely movement, spreading, and weathering characteristics of the material. Also included are the likely impacts the pipeline contents would have on living, economic, or cultural and historical systems.

The core activities of the contingency planning concept are covered in the planning and response phases of the contingency planning process (see figure 32).

The contingency planning/site specific planning cycle, as seen in figure 32, involves eight steps in a continuing process. The initial step is the development of an administrative contingency plan. The plan establishes overview responsibility and authority and generally provides for notification and fulfillment of other legal requirements. It interacts with other industries and national, state, and local government plans and should be consistent with them. A number of detailed components of the contingency planning steps are presented in table 14.

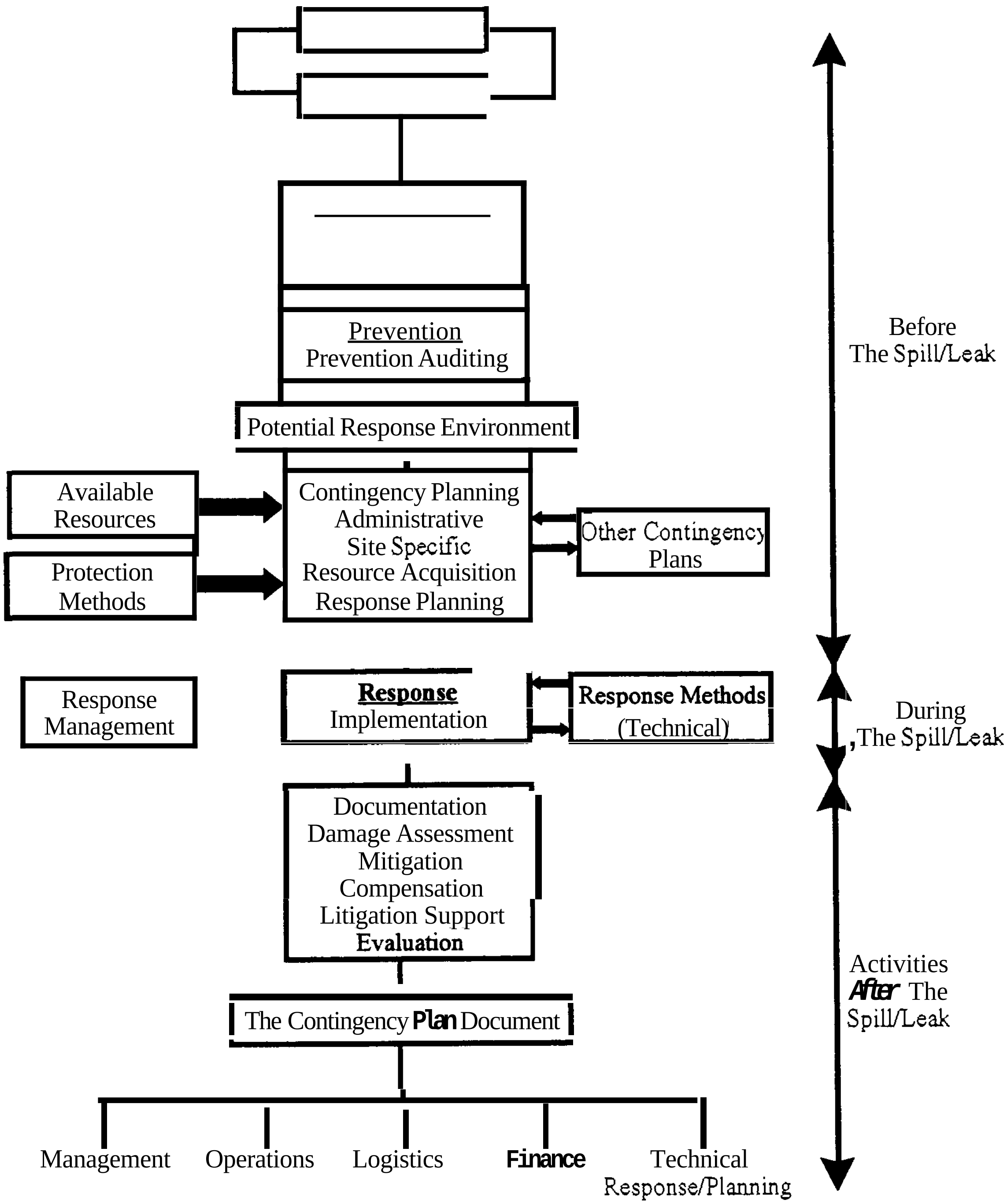

Figure 31: Integrated planning and response mechanism

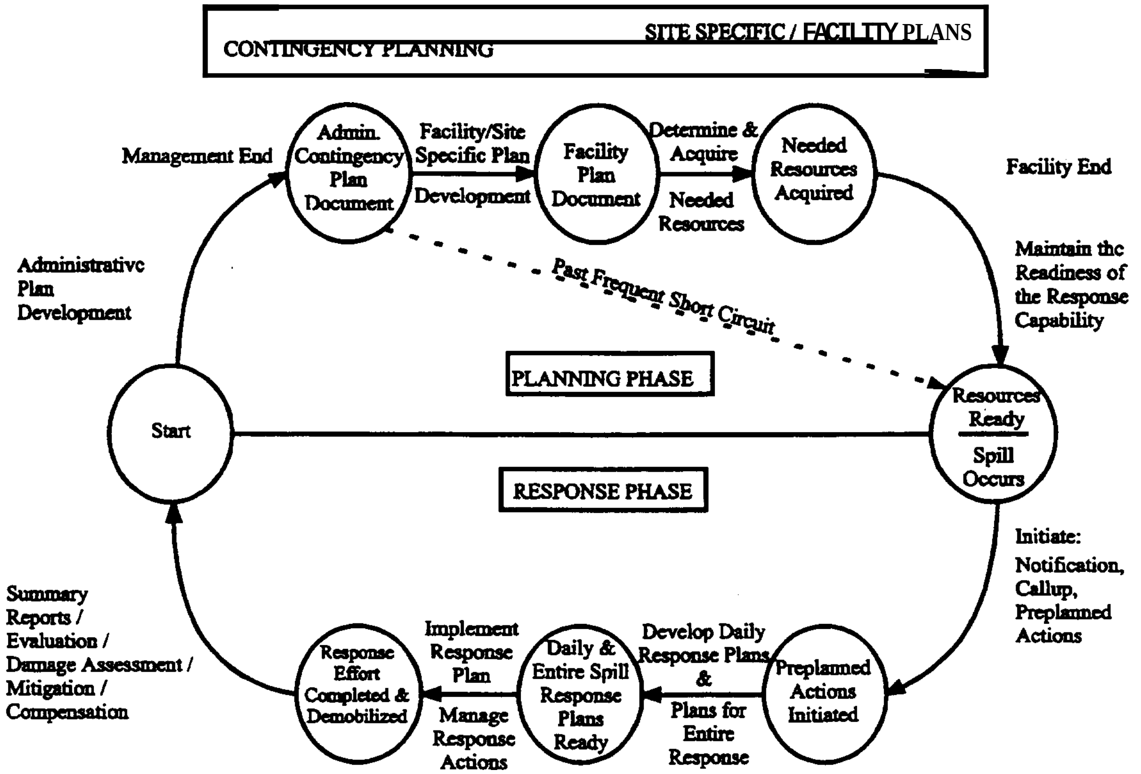

Figure 32: Contingency planning/site specific planning cycle

Unfortunately, before the Exxon Valdez oil spill and the passage of the Oil Pollution Act of 1990 (OPA 90), the contingency planning process of many organizations stopped with the creation of the Administrative Plan document, which was often left on the shelf to gather dust. Thus, when a spill occurred, the contingency plan shifted through the short circuit loop shown in figure 32 to the assembling of response elements and initiating response planning after the spill event rather than before it.

OPA 90 and the resulting federal regulations, including DOT/RSPA's, required the development of site-specific response plans. These regulations required that resources be developed and that readiness be maintained through training, inspections of equipment, and response drills.

Table 14: Steps to contingency planning

Develop Administrative Plan/Overall Corporate Pipeline Release Plan

1. Define authority, purpose, and objectives
2. Establish policy
3. Assign responsibility
4. Delegate authority
5. Provide financial resources
6. Designate institutional, manpower, and material resources to be used in response
7. Establish role of spiller, industry, and or government or governments
8. Establish common or core resources for use of subentity plans, i.e., equipment, supplies, training programs, etc.
9. Establish notification procedures for management and government agencies
10. Establish the format or structure for the response organization or team

Individual Pipeline Facility/Site-Specific Plan

(Note: DOT regulations will specify minimum content and format of these plans.)

1. Develop local site version of administrative plan components
2. Evaluate resources to be protected
   - Environmental systems: estuaries, marshes, breeding grounds, etc.
   - Economic systems: beaches, aquaculture, resort areas, fisheries, marinas, etc.
3. Develop the response goals and priority of action
4. Determine mechanism for initiating action
5. Develop the framework of authority, responsibility, and hierarchy of response to be followed in the area (i.e., spiller, industry group, government, contractor, etc.)

Table 14 (continued)

6. Inventory the various resources available to deal with the expected problem

A.	Laws	H.	Land
B.	Agreements	I.	Engineering plans
C.	Management structure	J.	Response personnel
D.	Communications personnel	K.	Technical assistance
E.	Specialized equipment and supplies	L.	Construction
F.	Traditional equipment and supplies	M.	Background studies
G.	Money	N.	Logistical support

7. Develop the detailed response strategy for control including equipment placement, protective booming, containment and removal locations, removal devices, chemical application devices, etc. for the expected problem
8. Develop the detailed technical response strategy
   - A. Provide technical input to the design process
   - B. Provide needed technical information
   - C. Document the behavior and impact of spills
   - D. Assess the damage caused by spill and response
9. Evaluate needed resources in excess of those already available (see #6)
10. Develop a plan of acquisition of the needed resources
11. Develop detailed job descriptions for people who will staff response team
12. Develop procedures to test the readiness of the plan or its components
13. Publish the plan for the use of those involved and for outside review and suggestion for improvement

Develop Resources Required by the Plans

1. Acquire specialized equipment and supply resources
2. Develop institutional arrangements, specifically memberships in oil spill cooperatives and contracts with other oil spill response organizations

Table 14 (continued)

3. Train personnel
4. Carry out background engineering and scientific studies
5. Build specialized defenses
   A. Storage
   B. Pooling areas
   C. Deployment
   D. Disposal areas

Maintain Readiness

1. Maintain and inspect equipment resources
2. Train/retrain response personnel
3. Develop and implement scheduled drills
   A. Notification drills
   B. Table top drills
   C. Equipment deployment
   D. Full-scale response deployment
5. Maintain readiness records

Assemble Response Management Entities

1. Initiate predetermined notification procedures
2. Assemble the response team
3. Initiate predetermined initial response activities, including preventive booming of valuable economic and environmental systems

Evaluate Specific Response Required

1. Evaluate nature, size, and potential impact
2. Evaluate response plan methods to be used and when, i.e., priority of operations
3. Modify predeveloped response plans as appropriate

Table 14 (continued)

4. Evaluate resource levels needed as compared to planning response scenario
5. Implement deployment of resources to be used (hierarchy of response levels to be used) for clean-up
6. Evaluate additional technical response resources
7. Develop and update a written response plan appropriate for the spill, including daily and shift plans, overall response plans, and specialized plans as needed for safety, security, special technologies, public information, etc.

Carry Out Response

1. Carry out containment, removal, disposal, and/or dispersion operations in accordance with response plans
2. Provide the necessary logistics, financial, and other operations support needed by the response operations
3. Carry out documentation of spill according to the planning/technical assistance plan
4. Carry out documentation of damage assessment and restoration according to technical assistance plan

Critique Response and Response Plan

1. Evaluate the effectiveness of the spill control response
2. Evaluate the effectiveness of the response team in the areas of management, operations, logistics, finance, and planning/technical response
3. Evaluate effectiveness of the contingency plan and response plan
4. Make recommendations for future plan revisions and responses

Perhaps the most important and most neglected aspects of contingency planning are site-specific planning and the acquisition of resources to deal with a release. These two components, which are described more fully in table 14, are coupled with the Administrative Plan to comprise pre-spill activities. Often the pre-spill planning group is different fiom the actual response personnel group for an industrial organization.

Site-specific planning involves careful evaluation of the type of incident that can happen to a pipeline and determination of what response would be needed to deal with the expected incident.

The next phase is the acquisition of the resources needed to deal with the incident. This may mean training response personnel in both administrative and line responses, obtaining specialized spilled material control equipment and supplies, negotiating contracts with spill material related contractors, carrying out scientific and engineering studies, building storage facilities, end anchorage, and temporary spill material storage areas, etc.

Pipeline spill control, like fire fighting, allows time €or only minor fine *tuning* of the plan after the alarm bell rings. After the pipeline release alarm bell sounds, the contingency plan shifts from the planning mode to the response mode. First the response team management is assembled. They then modify previous plans (if they exist) to adjust to the actual incident, document the plans to be followed, and *take* steps to put the response in motion. The response is then carried out. It may range fiom simply hiring a contractor to clean up a small spill to an effort like that of the six-month 10,000-person effort expended on the Amoco Cadiz oil spill in France or the 10,000+ person effort on the Exxon Valdez spill.

Part of the administrative, site-specific, and resource acquisition components is to create, equip, and train the response organization. For this report the response organization consists of five major divisions: (1) management; (2) operational components; (3) logistics; (4) finance; and *(5)* planning/technical response. The size can range **fiom** a five-person team on a small spill to hundreds of people in each division on a major spill.

At the time of the release event (or simulation), this team will be called up and will assemble. The team will activate predetermined activities to stop the release, contain the released material, and protect valuable resources. The team then evaluates the actual situation and modifies previously developed site-specificplans into the documented response plan. This plan may undergo major changes and modification from day to day as the response progresses.

The response itself will be carried out by the pipeline organization andor a host of general or specialized contracting or government resources. Some of the response implementation items which continue after the main part of the spill response are the components of documentation, damage assessment, mitigation, compensation, and litigation support. These have been included in figure 31 to emphasize the importance of those tasks and their longer lasting nature.

For this to occur, the response event, response plan, and response results must be clearly documented.

Figure 33 shows a typical response organizational diagram. This diagram of four major groupings shows: (1) the core management group; (2) an operation component to direct andor implement the protection, containment, removal, dispersion, disposal, and related operational activities; (3) operational support component of logistics and finance to provide the response resources and support them during the spill with transportation, housing, food, security, communications, accounting, safety, and a host of other support considerations; and (4) a planning/technical response component to provide response planning and plans, as well as scientific, engineering, legal, information, and other technical components of the response.

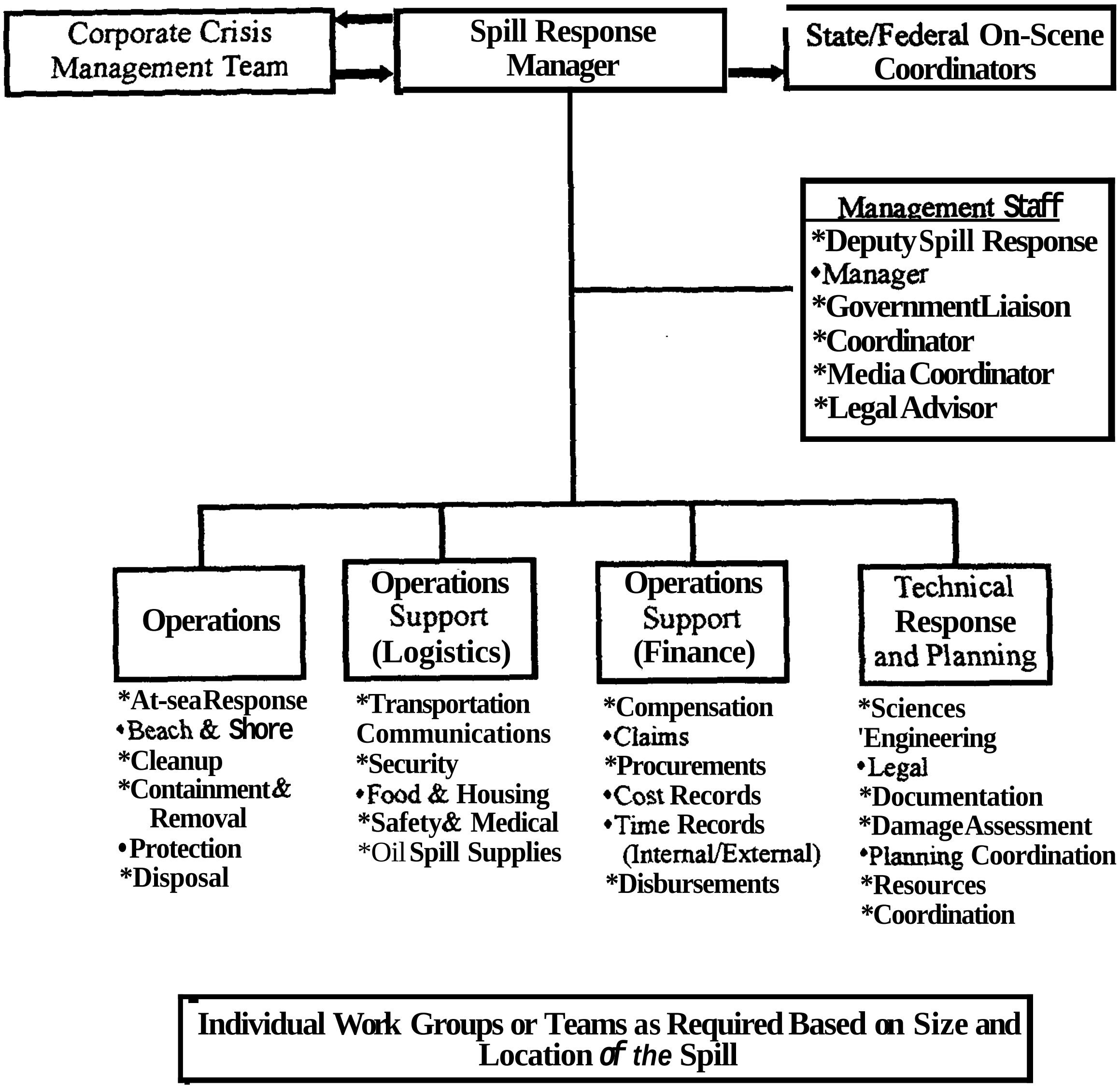

Figure 33: Typical response structure for a major pipeline release

The DOT-RSPA's response plan submittal requirements consist of those pipelines that are believed to cause "significant and substantial **harm,"** exempted pipelines, **and** all **others** (see figure **34).** As set forth in **49** CFR Part **194,** pipeline response plans must be reviewed and approved by DOT-RSPA for those response zones which include a line section that may be reasonably expected to cause "significant and substantial harm" to the environment **(see 49** CFR **194** for significant and substantial definition). All other pipelines not considered a "substantial and significant harm" are required to submit response plans to RSPA. The exemptions for submitting a response plan are provided in **49** CFR **194.101** (b).

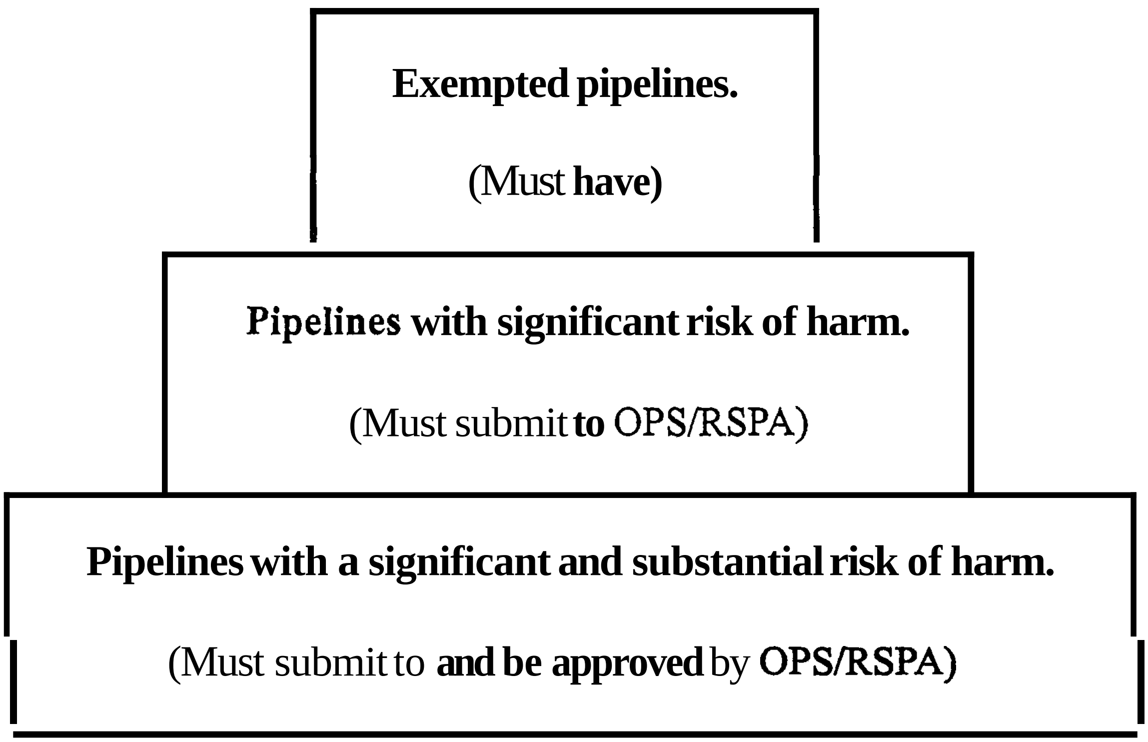

Figure **34:** Submission requirements for pipeline response plans

Although pipeline operators must demonstrate a tiered response in 6, 30, and 54 hours for high volume areas and 12, 36, and 60 hours for all other areas, there are no specific response planning standards established for these time periods as with the EPA and USCG. Therefore, the DOT-RSPA-OPS must be very capable to see if operators have a truly significant response plan.

A number of supporting concepts need be considered in further developing the Contingency Planning Concept.

The first is the interrelationship between contingency plans within an overview organization and with other exterior organizations involved with a release.

The federal government learned that it needed national, regional, and local or area contingency plans. Likewise a pipeline company needs a tiered structure of plans such as demonstrated in figure 35. This diagram shows that a corporation may have a high level overview plan that is highly administrative in nature and a regional or divisional plan which is more balanced.

Of particular importance is that the company's plans mesh with the government's contingency plans. For example, if a pipeline has a release in an area with a pipeline facility response plan, the company's plans are going to have to conform or mesh with the government's Area Contingency Plan (ACP). Since pipelines are a line source, meaning that they travel across country, they pose the potential of having to conform with several ACPs, EPA/USCG regional plans, and the US National Contingency Plan upon the event of a pipeline failure. Therefore, it is important to understand that these government plans are based on the Incident Command System (ICS), which can and should be used in a pipeline company's contingency plans. The ICS is a pyramid of ten major components as shown in figure 36. The system's foundation is in the bottom component of the diagram and includes maintaining readiness, inspections, training, record keeping, and drills. For detailed information on the ICS system the reader is referred to the publication "Incident Command Systems" published by National Interagency Incident Mauagement Systems and Fire Protection Publications, Oklahoma State University, Stillwater, Oklahoma 94078, and to documents on the Texas A&M Spill Incident Management System (SIMS) through Texas A&M University's Environmental Engineering Program.

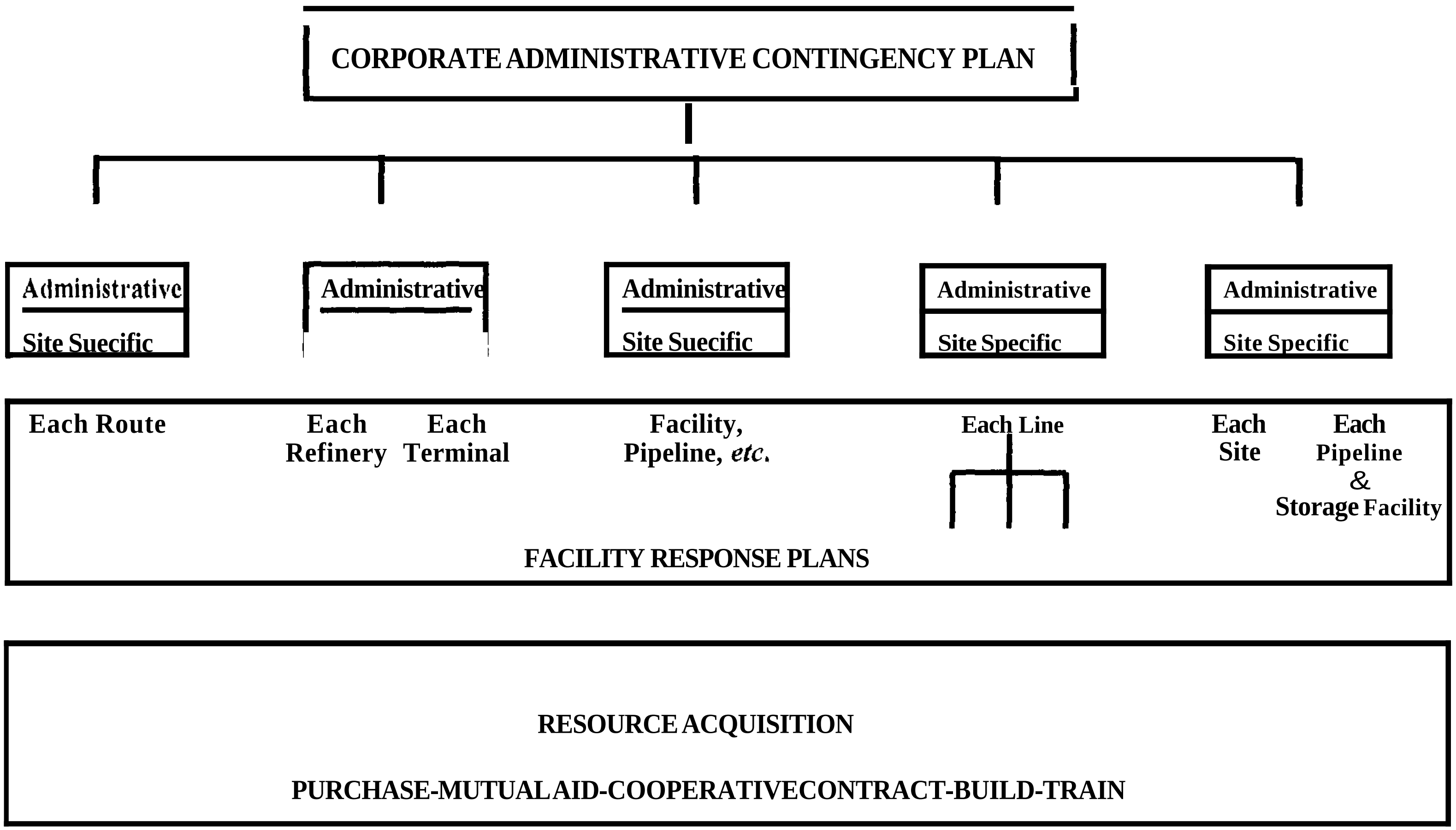

Figure **35:** Basic concepts applied to tiered contingency plans

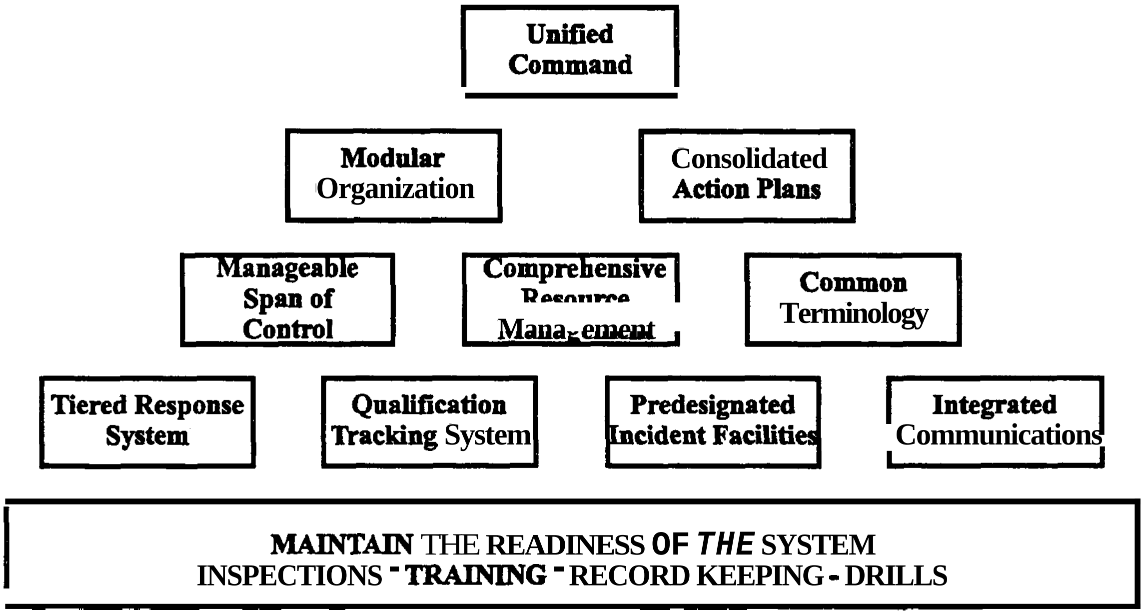

Figure 36: Major components of the Incident Command System as modified for oil spill/hazardous material spill control

Also of importance is that the highly site-specific plans of the pipeline company interact with one another. For example, in figure 37 a pipeline is shown to have four sections with site-specific plans. If the pipeline was to have a release in section 1, it would be beneficial to the pipeline company for the site-specific plan in section 1 to reference an overall response plan that utilizes its sister facilities' equipment and manpower. This is in contrast to a site-specific plan that does not call upon its sister facilities in the event of a release response.

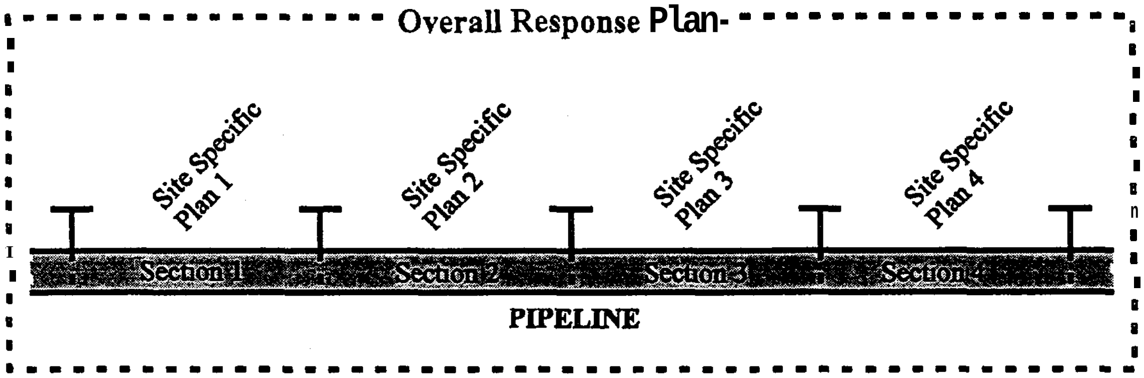

Figure 37: Interaction between site specific plans

Interrelationship with Outside Contingency Plans

An example which shows the importance of interrelationship with outside contingency plans is the Exxon Valdez spill, where it was reported that seven different contingency plans were executed at the same time with limited coordination between them. This is not unusual. Figure 38 indicates how various plans must mesh together to create an integrated effective response.

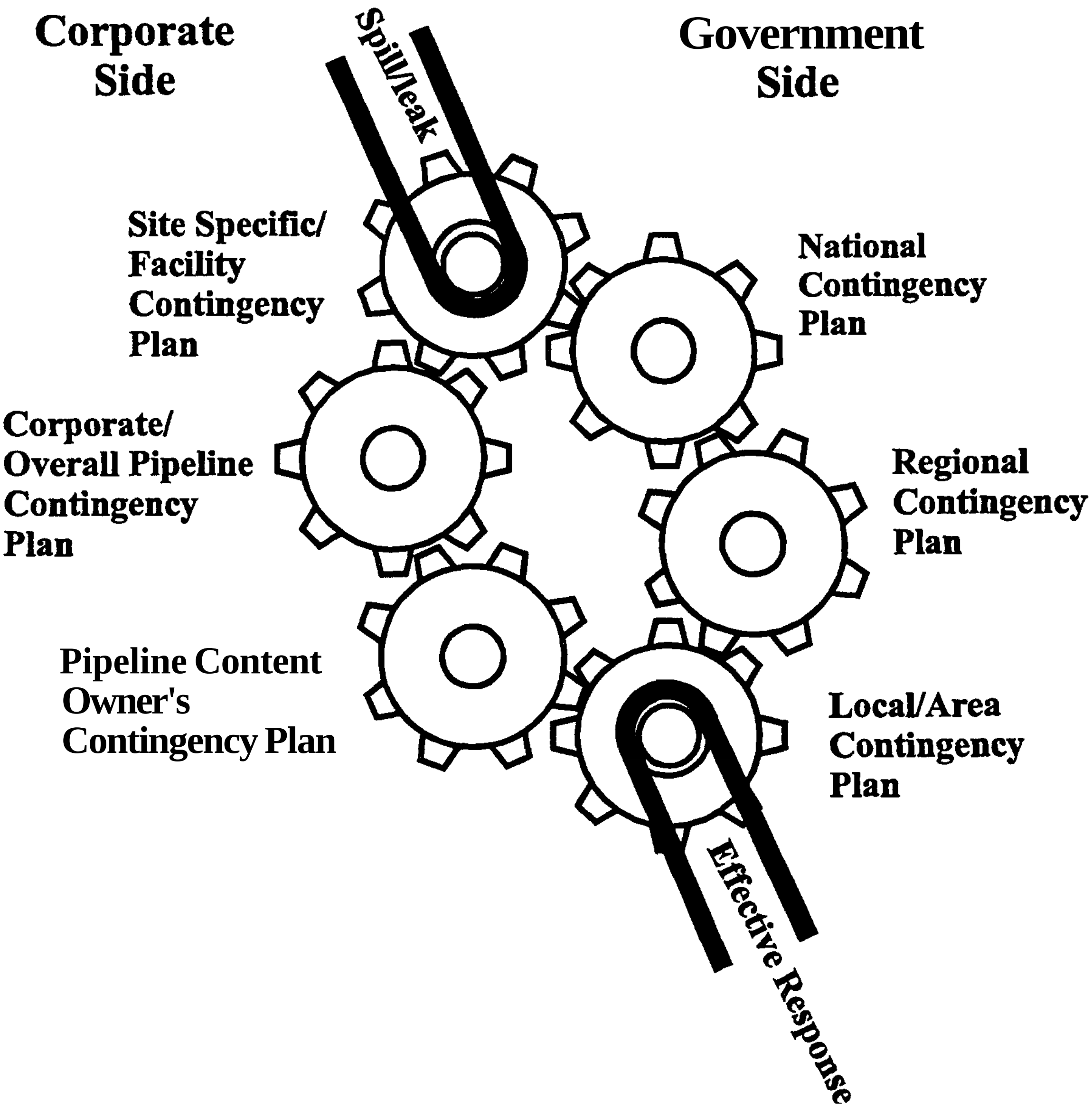

Figure 38: Contingency plans working together

The difficulty of achieving this interaction is shown in figure 39. Different organizations, which will have documented or undocumented contingency plans, may have widely divergent viewpoints with regard to the spill/leak. One may wish to minimize costs, another maximize negative publicity, another seek a high level of restoration, and another pursue a financial vested interest.

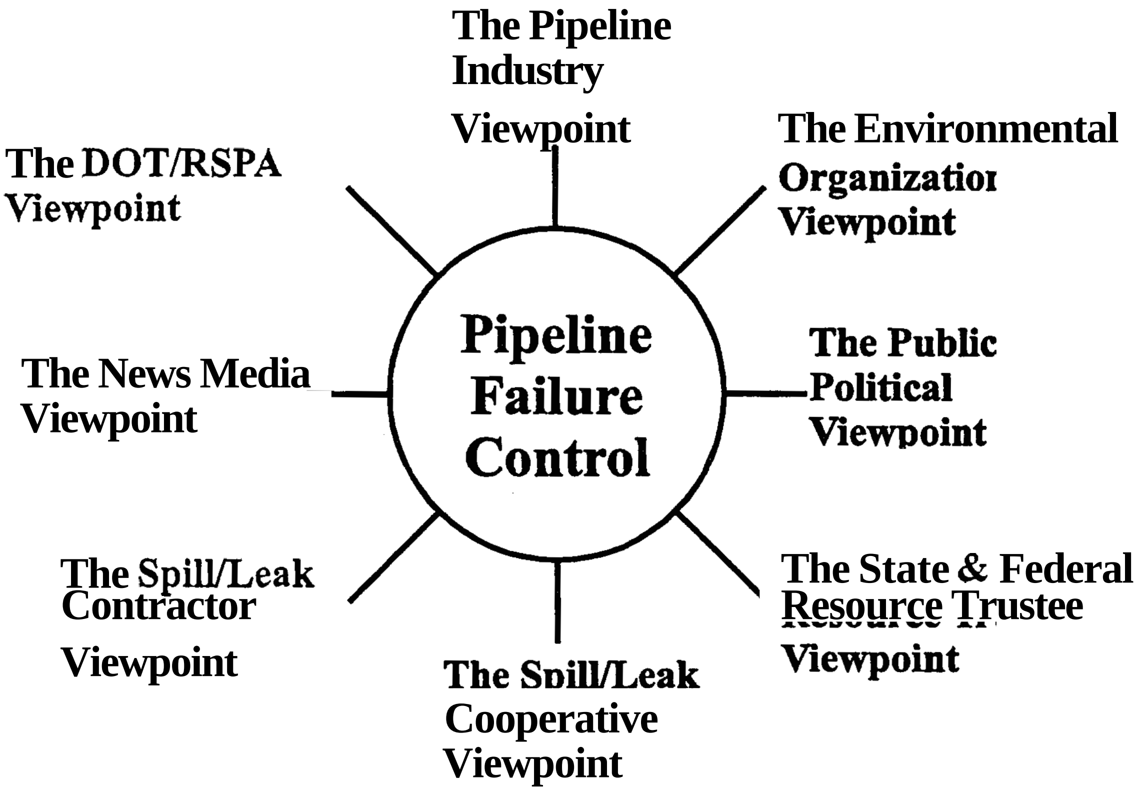

Figure 39: Different viewpoints of pipeline release control

These different viewpoints and plans must be considered throughout the planning and response implementation process.

Response Resources

A major component of the contingency planning process is the acquisition of response resources. Since few response organizations can maintain full resources themselves, a hierarchy of available resources is essential. Some of the possible resources to be considered are as follows:

1. company resources;
2. contractor resources (local);
3. cooperative resources (local or regional);
4. mutual aid relationships;
5. national contractors and consultants;
6. super cooperatives;
7. local and state public works resources;
8. federal resources; and
9. international resources.

Protection Methods

When a release has occurred or there is an imminent danger of a release, it is time to initiate activities to protect endangered environmental systems, economic systems, historical systems, and other valuable resources. If adequately planned and executed, these activities greatly limit the resulting damages and costs.

This concept was discussed earlier as part of the Probability of Harm equation since these activities prevent pipeline contents from reaching a damageable environment by replacing hazardous pipeline contents with a less harmful material, intercepting and diverting the contents, or by removing the damageable target. Evacuating human dwellings, closing off estuaries, using diversion booms, diking streams, or rivers, removing beach sands, harvesting or removing mariculture organisms, coating surfaces with plastic coatings, and herding birds and animals to other locations are examples of protection methods.

Response Methods

The release response makes use of a wide range of physical, chemical, and biological processes to deal with the pipeline release. These technologies include but are not limited to:

1. salvage concepts;
2. containment concepts;
3. removal concepts;
4. chemical treatment concepts;
5. burning concepts;
6. bioremediation concepts;
7. cleanup concepts; and
8. storage, transportation, and disposal concepts.

The timely availability of equipment and personnel is vital for effectiveness. The concept of "a chain (physical or logistical) is only as strong as its weakest link" will often be very important in the effectiveness of methods.

Scheduling of Response Activities

One of the key elements to an effective response is to continually evaluate the situation and to periodically revise the action plans and objectives as necessary before the next scheduled turnover of shift personnel. Spill responses are normally 24 hour operations requiring shift work; therefore, it is imperative that plans are made ahead of time for the next shift. This allows arriving personnel to be quickly briefed on the current situation, given specific assignments, and allows them to proceed immediately to their assigned destinations and duties. A typical response activity timetable is shown in figure 40.

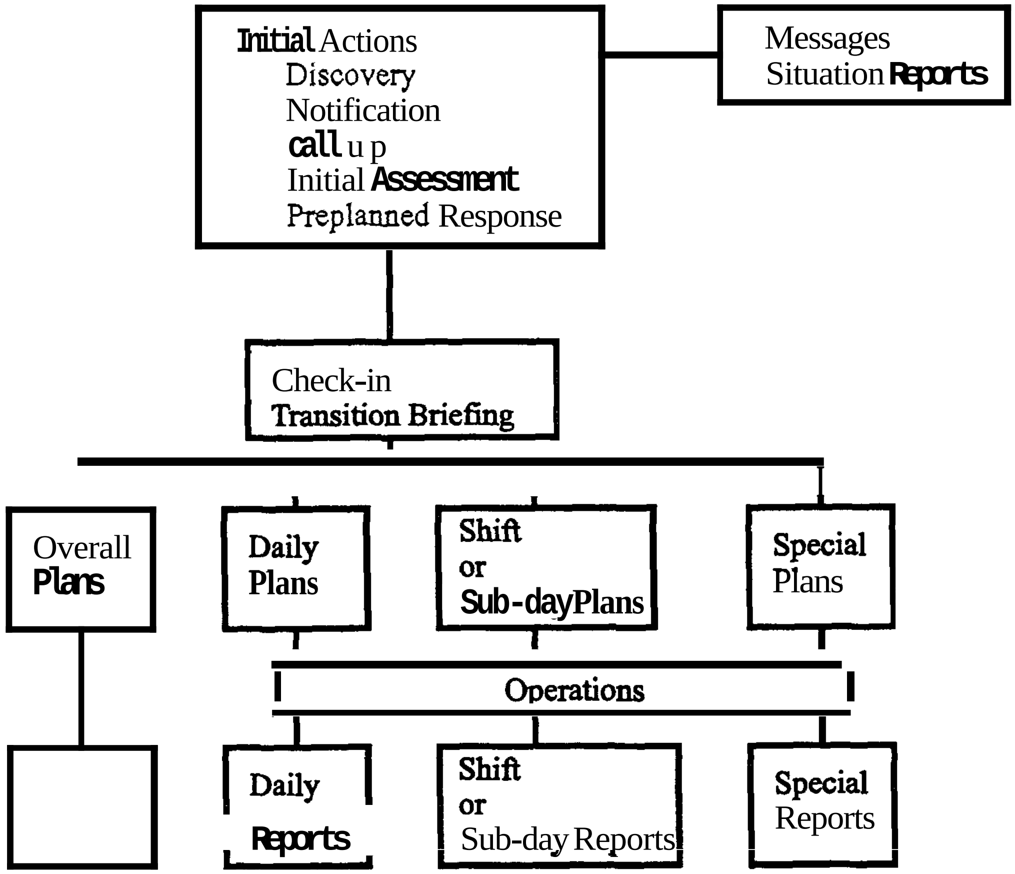

Figure 40: Response activity timetable

Figure 41 is a flow chart detailing the development sequence of initial and revised spill response objectives; shift, next day, and overall work plans; operational assignments and orders; and periodic briefings.

Response Management

Organizations which are smooth-running bureaucracies in other arenas often have difficulty handling the needs and requirements of an emergency event. Carefully contracting for resources in advance, selecting and training people to operate in stressful

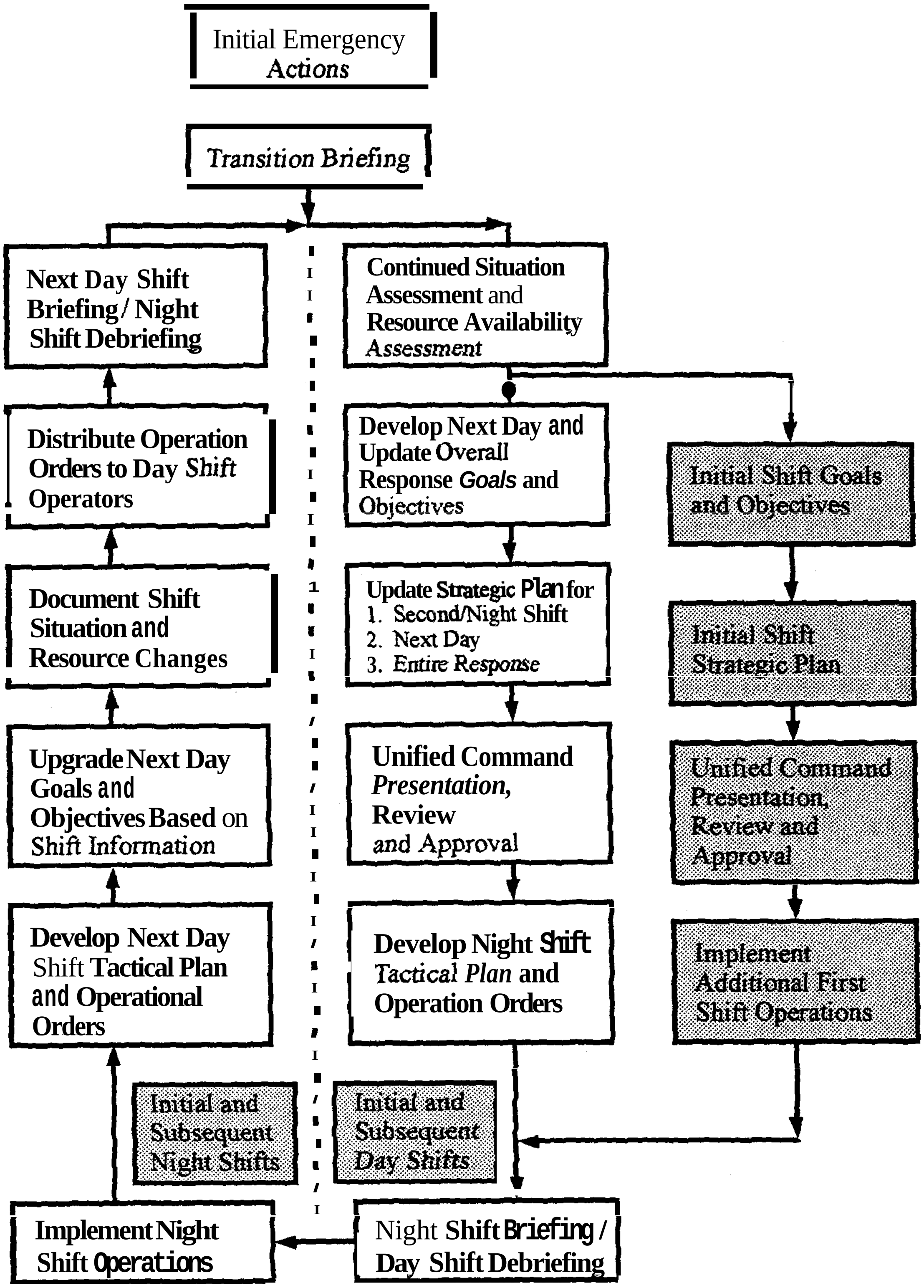

Figure 41: Typical response schedule of activities for initial and **subsequent days**

environments, learning to provide capable elevated levels of supervision, using innovative ways to account for materials and personnel, requiring rapid submittal and verification of charges, assuring personnel effectively interact with the public and the media, and other selected management methods can minimize both direct and indirect costs of the release.

The end result of the contingency planning process will be the generation of the contingency plan and response plan documents. Although facility response plans are now required for an operating facility, overall contingency plans are often not required or developed for major divisions or overall corporations. Plans are often most needed at this level because it takes division-level or corporate-level resources to deal with a large release. A Corporate Contingency Plan is integrated into an overall plan for all locations. The corporate plan allows the individual site-specific response plans to interact with one another; therefore, it utilizes a corporation's overall equipment, manpower, and resources.

Whereas response plans at the facility level generally become open public documents because of governmental review, higher level contingency plans may be more confidential and less accessible to outsiders.

A model pipeline organization contingency plan table of contents with an ICS format is shown in table 15. This format is integrated with the pipeline release contingency plan cycle; response plan and the before, during, and after the release concept. Table 15 is used here only to show an ICS format that ties in with the concepts discussed in this report. To insure that the DOT-RSPA response plan requirements are fully met, researchers suggest reviewing the requirements listed in 49 CFR Parts 192, 194, and 195.

Table **15:** Pipeline organization contingency plan (typical table of **contents)**

Insert: Current telephone numbers of personnel, agencies, contractors, etc.
Title
Update Processes and Control Sheet

I. Introduction
   Table of contents
   How to use this plan
   Purpose and objectives
   Description of organization
   Abbreviations
   Definitions

11. Policy and responsibility
   Responsibility for contingency planning, resource acquisition, and response planning during non-event period and related updating, improvement, and testing

   Authority for response

   Responsibility for response in the company
   Commitment of financial resources and source

   Coordinating response with government entities

   Policy **on** resources to be **used**
   Priority
   Company
   Mutual aid
   Cooperative
   Contract
   Local government
   State government
   Federal government

III. Initial action

   A. Observation
   B. Notification
      Internal
      External
   C. Classification

Table 15 (continued)

D. Assumption of interim spill/leak response manager duties
E. Initiation of predetermined response actions, i.e., pipeline shutdown, initial containment, contractor call-up
F. Assessment of the situation
G. Activation of the various levels of the response team (Include in National Contingency Plan as an action the facility or functional area plan should have been initiated. Include verification that they have done so.)

IV. General response organization structure
Financial management and control
Report requirements
Documentation for cost control
Management of contractor resources

V. Response management concepts

A. Assembly of suitable management team for spill/leak size and situation.
B. Modification or creation of response strategy including response decision tree utilization
C. Approval of the response plan
D. Approval of implementation for the response plan
E. Approval of methods and resources
F. Legal contract management and litigation
G. Media relations
H. Government agency relations, including integrated ICS response operations

VI. Response operation concepts

A. Salvage, pipeline contents transfer, system damage repair, etc.
B. Protection
C. Containment
D. Removal
E. Chemical treatment operations
F. Transportation, interim storage
G. Disposal

Table 15 (continued)

VII. Response operational support concepts (logistics)

A. Acquisition of equipment and supplies
B. Housing, food
C. Purchasing
D. Security
E. Communications
F. Company resources
G. Contractors

VIII. Planning/response operational support concepts (finance)

A. Procurement purchase documents
B. Contractor management
C. Purchase orders
D. Documentation of costs
E. Financial management and control
F. Cash disbursements at the scene
G. Claims and compensation

IX. Response technical concepts

Situation assessment
Plan preparation and documentation

Evaluation of trajectory, fate, and effect of spilled/leaked material
Engineering methods of containment and removal, transportation, storage, treatment, and disposal
Chemical response methods, logistics, and environmental considerations
Providing scientific baseline and support information

Identification of high risk economic and environmental resources to be considered in the response
Documentation for litigation and for response evaluation

Environmental assessment of impact and damage assessment

Wildlife restoration

Restoration plans

Table 15 (continued)

Safety

Public relations and agency interaction

X. Maintain the readiness of the plan

Periodic plan revision
Personnel selection
Individual training
Contract maintenance
Contractor auditing for capability and readiness

Response exercises
Record keeping

Equipment maintenance and readiness verification, etc.

Appendix 1. Organization structure
- A. General
  1. Management
  2. operations
  3. operational support
  4. Technical response
  5. Position descriptions

Appendix 2. Site-specific response scenarios

Appendix 3. Available resources and costs
- A. Company
- B. Mutual aid
- C. Cooperative
- D. Contractor
- E. Local government
- F. State government
- G. Federal government

Appendix 4. Contract and rate sheets

Appendix 5. Forms for use during the spill/leak event

Table 15 (continued)

Appendix 6. Federal response structure
- A. Reporting
- B. Contingency Plan (National)
- C. Contingency Plan (Regional)
- D. Laws

Appendix 7. State government
- Reporting
- Contingency Plan
- Law

Appendix 8. Local response structure
- Reporting
- Contingency plan
- Law

Appendix 9. Contingency plans of users of the pipeline, i.e., facilities, pipeline content owners, etc.

Appendix 10. Background environmental information in areas other than those covered in specific plans

Appendix 11. Communications

Appendix 12. Specific technology
General technology, i.e., specific operation and maintenance instructions for equipment

Appendix 13. Hazardous materials control technology basics (optional)
Definitions and affirmations continued

The contingency plan serves several purposes.

1. It is an instructional document to those responsible for a pipeline spill/leak response telling them how to carry out the response.
2. It is a reference guide to provide quick recall of material and to provide supportive reference material in a quick access location.

3. It serves to show those outside the organization that the organization is properly prepared and knows how to implement a response.

The structure used in table 15 shows the most essential information on organizational structure, responsibility, and authority presented in a concise, easy-to-access manner followed by more detailed instructions for management, operations, operation support, and technical response components. Much information is relegated to appendices.

The first appendix contains additional information on the organization structure, the job descriptions of the different positions, and the names and phone numbers of personnel assigned to the positions. Position descriptions are developed with before the spill/leak, during the spill/leak, and after the spill/leak event components. The before the spill/leak component is most valuable if the person or persons assigned to the activity have the responsibility assigned before the spill/leak as part of a program of "between" spill/leak activities. Otherwise it merely becomes a guide of what to do before impact "if possible."

The second appendix covering site-specific facility planning spells out the site-specific response activities for most likely events. If the real event closely mimics a planned site-specific event, the response plan and response implementation should be faster and more effective.

The third appendix clearly defines resources available for use. This resource list needs to be backed up with contracts, price lists, training certifications, and other documents which assure availability of the resources. Included are call-up procedures to implement the deployment of resources. This appendix should also include the needed legal authorization such as purchase orders, fax letters, and so forth.

The fourth appendix lists phone numbers for agencies, local government, and peripheral resources such as security services, medical services, etc.

The next four appendices include the contingency plans and coordinating information for:

1. the Federal government;
2. the State government;
3. local government; and
4. companies who use the pipeline, i.e., product owners, etc.

Appendix 9 includes background environmental information on risk areas not covered in the site-specific plans. This can include meteorological, oceanographically, hydrologic, and related information, resource maps, etc.

Appendix 10 includes configuration and operation procedure and maintenance instructions for equipment (primarily company owned) which would be used in the response.

Appendix 11 (optional) contains general spilled/leaked material control concepts collected in the absence of provided specialized library resources to the response team.

CHAPTER V
EVALUATION OF SELECTED SITES

Previous sections of this report detail a methodology developed for considering pipeline risks along with prevention and response capabilities in a pipeline safety management program. In developing this methodology we were asked to select five focus areas where pipelines were exposed to significant natural hazards. It was originally contemplated that a FEMA project would provide ten potential locations from which to choose. When the timing of the other project did not mesh, we chose the final locations based on our knowledge, experience, and project literature surveys which included maps, reports, and Office of Pipeline Safety furnished information.

The five areas chosen were:

1. San Jacinto-Houston Ship Channel area in Texas;
2. southern Louisiana coastal area;
3. Ventura County-southern California area;
4. pipeline comdor from Cushing, Oklahoma, to the Northeastern U.S.; and
5. Either south central Alaska (excluding the Alaskan Pipeline) or the San Francisco Bay area.

These areas were selected for the following reasons:

1. San Jacinto/Houston Ship Channel Area

The San Jacinto River system recently experienced a major multiple pipeline release catastrophe, which was triggered by heavy rainfall and subsequent flooding. This region is exposed to potential hurricane-related tidal surges, rainfall, tornadoes, winds, etc.; subsidence triggered by excessive ground water usage and petroleum production; expansive clay soils and considerable local faulting.

This area also has, perhaps, the highest density of crude oil, refined product, natural gas, LPG, and petrochemical pipelines in the United States.

2. Southern Louisiana

Southem Louisiana is plagued by hurricanes. In addition, it has low coastal land influenced by subsidence and land erosion caused by oil production and modification of natural sediment inflows.

Southern Louisiana also has an extensive onshore and offshore network of oil pipelines and natural gas pipelines.

3. Ventura County in California

This area is in a high earthquake-prone area and has soil systems near the coast which are susceptible to exceptionally high earthquake effects. The coastline is also exposed to possible tsunamis.

The pipeline system in the Ventura County area is extensive, including older crude and natural gas pipelines, urban natural gas, and petroleum product distribution pipelines.

4. Cushing, Oklahoma

The Cushing area has been long noted as a pipeline capital. This is due to the fact that many of the pipelines from Texas, New Mexico, and Oklahoma join at the community of Cushing and proceed to the northeast part of the country. These pipelines are linear risk potential sources which are exposed to floods at river crossings, temperature changes, and earthquakes, particularly if routed near the New Madrid earthquake zone, which is downstream from the confluence of the Ohio and Mississippi rivers.

5. San Francisco

In the San Francisco area product and natural gas pipelines of the region are exposed to high earthquake risks. We qualified south central Alaska (excluding the Alaskan Pipeline) evenly with the San Francisco Bay area during initial evaluations of our selections. The San Francisco area was ultimately selected because more information was available.

Pipeline Map Resources

The pipeline networks of these five areas, as well as those in other regions of the country, can be viewed from pipeline-specific maps, atlases, and Geographical Information Systems (GIS) maps such as those prepared by the PennWell Publishing Company. The Office of Pipeline Safety has these references available.

Preliminary results from FEMA-GIS hazard evaluation study agree closely with our selection of high risk pipeline areas.

Figure 42 fiom the FEMA report shows earthquake risk areas in the contiguous United States. It places the Ventura County and San Francisco regions in California in the highest risk earthquake zones. It shows the Cushing, Oklahoma, area in a moderately high earthquake zone, with routes fiom Cushing to the northeast passing through mid-America and the Appalachian earthquake zones.

Figure 43 shows the tornado risk map for the United States. Although pipelines are generally not severely impacted by tornadoes, the map does indicate that the San Jacinto-Houston, Texas, area and the central Oklahoma area, including Cushing and many of the pipelines routed to and from Cushing, are at high risk.

Figure 44 fiom the FEMA report shows the flood risks for the San Jacinto-Houston Ship Channel coastal region. Risk potential exists wherever a pipeline crosses under or over a river. Risk also exists where the pipelines cross floodable land where pipeline personnel could be prevented, by flooding, fiom carrying out necessary monitoring, operations, or maintenance activities.

The data sources for pipeline location and content, coupled with data sources for risk potential, provide the input needed to quantify the rating system utilized in this report.

Earthquake Risk Rank

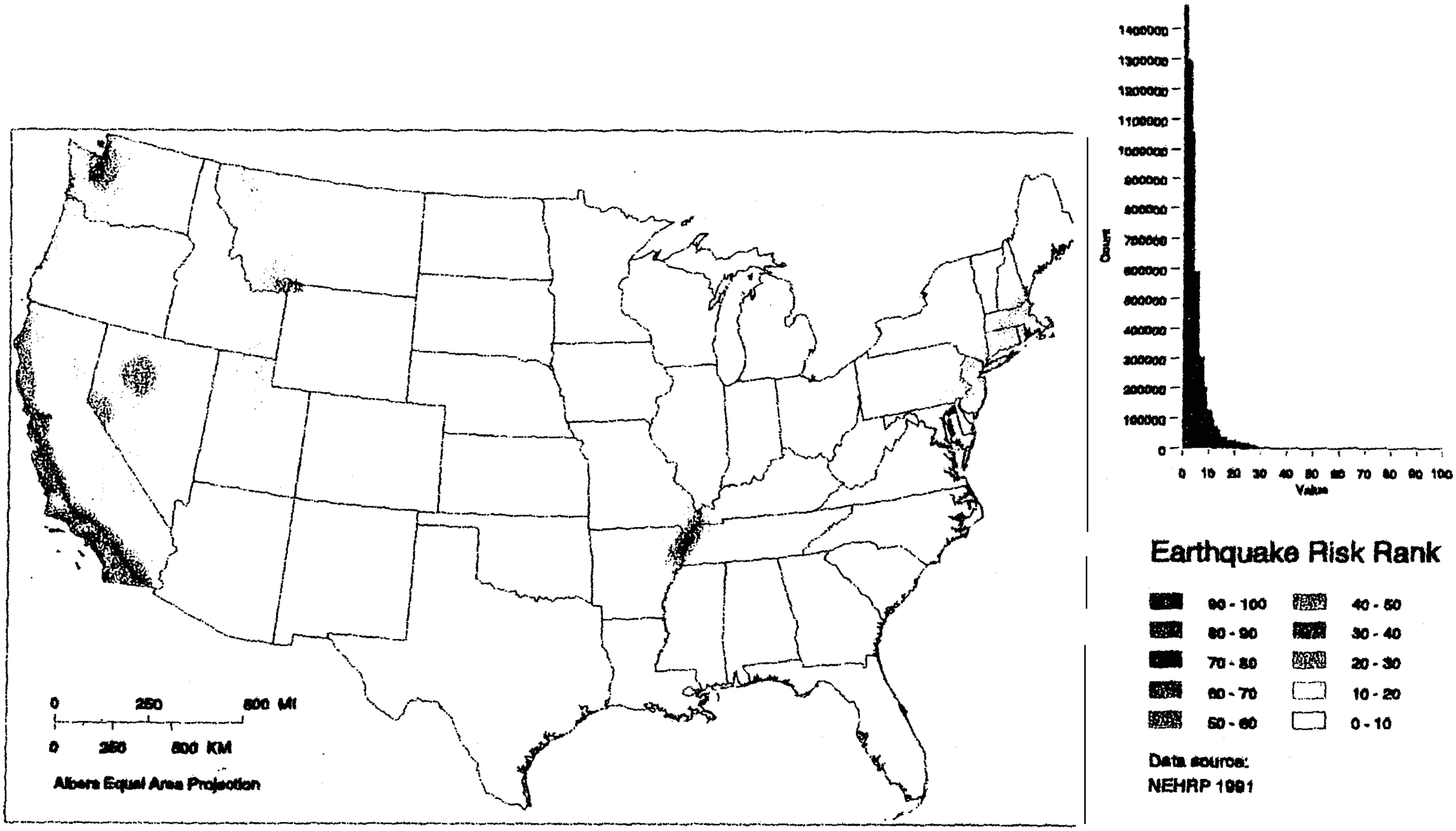

Figure 42: FEMA map showing earthquake risk *areas* (FEMA 1995b, Figure 3(a))

Earthquake Risk Rank

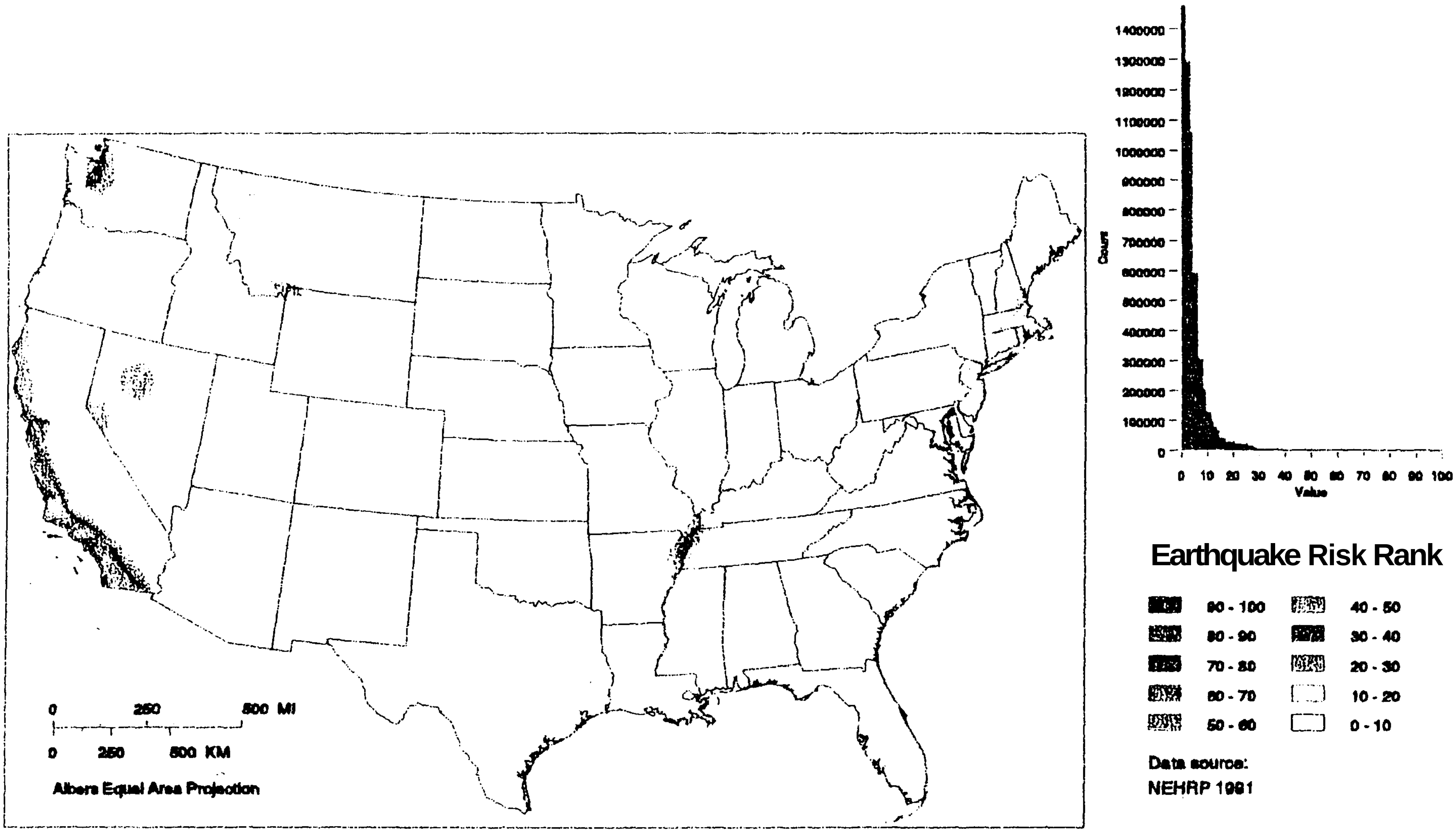

Figure 42: FEMA **map showing earthquake risk areas** (FEMA 1995b, **Figure** 3(a))