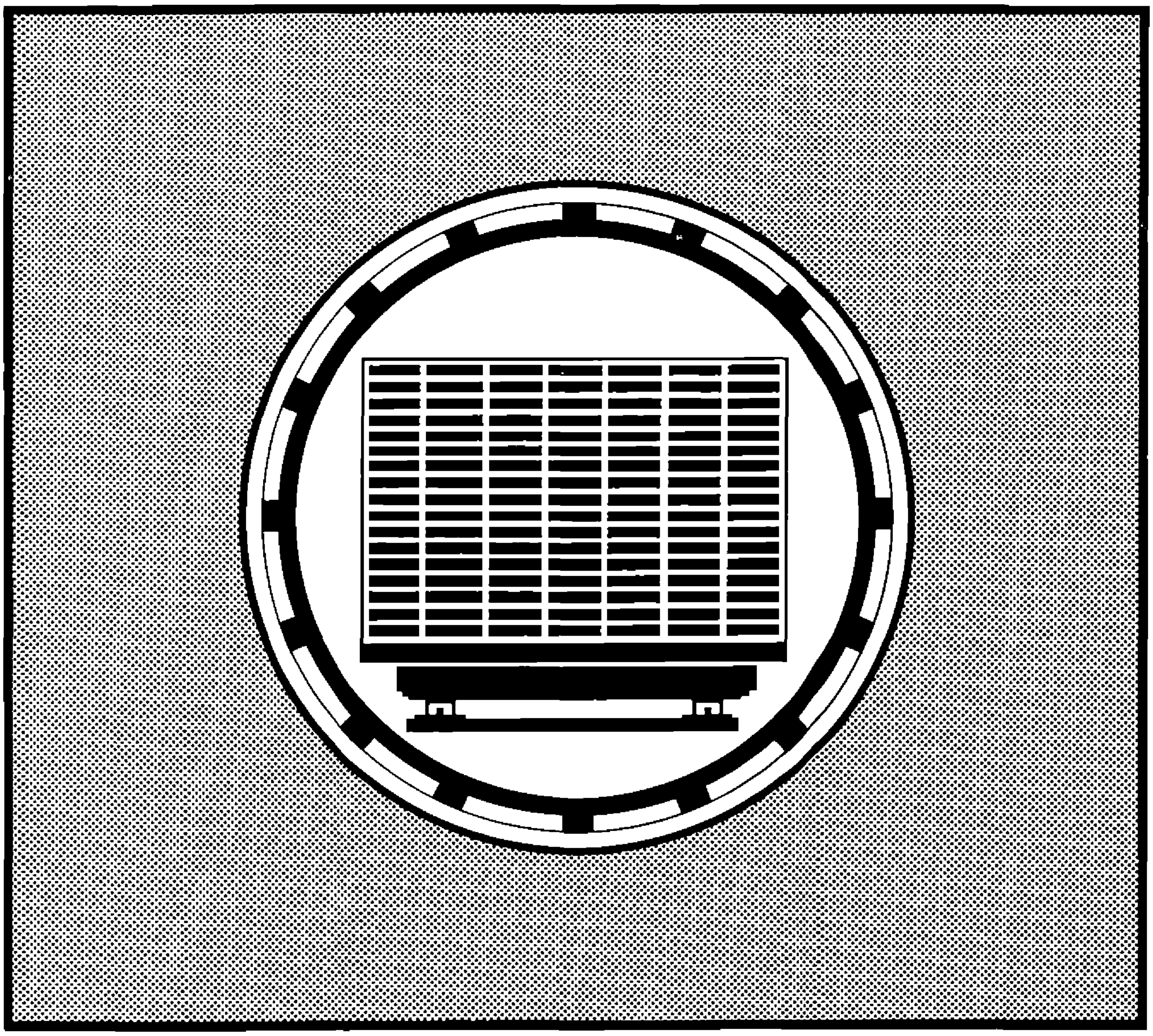
Ammoniacal Copper Arsenate (ACA) Wood Preservation Facilities

Recommendations for Design and Operation

Report EPS 2/WP/4
April 1988



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AMMONIACAL COPPER ARSENATE WOOD PRESERVATION FACILITIES

Recommendations for Design and Operation

prepared by

D.E. Konasewich and F.A. Henning
Envirochem Services

under the direction of the
Wood Preservation Industry Technical Steering Committee

for

Conservation and Protection
Environment Canada

Report EPS 2/WP/4
April 1988

COMMENTS

Comments on the content of this report should be directed to:

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FOREWORD

As part of a federal strategy to protect the environment and human health from potentially toxic commercial chemicals, Environment Canada has evaluated chemical use practices within the wood preservation industry. During 1982-84, Envirochem Services was retained to visit and review practices at 19 wood preservation facilities operating in four Canadian provinces, and to document the findings.

In July 1984, Environment Canada established a Wood Preservation Industry Technical Steering Committee to develop technical recommendations for wood preservation facility design and operational measures which would:

- reduce or eliminate the release of wood preservative chemicals to the environment; and
- minimize the exposure of workers to wood preservation chemicals.

The Steering Committee included representatives from federal and provincial government agencies, wood preservation companies, forest industry labour unions, and provincial workers' compensation boards.

Envirochem Services was subsequently retained to develop an initial draft technical recommendations document for review by the Steering Committee. During the review, input was also obtained from other experts in both industry and government. This technical recommendations report is the result of this comprehensive development and review process.

Design and operational measures presented are based on current knowledge of existing technology of the physical, chemical and biological properties of ammoniacal copper arsenate (ACA) and its components. Although the recommendations are not part of any environmental legislation, they reflect the intent of the Federal Fisheries Act, and of provincial environmental and worker safety legislation and regulations.

The Steering Committee recommends that new ACA pressure treatment facilities comply with the objectives of the technical recommendations. Although methods to achieve those objectives are provided, the Committee fully supports the option of industry to achieve those objectives using other design features or operational procedures that can be shown to be at least equally effective.

The Steering Committee recommends that existing facilities modify their operations as much as possible to meet the objectives of the recommendations. Site-specific circumstances will influence the applicability and implementation of specific measures at both new and existing facilities. It is further recognized that the recommendations are based on existing knowledge, and ongoing and future studies may suggest the need for modifying these recommendations. The authors therefore recommend a definitive periodic review of the technical recommendations.

The Technical Steering Committee believes that the proper implementation of the technical recommendations will allow the continued beneficial use of ammoniacal copper arsenate as a wood preservative and will protect both the environment and workers from potential harmful effects.

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ACKNOWLEDGEMENTS

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Dr. R. Dawson	Waste Management Branch B.C. Ministry of Environment
Mr. E. Ricard	International Woodworkers of America
Dr. J. Ruddick	Canadian Wood Preserver's Association

1 THE NEED FOR WOOD PRESERVATION

1.1 Introduction

Wood preservation is the pressure or thermal impregnation of chemicals into wood to a depth that will provide effective long-term resistance to attack by fungi, insects, and marine borers. By extending the service life of available timber, wood preservation reduces the harvest of already stressed forestry resources, reduces operating costs in industries such as utilities and railroads, and ensures safe working conditions where timbers are used as support structures.

The chemicals predominantly used in Canada for wood preservation are:

- pentachlorophenol,
- creosote, and
- aqueous formulations of arsenic, copper, and chromium or ammonia.

The wood preservation process deposits or fixes these chemicals in the wood, and the toxic nature of the chemicals effectively prevents the attack of living organisms on the wood. Because the chemicals are also toxic in varying degrees to humans and aquatic organisms, their use in industry must be carefully controlled. This document is intended to provide consistent guidelines for the design and operation of wood preservation facilities in a manner that will protect workers and the environment from harmful exposure to wood preservation chemicals.

1.2 Wood Deterioration

Timber is subject to several types of deterioration following its removal from the forest. Wood-decaying fungi and insects drastically reduce the usefulness of unprotected lumber and other forest products. As an example, untreated timbers used in underground workings of mines could have a life-time of no greater than two years because the temperature and moisture conditions in mines favour decay. Another example is the railway cross-ties used in North America, which would have an average life-time of five years without treatment. Protection is also required against wood-boring insects. For example, termites are responsible for extensive damage to wood in storage and in service. Marine structures such as untreated dock pilings along the North American coast can be destroyed by marine borers in less than one year.

The growth of wood-destroying fungi is dependent upon temperature, oxygen levels, the moisture content and nature of the wood. Wood products such as railway ties, bridge and mine timbers, and utility poles are usually in direct contact with moist soil or in locations where moisture collects and cannot readily evaporate. When there is no practical means of limiting moisture content, oxygen levels or temperature, the option for the protection of such wood products is limited to the application of chemicals which act as agents to limit fungal growth by "poisoning" the wood food source. Simultaneously, the treatment can limit the other wood-destroying organisms, such as insects and wood-borers.

1.3 Wood Preservation Chemicals

Historically, the preservation of wood by chemical means can be traced back over 4000 years, to the time when the Egyptians apparently used bitumen to treat wooden dowel-pins in the stonework of temples (1). At the time of the Roman Empire, tar, linseed oil, oil of cedar, and mixtures of garlic and vinegar were used for the preservation of wooden statues. Alexander the Great of Persia is reported to have ordered piles and other timber for bridge building to be covered with olive oil as a precaution against decay (2). Investigations to define alternative wood preservation agents were reported in the late 1600's with escalating efforts during the 1800's. A review of the many chemicals and chemical formulations used historically and currently, can be found in the above references and in texts such as those written by Hunt and Garratt (3) and Wilkensen (4).

The choice of wood preservatives depends upon the character of the wood to be treated, the required service, and the properties of the chemical or formulation. Wood preservation formulations must:

- be toxic to attacking organisms;
- be able to penetrate wood;
- be chemically stable;
- be safe to handle;
- be economical to use;
- not weaken the structural strength of the wood; and
- not cause significant dimensional changes within the wood.

Other factors which determine the selection of wood preservation chemicals or formulations include: fire resistance; colour or odour; paintability; corrosiveness; electrical conductivity; and, leachability from wood.

In Canada the predominant wood preservative chemicals or formulations in use are:

- CCA (chromated copper arsenate). Major CCA-treated products include: fence posts, lumber for patios and landscaping, and foundation lumber and plywood.
- ACA (ammoniacal copper arsenate). Major ACA-treated products include: utility poles and landscaping timbers.
- PCP (pentachlorophenol). Major PCP-treated products include: railway ties and utility poles.
- Creosote. Major uses include treatment of railway ties, utility poles, and marine piling.

Although other wood preservatives have been used in the past in Canada, these four chemicals or formulations are the only preservatives in use in Canada since 1985. The development of alternative chemicals for wood preservation is the subject of ongoing research. The actual use of alternative chemicals will depend on industry and safety evaluations, and on approval under the Federal Pest Control Products Act administered by Agriculture Canada.

1.4 The Value of Wood Preservation

Controlled studies have shown that wood preservation enhances the lifetime of wood by a factor of 5 to 15, depending on the wood species, use and efficacy of treatment. It has been estimated that, if in the U.S.A. "untreated wood were used for the applications now employing preservative-treated wood, the added annual cost to the transportation, utility, and construction industries would be over $15 billion dollars. Energy savings, depending on the substitute materials envisioned, are from 19 to 32 million barrels of petroleum per year" (5).

It has also been estimated that if wood were not treated with preservation chemicals, timber requirements would increase by three- to six-fold. Such requirements would have exhausted many timber resources required for railway, utility, construction, and marine industries (3). Wood preservation also enables the use of smaller and faster growing trees such as lodgepole pine. Prior to the widespread use of wood preservation, timbers used in structures such as railway bridges were required to be over-sized in order to accommodate a degree of decay.

2 OVERVIEW OF AMMONIACAL COPPER ARSENATE WOOD PRESERVATION FACILITIES

2.1 Description of Process

Wood preservation requires the penetration of chemical agents, such as ACA, several centimetres into the wood. Pressure treatment is used to achieve such penetration and subsequent fixation of the preservative within the wood (Figure 2.1). Ammoniacal copper arsenate is prepared on-site at wood preservation facilities by mixing and aerating cuprous oxide powder, arsenic acid, aqueous ammonia and water. Initially an ACA concentrate is prepared which consists of 8 to 12% total oxide (as CuO and As_2O_5). Subsequently the concentrate is diluted with water, generally to a 2 to 4% total oxide content, by means of pumping transfers and recirculation between bulk tanks. The working solution is then applied to the wood in a pressure cylinder which may be up to 45 m long and 2 m in diameter.

The treatment process used in ACA treatment plants consists of the following steps (Figure 2.2):

- application of an initial vacuum to remove air from the wood cells;
- flooding with ACA working solution and pressurization (up to 1034 kPa (150 psig)) until the target ACA retention level is achieved;
- draining of the excess ACA working solution (to the working tank for reuse with subsequent charges); and
- application of a final vacuum.

The specific treatment times and pressures are dictated by the species of wood, the wood product, and the moisture content of the wood. A predetermined range of process parameters is defined by the applicable treatment standards (6), and numerous quality control tests are carried out to ensure that a minimum treated product quality is maintained. The treated wood is then withdrawn from the treating cylinder and stored on-site for periods ranging from days to months.

2.2 Potential Chemical Releases

ACA wood preservation plant design and operational practices vary (7,8,9), and within each plant there are various potential emission sources which may affect worker health and/or the environment. The potential sources and releases are illustrated in Figure 2.3.

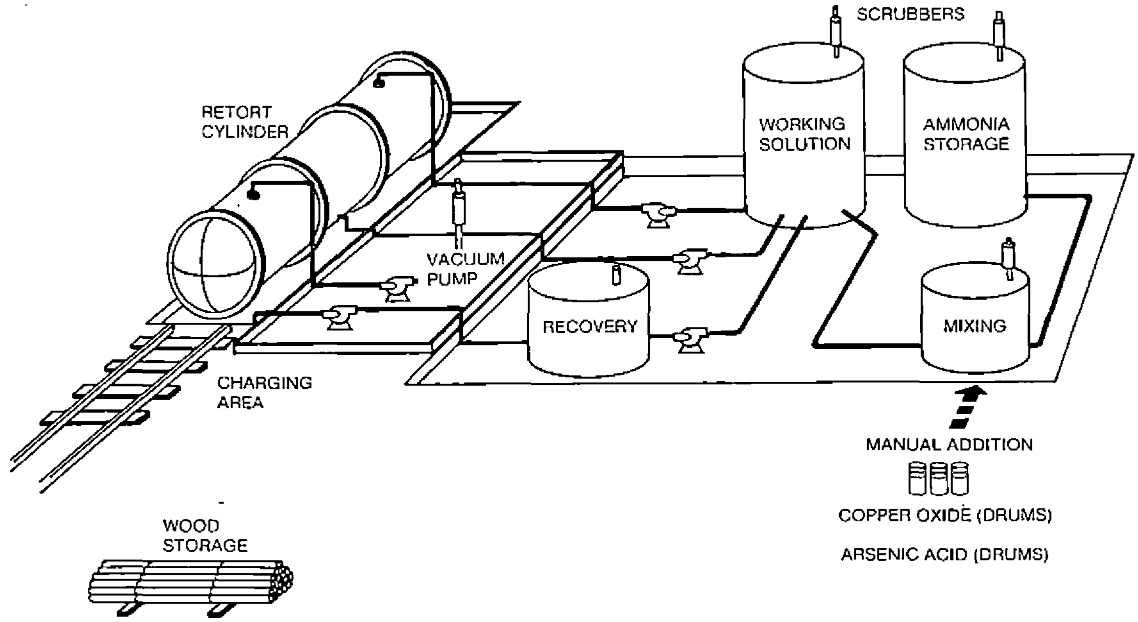

FIGURE 2.1 CONCEPTUAL DIAGRAM OF AN ACA TREATMENT FACILITY

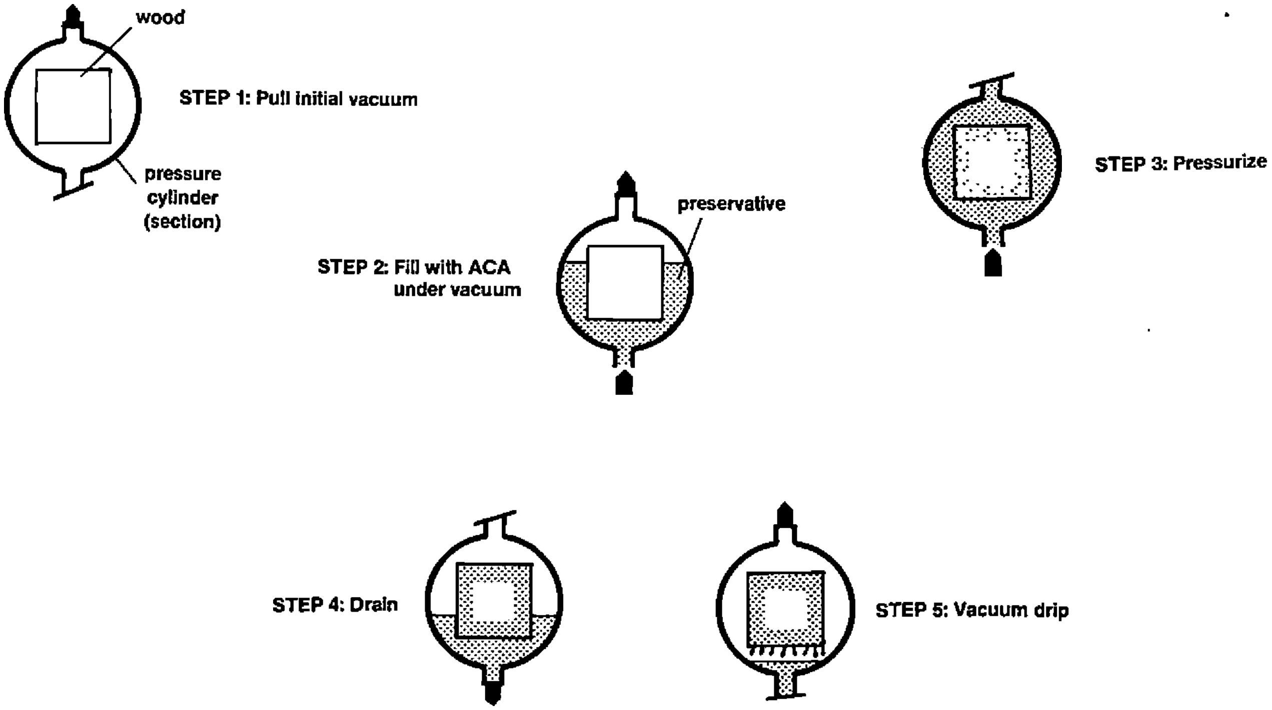

FIGURE 2.2 THE FULL-CELL ACA PRESSURE TREATMENT PROCESS

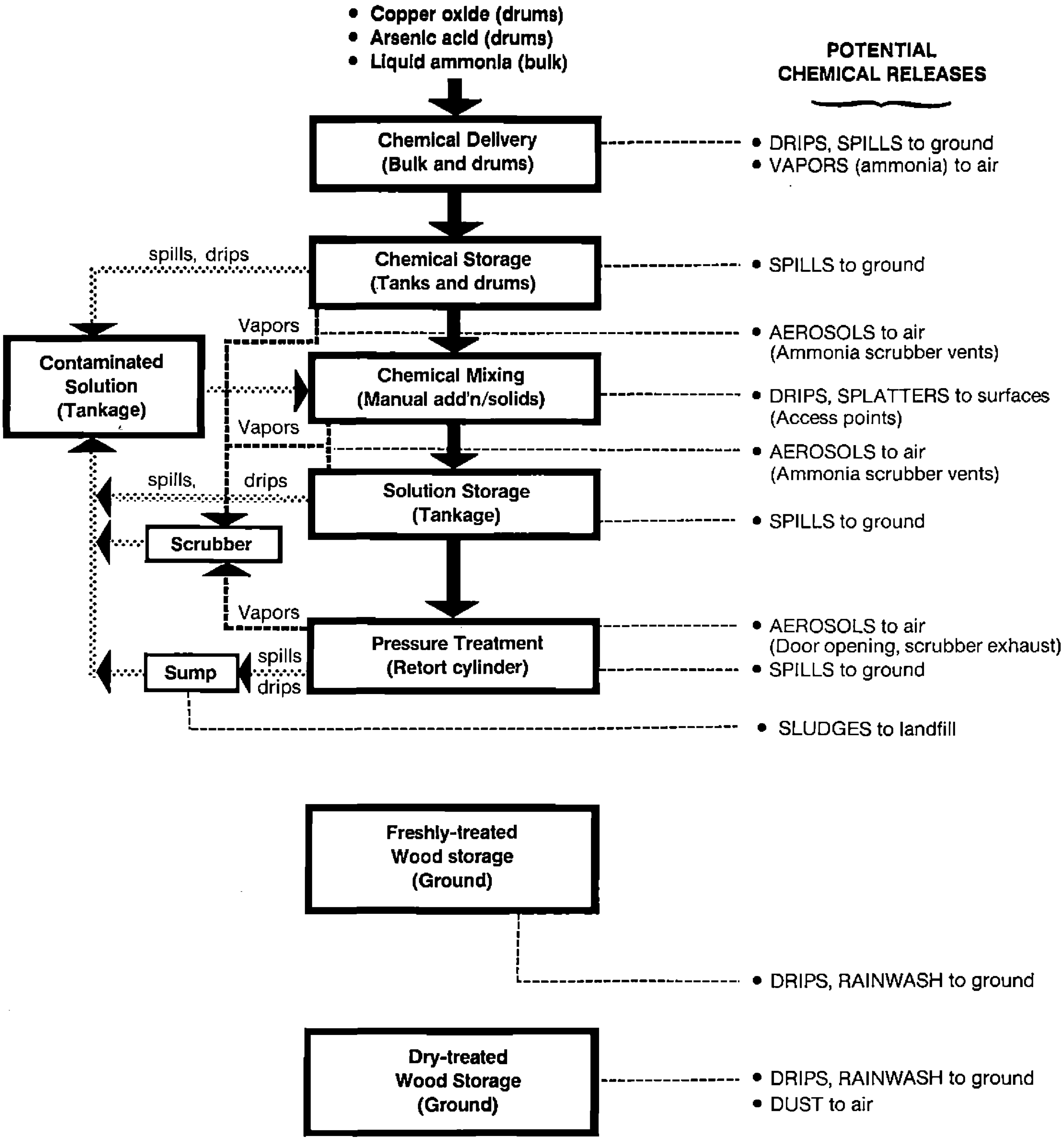

FIGURE 2.3 POTENTIAL CHEMICAL RELEASES FROM ACA PRESSURE TREATMENT PLANTS

2.2.1 Liquid Discharges. The ACA process utilizes waterborne ingredients, and can be operated as a "closed system". Dripped solution or contaminated storm runoff water can be readily reused in the process. Primary facility design features that may be used for ACA containment and recycling at well-operated facilities are illustrated in Figure 2.1. These features include:

- paved containment surfaces and dyking of major process components including the cylinder and ACA tankage;
- containment surfaces for chemical drips from treated wood on the cylinder charging track and in the freshly-treated wood storage area; and
- a collection sump to receive residual preservative from the cylinder (following the treatment cycle) and the accumulated contaminated runoff from other containment surfaces. This material can then be reused in the treatment process following filtration to remove dust and debris.

Under normal operating practices, the most common potential sources of contaminated liquid discharges from ACA facilities are stormwater runoff waters from unpaved and unroofed treated-product storage areas (7,8,9). The quantities of ammonia, copper or arsenic in these waters depend on many factors including: quantity of precipitation; fixation time and temperature prior to a precipitation event; and soil characteristics of the storage yard. Uncontained liquid releases other than stormwater, are generally confined to yard soils particularly those near locations where drip pads are not used in charging areas and where containment surfaces are not used for freshly-treated wood. These contaminated yard soils have potential for causing groundwater contamination.

2.2.2 Solid Wastes. Solid waste generation at ACA facilities is usually minimal. During normal operating conditions solid waste sources are limited to cartridge filters, which are used to remove dust and debris from recycled waters, and debris that is periodically scooped from the sump, cylinder and tanks.

2.2.3 Air Emissions. The use of aqueous ammonia implies a significant potential for ammonia emissions at ACA facilities if proper controls are not in place. Potential sources of ammonia releases include storage tank vents, freshly-treated charges, ACA mixing tank hatches and vents, vacuum pump exhausts, and vapours released when retort cylinder doors are opened. Scrubbers can be used to control ammonia releases. Potential sources of copper and arsenic emissions include mists from vacuum pump exhaust, cylinder doors and tank vents. Air emissions are generally intermittent and restricted to localized areas.

Arsenic and copper concentrations in such localized areas have been reported to be less than occupational health limits; however, ammonia emissions in the vicinity of ACA retort cylinder doors during openings and near freshly-treated wood could exceed existing occupational health limits (10).

2.2.4 Potential Effects of Chemical Releases. The actual impact of any chemical release depends on many factors including: the location of the wood preservation facility relative to ground or surface waters; the amount of preservative released; the frequency of releases; and contingency measures in place at the facility.

There have been no documented environmental or worker health effects as a result of "normal" ACA usage at wood preservation facilities. From available data, it has been shown that improperly designed and/or operated facilities do have the potential to contaminate site soils and groundwaters to levels which would prevent the use of such groundwaters for drinking (7). A small degree of contamination has been detected in storm runoff waters from treated wood storage areas with arsenic found to be the most mobile component (7, 11).

Human health effects could occur as a result of improper controls during manual preparation of ACA, exposure to minor spills and residues in working areas, and improper handling of treated products.

2.3 Chemical Management at ACA Facilities

All ACA facilities surveyed for Environment Canada purchased arsenic acid and copper oxide from J.H. Baxter of San Mateo, California. Ammonia was purchased from local sources (7,8,9).

The Environment Canada study also found that technical support for Canadian ACA facilities was solely dependent upon internal resources (7,8,9). As a result, design and operating practices were found to be highly individualized. The contractors who conducted the Environment Canada survey characterized the industry segment as highly variable in the overall control of ACA. The variability was attributed to:

Differences in design aspects:

- control of drips from freshly-treated wood,
- control of vacuum exhausts,
- containment of chemical storage and process areas,

- containment of surface washoff from dry-treated wood storage areas,
- prevention of tracking from drip pads,
- emission controls on vents containing ammonia vapours, and
- auxiliary equipment for handling of ingredient containers.

Differences in operational procedures:

- monitoring effectiveness of pollution control measures,
- worker safety precautions particularly during and after handling of ingredients,
- housekeeping requirements,
- definition of acceptable disposal practices for ACA-containing solid wastes.

The intent of this report, therefore, is to define objectives and to suggest means of achieving those objectives to ensure consistency within the industry and to minimize the potential for harmful effects to the environment and workers.

3 AMMONIACAL COPPER ARSENATE

3.1 Production and Use

Ammoniacal copper arsenate is a waterborne formulation that is prepared on-site at wood preservation facilities by mixing and oxidizing arsenic acid, copper oxide, ammonium hydroxide and water. At Canadian facilities assessed by Environment Canada, arsenic acid and copper oxide were received in drums and ammonia was delivered by bulk tank trucks (7,8,9). The drum weights of arsenic acid and copper oxide were such that operators prepared batches of ACA by mixing the contents of equal numbers of drums. The drums were labelled with the trade name "Chemonite".

ACA is first prepared as a concentrate (usually from 8 to 12% total oxide as CuO and As_2O_5). The concentrate is prepared by initially adding a known quantity of copper to a measured amount of water in a mix tank to form a slurry. Aqueous ammonia is then added to give an NH_3:CuO ratio of 1.5 to 3.5 by weight. Arsenic acid is then added below the solution surface level in order to effect immediate acid neutralization and to prevent contact of the highly corrosive arsenic acid with the body of the mix tank. Air is drawn into the mix tank by an agitator, which causes copper oxidation; copper, in its oxidized state, reacts with arsenic and ammonia to form a soluble complex. A rapid temperature rise occurs during the reaction, and mixing generally continues one hour after the maximum temperature is reached. A clear blue solution will result. A sample is then removed and submitted to analysis to assess the completeness of copper oxidation. The solution is subsequently diluted with water to form working solutions that contain 2 to 3% total oxides.

Major ACA-treated products are utility poles, construction timbers (e.g., highway timbers), fence posts and foundation timbers. The 1982-84 Environment Canada surveys (7,8,9) predicted neither upward nor downward trends for usage of ACA. Table 3.1 provides an overview of ACA usage in Canada.

3.2 Physical and Chemical Properties

Copper and arsenic, two of the components of ACA, are used because of their biocidal properties and their ability to be retained by wood for long-term protection. Ammonium hydroxide is used as a solvent carrier for copper arsenate and once the ammonia evaporates from the wood the copper arsenate precipitates in the wood cells. The resultant precipitate is highly resistant to leaching. The use of ammonia also prevents copper from corroding iron-components in the treating equipment.

TABLE 3.1 AMMONIACAL COPPER ARSENATE USAGE IN CANADA

Feature	Characteristics
Delivery format	as individual components: • Copper oxide/drums (@ 136 kg) • 75% arsenic acid liquid/drums (@ 205 kg) • 29% aqua ammonia liquid (bulk)
Suppliers to Canadian facilities	• J.H. Baxter (San Mateo, CA) (arsenic acid and copper oxide) • local suppliers (ammonia)
Estimated use quantity (1983)	Canada - data unavailable (British Columbia - 1 816 000 L as 3% solution)
Concentration of work solutions	2 to 4% as total oxides 2% solution: 20 000 ppm Ammonia 8000 ppm Cu 6700 ppm As
Typical preservative retention in treated wood	4.0 to 12.8 kg/m^3 treated wood (0.25 to 0.8 lb/ft^3)
Major products treated in Canada	utility poles, construction timbers, fence posts, foundation timbers

Tables 3.2 to 3.5 summarize the physical and chemical properties of ACA (12) and the three compounds (13,14,15) used to prepare ACA. The data indicate that a wide variety of properties must be considered for the safe management of ACA solutions and the compounds used to formulate ACA.

3.3 Environmental Effects

All wood preservation chemicals are potentially highly toxic to the environment. Both short-term (acute) and long-term (chronic) toxic effects could result from the improper use of ACA.

3.3.1 Distribution in the Natural Environment. Ammonia and the two elements, chromium and arsenic, are found naturally in the environment. Typical background levels of ACA constituents are listed in Table 3.6. Considerable variation occurs in natural concentrations of copper and arsenic in soils and waters (16,17). Since ammonia concentrations may vary both spatially and temporally (18), it is important to determine

TABLE 3.2 PHYSICAL AND CHEMICAL PROPERTIES OF ACA SOLUTION

Identification

Common Synonyms: Chemonite
ACA
Ammoniacal copper arsenate

Manufacturers: Prepared on-site from copper oxide and arsenic acid provided by J.H. Baxter and Co. (San Mateo, CA) and aqua ammonia from local suppliers.

Transportation and Storage Information

Prepared State: Treating solution prepared on-site (not transported).

Concentration: (by wt., as oxides) Concentrate, 8 to 12%
Working solution, 2 to 4%

Classification: Poisonous, corrosive liquid

Storage Temperature: Ambient

Hoses: PVC, rubber, polyethylene steel or stainless steel fittings only

Venting: Provide scrubbing to meet air discharge regulatory requirements

Containers/Materials: Plastic, steel, or steel polylined

For labels and classification:

Check with the Department of Transport

Physical and Chemical Properties

Physical State: Liquid (20°C, 1 Atm)

Density: 2% solution, 1.02
8% solution, 1.05

Vapour Pressure: (27°C) 2% solution 21 mm Hg
8% solution 72 mm Hg

Solubility: Freely soluble (water)

Floatability: Floats and mixes with water

Freezing Point: -3°C to -5°C

Flash Point: Not applicable (see ammonia)

Explosive Limits: Mixtures of ammonia in air (16-25% by volume) in an enclosed space can ignite or explode if sparked or exposed to temperatures exceeding 650°C (1200°F)

Colour: Light blue

Odour: Sharp, characteristic odor (50 ppm threshold)

pH: 2% solution 10.2
8% solution 12.0

Hazard Data

Fire

Extinguishing Data: Liquid is non-flammable. Most extinguishing agents can be used on fires involving ammonium hydroxide and arsenic acid.

Fire Behaviour: Liquid not flammable. Mixtures of ammonia and air can ignite or explode (see above). When exposed to fire, the liquid solution releases ammonia gas and arsenic fumes.

Ignition Temperature: Not flammable as liquid; ammonia is flammable at 649°C.

Burning Rate: Not applicable

Reactivity

With Water: No reaction; soluble

With Common Materials: Copper, tin, zinc alloys are readily corroded. Reacts with acrolein, acrylic acid, chlorosulphonic acid, dimethyl sulphate, halogens, hydrochloric acid, hydrofluoric acid, nitric acid, sulphuric acid, oleum, propylene oxide and silver nitrate. Avoid contact with aluminum or zinc.

Stability: Stable

TABLE 3.3 PHYSICAL AND CHEMICAL PROPERTIES OF AMMONIUM HYDROXIDE

Identification

Common Synonyms: Aqua ammonia, Ammonium hydrate, Ammonium solution, Ammonia water, Ammonia liquor

Manufacturers:
- Canadian Industries Ltd., Coutright, Ontario
- Canadian Fertilizers Ltd., Medicine Hat, Alberta
- Cominco Ltd., Carseland, Alberta
- Cyanamid Canada Ltd., Niagara Falls, Ontario
- Simplot Chemical Ltd., Brandon, Manitoba
- Western Co-op Fertilizers Ltd., Calgary, Alberta

Transportation and Storage Information

Shipping State: Liquid

Concentrations

Grade		
A:	29.4%	USP: 27 to 29%
B:	25%	CP: 28%
C:	15%	

Classification: Corrosive liquid

Storage Temperature: Ambient

Hoses: PVC, rubber, polyethylene steel or stainless steel fittings only

Venting: Provide scrubbing of vents to meet air discharge regulatory requirements

Containers/Materials: Plastic bottles, drums, tank trucks tank cars (steel or steel polylined). Use all iron or SS pumps (no copper alloys, brass or bronze).

Labels:
Check with the Department of Transport

Physical and Chemical Properties

Physical State: Liquid (20°C, 1 Atm)

Vapour Pressure:	(0°C)	(27°C)
10% ammonia	31 mm Hg	159 mm Hg
20% ammonia	88 mm Hg	310 mm Hg
30% ammonia	238 mm Hg	786 mm Hg

Solubility: Freely soluble (water)

Floatability: Floats and mixes with water

Flash Point: Flammable as ammonia

Explosive Limits: Mixtures of ammonia in air (16-25% by volume) in an enclosed space can ignite or explode if sparked or exposed to temperatures exceeding 650°C (1200°F).

Colour: Colorless

Odour: Sharp, characteristic odour (50 ppm threshold)

Vapour Density: 0.6

Specific Gravity: 0.90 (15.5°C)

Hazard Data

Fire

Extinguishing Data: Liquid is non-flammable. Most extinguishing agents can be used on fires involving ammonium hydroxide.
Fire Behaviour: Liquid not flammable. Mixtures of ammonia and air can ignite or explode (see above).

When exposed to fire, the liquid solution releases ammonia gas and arsenic fumes.

Ignition Temperature: Not flammable as liquid; ammonia is flammable at 649°C.

Burning Rate: Not flammable

Reactivity

With Water: No reaction; soluble

With Common Materials: Copper, tin, zinc alloys are readily corroded. Reacts with acrolein, acrylic acid, chlorosulphonic acid, dimethyl sulphate, halogens, hydrochloric acid, hydrofluoric acid, nitric acid, sulphuric acid, oleum, propylene oxide and silver nitrate. Avoid contact with aluminum or zinc.

Stability: Stable

TABLE 3.4 PHYSICAL AND CHEMICAL PROPERTIES OF ARSENIC ACID (75% Solution)

		Identification	
Common Synonyms:	Orthoarsenic acid	Manufacturers: ASARCO Inc., N.Y., N.Y. Supplied by J.H. Baxter and Co. (San Mateo, CA)	
		Transportation and Storage Information	
Shipping State:	Liquid concentrate	Storage Temperature: Ambient	Labels:
Concentration:	75% by weight	Venting: Liquid solution requires venting	Check with the Department of Transport
Classification:	Poisonous liquid	Containers/Materials: Plastic (poly) drums	
		Physical and Chemical Properties	
Physical State:	Liquid (20°C, 1 Atm)	Molecular Weight: 150.9 ($H_3AsO_4 \cdot 1/2H_2O$) Specific Gravity: 1.8-2.0	Colour/Appearance: Clear liquid. Yellowish brown nitrogen dioxide may be released.
Vapour Pressure:	No available information	Boiling Point: 160°C Vapour Density: No information	Odour: Odourless
Solubility:	Freely soluble (water)	Flash Point: Not flammable Explosive Limits: Not applicable	
Floatability:	Sinks and dissolves in water		
		Hazard Data	
Fire	Extinguishing Data: Liquid is non-flammable. Most extinguishing agents can be used on fires involving arsenic acid. Fire Behaviour: Liquid not flammable. At high temperatures, the liquid will volatilize, releasing toxic fumes. Ignition Temperature: Not flammable Burning Rate: Not applicable.	**Reactivity**	With Water: No reaction; soluble With Common Materials: Contact with reducing agents will liberate arsine (AsH_3), a colorless, highly toxic gas. Reacts vigorously with fluoride and chlorate. Avoid contact with aluminum or zinc. Stability: Stable

TABLE 3.5 PHYSICAL AND CHEMICAL PROPERTIES OF COPPER OXIDE

	Identification		
Common Synonyms:	Cuprous oxide	Manufacturers: Supplied by J.H. Baxter and Co. (San Mateo, CA)	
	Transportation and Storage Information		
Shipping State:	Solid	Storage Temperature: Ambient	Labels: Not regulated
Concentration:	97% by weight purity	Venting: No requirement	
Classification:	Not regulated	Containers/Materials: Steel drums	
	Physical and Chemical Properties		
Physical State:	Solid (20°C, 1 Atm)	Melting Point: 1235°C	Colour: Reddish-brown
Molecular Weight:	143	Boiling Point: 1800°C	
Specific Gravity:	5.75-6.09 (20°C)	Vapour Density: Not applicable	Odour: Odourless
Solubility:	0.02 milligrams/100 mL (water/30°C)	Vapour Pressure: Not applicable Flash Point: Not flammable	
Floatability:	Sinks in water	Explosive Limits: Not generally applicable - dust can explode under some conditions.	
	Hazard Data		
Fire	Extinguishing Data: Solid is non-flammable Fire Behaviour: Solid is not flammable Ignition Temperature: Not flammable Burning Rate: Not applicable	**Reactivity**	With Water: No reaction With Common Materials: Reacts violently with acetylene, ammonium nitrate, bromates, chlorates, iodates, chlorine, ethylene oxide, fluorine, hydrogen peroxide and hydrogen sulphide. Stability: Stable

TABLE 3.6 TYPICAL BACKGROUND LEVELS OF ACA CONSTITUENTS (17,18,19)

	Typical Concentrations in Non-polluted Environments	
Element	Surface Waters (mg/L)	Soils (mg/kg)
Copper (Cu)	<0.001 to 0.04	2 to 100
Arsenic (As)	<0.001 to 0.01	1 to 50 (up to 500 mg/kg found in sulphide deposits)
Ammonia (NH_3)	<0.1	1 to 5 ppm (as NH_4^+)

background levels immediately prior to operation of a facility, to enable meaningful future assessments of pollution control.

3.3.2 Aquatic Toxicity

Discussions on aquatic toxicity of ACA require recognition that:

- Ammonia, copper oxide and arsenic acid are individually delivered and handled at ACA facilities; therefore, the toxicity of each as well as the toxicity of the ACA mixture must be considered.
- The valences of arsenic and copper may change in the environment, and these changes may reduce or enhance the toxicities of the elements. No studies have been reported in the literature on valence interconversion of copper or arsenic in soils, groundwaters, or surface runoff waters at or from ACA facilities. Nonetheless it is known that reduced forms of copper rarely occur in aqueous environments (17). A limited study to assess arsenic speciation in samples of soils and waters in the vicinity of chromated copper arsenate (CCA) facilities showed that the samples contained at least 97% of the original pentavalent form of arsenic (20). A similar predominance of the pentavalent form is assumed at ACA facilities.

The observed chronic toxicity and acute toxicity values of ammonia, copper, arsenic and ACA (as a mixture) for salmonid species such as trout and salmon are summarized in Table 3.7. The data indicate that 15 ppm of a 3% ACA solution (i.e., a 60 000-fold dilution of the 3% work solution) would still be acutely toxic to salmonids. A spill of ACA work solution into a waterway, therefore, would have a high potential for deleterious environmental effects.

TABLE 3.7 AQUATIC TOXICITY OF AMMONIA, COPPER, ARSENIC AND ACA

Element	Concentration (mg/L)	Effect
Ammonia	0.03	- no effect concentration for salmonid growth
	0.1 to 1.4	- 96-h LC_{50}* Rainbow trout (18)
Copper (+2)	0.002	- avoidance Atlantic salmon (21)
	0.006 to 0.015	- cough-frequency increase Brook trout (21)
	0.02 to 0.89 (dependent upon water hardness)	- 96-h LC_{50}* Rainbow trout (22)
Arsenic (+5)	0.9	- early lifestage effects Fathead minnow (23)
	100	- lethal in 46 minutes Sunfish (24)
	10.8	- 96-h LC_{50}* Rainbow trout (23)
ACA 3% work solution	12.4 to 17.1	- 96-h LC_{50}* Rainbow trout (25)

* LC_{50} is defined as that concentration which results in death of 50% of the fish population within 96 hours. For ACA, the cited value denotes the quantity (mg) of 3% work solution per litre of diluted solution which will cause death of 50% of the fish population within 96 hours.

Based on extensive reviews of the literature and unpublished information, regulatory agencies have derived upper limits for many water quality parameters, including ammonia, copper, and arsenic. As of July 1987, upper limits applicable to Canadian waters include those derived under the auspices of the International Joint Commission (IJC) for Great Lakes waters (26), those derived by Health and Welfare Canada as "Canadian Drinking Water Objectives" (27), and the guidelines developed under the auspices of the Canadian Council of Resource and Environmental Ministers (19). The recommendations of the IJC are outlined in Table 3.8 and have been generally accepted by the governments of Canada and the United States for the Great Lakes. The IJC limits,

TABLE 3.8 CANADIAN LIMITS FOR ARSENIC, AMMONIA, AND COPPER

Element	IJC Recommendations Great Lakes Waters[a]	Canadian Drinking Water Objectives[b]	Canadian Water Quality Guidelines[e]
Arsenic	0.05 mg/L for the protection of human health	Maximum acceptable: 0.05 mg/L[c] Objective: <0.005 mg/L[c]	0.05 mg/L for protection of aquatic life
Ammonia	0.02 mg/L (non-ionized) for the protection of aquatic life	Maximum acceptable: 0.01 mg/L[d] Objective: <0.01 mg/L (as N)[d]	Guideline depends on pH and temperature, e.g., 2.2 mg/L at pH 6.5 to 7.5 and 10°C; 0.45 mg/L at pH 8.5 and 10°C[f]
Copper	0.005 mg/L for the protection of aquatic life	Maximum Acceptable: 1.0 mg/L[d] Objective: <1.0 mg/L[d]	For protection of aquatic life 0.002 mg/L, hardness 0 to 60 mg/L as $CaCO_3$; 0.002 mg/L, hardness 60 to 120 mg/L as $CaCO_3$; 0.004 mg/L, hardness 120 to 180 mg/L as $CaCO_3$; 0.006 mg/L, hardness >180 mg/L as $CaCO_3$.

[a] Recommendations of the International Joint Commission to the Governments of Canada and the United States, 1977. Arsenic refers to total arsenic and does not distinguish between (+3) and (+5) forms.

[b] Health and Welfare Canada. Guidelines for Canadian Drinking Water Quality, 1978. Arsenic refers to total arsenic and does not distinguish between (+3) and (+5) forms. "Maximum Acceptable" is defined as: "Drinking water that contains substances in concentrations greater than these limits is either capable of producing deleterious health effects or is aesthetically objectionable". "Objective" is defined as: "This level is interpreted as the ultimate quality goal for both health and aesthetic purposes".

[c] From H & WC, "Recommended Limits for Chemical Substances Related to Health", 1978.

[d] From H and WC, "Recommended Limits in Substances Related to Aesthetic and Other Considerations", 1978.

[e] Guidelines require consideration of local conditions (e.g., background levels) (19).

[f] Guideline is based on total ammonia concentration (non-ionized and ionized forms).

which take into consideration the background levels in the Great Lakes, are based on toxicity to freshwater organisms and human health and are intended to protect the most sensitive biological species within the Great Lakes ecosystem. In the case of arsenic, the most sensitive species is assumed to be man. The species most sensitive to copper were alevins of brook trout (toxic effects at 0.009 mg copper/L) and the amphipod, *Gammarus pseudolimnaeus* (toxic effects at 0.0046 mg copper/L). The most sensitive response of aquatic biota to ammonia reported in the literature was the retardation of growth in salmonid species (at 0.03 mg NH_3/L). This level is lower than the ammonia limit of 0.5 mg/L for protection of raw drinking water supplies.

The Canadian Council of Resource and Environmental Ministers (19) adopted the Health and Welfare Canada drinking water quality guidelines for "raw water for drinking water supply". However, the Council's guidelines for protection of "freshwater aquatic life" are based on an independent review of the literature. The preface of the Council's report emphasized "that these guidelines do not constitute values for uniform national water quality and that their use will require consideration of local conditions" (e.g., background concentrations) (19).

The guidelines and limitations for copper and arsenic noted in Table 3.5 are based on total concentrations, reflecting the recommendations of many scientific reviews which indicate that the current state of knowledge does not enable water quality limitations to be based on either valence state or dissolved fractions in water (26).

3.4 Human Health Concerns

Ammonia, copper and arsenic are found naturally in food, water, and air. Tables 3.9 to 3.11 provide estimated daily intakes by the general population (27).

One safety objective of industrial usage of any chemical (in this case ammonia, copper or arsenic) is to minimize worker exposure to the chemical, ideally so that natural intake levels are not exceeded. If safeguards are not provided or implemented, a variety of human health effects can occur depending on: the duration and manner of exposure; concentration of chemicals; chemical forms (valence); and varying metabolic sensitivities of individual workers.

On the basis of information from material safety data sheets, data compilations by regulatory agencies, and an assessment of existing literature, Tables 3.9 to 3.12 outline the possible human health effects of over-exposure to the ingredients, ammonium hydroxide, copper oxide and arsenic acid, and the formulated ammoniacal copper arsenate. Extensive reviews of the potential health effects of individual elements

TABLE 3.9 POTENTIAL HEALTH EFFECTS OF EXPOSURE TO AMMONIUM HYDROXIDE

		Possible Health Effects	
Exposure Category	Type of Exposure	Short-term Exposure	Long-term Exposure
General population	Estimated daily intake of ammonium from food, air, water,		
	Food: 571 mg (27)	None	None
	Water: 0.4 mg (27)	None	None
	Air: 0.46 mg (27)	None	None
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin or eye contact	Skin or eye contact with 28% solutions Eye contact is very dangerous - cornea can be perforated (29)	• Skin irritation • Contact of several minutes can cause corrosive damage (28)	Not applicable
Exposure to contaminated aerosols	Inhalation of vapours	• Severe irritation to nose and throat at 400 ppm (30) • Irritation to eyes at 700 ppm (30)	• No serious effects for exposures of less than one hour
		• Convulsive coughing at 1720 ppm (30)	• May be fatal after 0.5-hour exposure
		• Respiratory spasm and asphyxia at 5000 to 10 000 ppm (30)	• Rapidly fatal for exposure causing these symptoms
Ingestion	Ingestion of work solutions or concentrates	• Nausea, abdominal pain, vomiting, shock, coma • Death may occur from ingestion of more than 30 mL (1 ounce) of 25% solution (28)	Not applicable

TABLE 3.10 POTENTIAL HEALTH EFFECTS OF EXPOSURE TO COPPER OXIDE (10,27,28)

		Possible Health Effects	
Exposure Category	Type of Exposure	Short-term Exposure	Long-term Exposure
General population	(estimated daily intake from food, air, water)		
	3 mg	None	None (copper is an essential element)
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin contact	Repeated or prolonged skin contact	None	None
Exposure to contaminated aerosols or dusts	Repeated or prolonged inhalation of mists, droplets or aerosols	Irritation of the nose and upper respiratory tract	Perforation of nasal septum
Ingestion	Oral LD_{50} (rat) >5 g/kg of body weight (31) This suggests a fatal oral dose for humans is greater than 350 g	Metallic taste, Nausea, Gastrointestinal problems	Possible kidney damage, jaundice

TABLE 3.11 POTENTIAL HEALTH EFFECTS OF EXPOSURE TO ARSENIC ACID (10,16,27,28)

		Possible Health Effects	
Exposure Category	Type of Exposure	Short-term Exposure	Long-term Exposure
General population	(estimated daily intake from food, air, water)		
Arsenic (in foods especially seafoods)	0.11 mg	None	None
Properly protected worker	Minimal	None	None
Exposed worker with significant skin contact	Repeated or prolonged skin contact	Skin inflammation, redness, pain, burns	Dermatitis, increased pigmentation, skin eruptions. Possibly cancer (32,33)
Significant exposure to contaminated aerosols or dusts	Repeated or prolonged inhalation of mists, droplets or aerosols	Sore throat, coughing, vomiting, weakness, thirst	Potential carcinogenic action (16,33,34)
Ingestion	Ingestion of solution containing > 130 mg of arsenic	Weakness, nausea, abdominal pain, vomiting, diarrhea, death*	Potential carcinogenic action (16,33,34)

* Historical information reports death from doses of 0.1 to 1 g arsenic (16,28,35)

TABLE 3.12 POTENTIAL HEALTH EFFECTS OF EXPOSURE TO ACA SOLUTIONS

		Possible Health Effects	
Exposure Category	Type of Exposure	Short-term Exposure	Long-term Exposure
Properly protected worker	Minimal	None reported	None reported
Exposed worker with significant skin contact	Skin contact with work solutions or concentrates	• Skin irritation • Inflammation	Potential carcinogenic action (16, 32, 34)
Exposure to contaminated aerosols	Inhalation of mists, droplets or aerosols of work solutions or concentrates	• Severe irritation to nose and throat • Irritation to eyes	Potential carcinogenic action (16, 33, 34)
Ingestion	Ingestion of work solutions or concentrates	• Nausea, abdominal pain, vomiting, shock, coma • Death may occur if the absorbed amount of solution contains more than 130 mg arsenic or ammonia equivalent to 30 mL of 25% solution • Animal tests have indicated that the LD_{50} of 8% ACA concentrate is 1000 to 1500 mg/kg body weight (12).	• Possible liver and kidney damage, jaundice, reduced white blood cells upon long-term exposure to 0.15-0.6 mg arsenic per day (16) • Potential carcinogenic action (16, 33, 34)

and ammonia are provided in documents by the National Research Council of Canada (16, 17), the World Health Organization (34), and the International Labor Organization (29). The interpretations provided in these reviews are summarized briefly in Table 3.13.

Although epidemiology studies were not found, the results of the few reported health studies of ACA workers showed that air concentrations of arsenic and copper were well within the regulated guidelines (10) and that arsenic and copper levels in urine were not excessive (36). Air samples showed high concentrations of ammonia during cylinder door openings and downwind of freshly-treated loads. Ammonia fumes are "obnoxious" at very low concentrations; therefore, workers routinely avoid exposure to ACA mists. An identified significant source of potential exposure is through skin contact resulting from poor work practices such as handling freshly-treated wood without the use of impermeable gloves (10). There have been no reports of occupational illness from normal handling of ACA-solutions and ACA-treated products.

The data in Tables 3.9 to 3.13 suggest a potential for the constituent chemicals of ACA to cause adverse effects on human health, particularly at sites where

TABLE 3.13 SUMMARY OF POTENTIAL HEALTH EFFECTS OF OVER-EXPOSURE TO AMMONIA, COPPER OR ARSENIC

<table>
<tr><th>Element</th><th>Effect</th></tr>
<tr><td>**Ammonia**</td><td>Liquid ammonium hydroxide is used at ACA facilities (Ammonia is present as liquids and vapours)
• Ammonia is formed in nature by:
- chemical and biochemical transformation of nitrogenous organic and inorganic matter in soil and water;
- nitrogen fixation of dissolved nitrogen gas in water; and
- ammonia excretion by biota.
Ammonia is also commonly discharged in effluents from urban, industrial and agricultural activities.
• The odour of ammonia vapours can be detected by humans at concentrations as low as 1 ppm. The maximum acceptable range of ammonia concentrations has been reported to be 20 to 25 ppm (33).
• Ammonia and ammonium hydroxide damage cells by direct alkaline caustic action, and cause extremely painful irritation of all mucous membranes (29).
• Industrial poisoning is usually acute; chronic poisoning is possible, but less common. The irritant effect is especially felt in the upper respiratory tract; high concentrations can affect the central nervous system, causing spasms (29).
• Skin contact with liquid aqua ammonia is dangerous; severe burns can result from short duration contact. Eye contact can lead to perforation of the cornea and/or loss of the eyeball (32).
• The oral LD$_{50}$ (rats) is 350 mg aqua ammonia/kg body weight.
• The potential effects of ammonia vapours on an unprotected worker are summarized below:
<table>
<tr><th>Gaseous Concentration (ppm)</th><th>Potential Effects on an Unprotected Worker</th></tr>
<tr><td>1</td><td>Threshold of detectable odour</td></tr>
<tr><td>20 to 25</td><td>No adverse effects for the average, unprotected person.</td></tr>
<tr><td>400</td><td>Throat irritation.</td></tr>
<tr><td>700</td><td>Irritation of the eyes.</td></tr>
<tr><td>1720</td><td>Convulsive coughing.</td></tr>
<tr><td>5000</td><td>The lowest published lethal concentration for humans.</td></tr>
</table>
</td></tr>
<tr><td>**Copper (29)**</td><td>The form of copper used at CCA facilities is Cu^{+2}.
• Copper is a natural element and is present in the bivalent form in most living organisms.
• Except in instances of ingestion of relatively large amounts or massive over-exposure, most of the world's population is essentially immune to poisoning by copper. However, about 1 of 200 000 individuals inherit a pair of abnormal genes and will ultimately develop Wilson's disease (copper toxicosis). The disease develops slowly with the ingestion of copper at normal levels of dietary intake, and develops more rapidly if industrial exposure to copper occurs. The disease can be fatal if not treated.
• The ingestion of large (gram) quantities of copper solution may result in nausea, vomiting and death. Skin irritations are rare. Inhalation of dusts and mists of copper salts can cause congestion of the nasal and mucous membranes and ulceration and perforation of the nasal septum.</td></tr>
<tr><td>**Arsenic (28,31)**</td><td>The form of arsenic used at ACA facilities is As^{+5}.
• Arsenic is a natural, low-level constituent of most human tissues. There is no general agreement on what levels reflect normal or excessive exposure to arsenic. One study of background arsenic levels in urine showed concentrations from 5 to 365 μg/L (32). WHO reported that 95% of arsenic in urine background levels would be <80 μg/L. (Consumption of fish or other marine organisms (containing non-toxic organic arsenic compounds) prior to testing may erroneously reflect on actual industrial exposure.)
• There is much disagreement in interpretation of biological studies on arsenic poisoning. Many studies did not distinguish the chemical form of arsenic. Also, bioassay results with laboratory animals cannot be readily extrapolated to predict effects on humans.
• Although the literature generally states that trivalent arsenicals are more toxic to humans than pentavalent arsenicals, and inorganic forms are more toxic than organic, the toxicity database for As^{+5} is poor. The U.S. EPA has taken the position that an adequate database demonstrates the in vivo reduction of arsenate to arsenite. Accordingly, the interconversion justifies the regulation of both chemicals together (i.e., as one entity) rather than as arsenate (As^{+5}) and arsenite (As^{+3}) separately.
• Chronic arsenic intoxication produces:
- nervous disorders,
- respiratory distress,
- skin changes,
- heart and occlusive arterial disease, and
- liver cirrhosis and cancer.
Chronic intoxication may result from an extended period of daily ingestion of 22 to 63 μg As/day.
• The lowest range of As concentrations in air associated with increased cancer is 0.1 to 150 μg/m^3 (16).
• The International Labour Organization recommends that employees exposed to arsenic in their work should not include: those with diabetes, cardiovascular diseases, allergic or other skin diseases, neurological disorders, or hepatic or renal lesions (29).
• There is sufficient evidence that inorganic arsenic compounds are carcinogenic in humans (16). However, the occupations in which cancer was associated with arsenic exposure involved the manufacture and use of arsenicals other than ACA.</td></tr>
</table>

excessive exposure may occur. Various investigators have suggested that the following protective measures be ensured within the industry:

- use of clean and undamaged impervious gloves when handling ACA-solutions and freshly-treated ACA products, to reduce potential for dermal exposure (10);
- adequate worker education, and good safety practices at all sites (7,8);
- proper eye, skin and respiratory protection (7,10);
- biological monitoring for arsenic levels as an index of occupational exposure and for evaluating the effectiveness of measures for reducing exposure (33);
- exemplary precautions during formulation of ACA (10).

Options for biological monitoring include analyses of urine or analysis of hair (see Section 4.3). An analytical method is available for differentiating inorganic from organic arsenic in human urine (37).

4 PERSONNEL PROTECTION

4.1 Precautions and First Aid

The potential hazards of exposure to ammonia, arsenic acid, copper oxide or ACA solutions include immediate and long-term toxic effects of ingestion, skin contact, eye contact, and inhalation (Tables 3.9 to 3.13). These potential hazards can be adequately controlled by proper protective measures.

When exposure to a chemical occurs the severity and speed of damage to human health depends on the concentration. Both factors are highest with concentrated solutions and diminish as solutions are diluted. The general rule is: High concentration requires the highest level of protection. Immediate response is required if a worker is exposed to aqua ammonia, arsenic acid, or ACA concentrate or work solutions. If in doubt, play it safe and respond as if exposure is to a concentrated solution. First-aid procedures for chemicals used at ACA facilities are described in Tables 4.1 to 4.3. It is recommended that first-aid procedures for ammonia exposure be followed in case of exposure to ACA solutions.

Specific objectives for an overall worker protection program in an ACA wood preservation facility are outlined in Table 4.4. Means to achieve the objectives are presented in the table; however, the recommendations may not be the sole options available to attain the objectives. Alternative approaches may be equally effective or more suitable in view of site-specific conditions. When programs are developed for a particular facility, the recommendations may be modified if it can be demonstrated that an alternative approach, more suitable to plant-specific conditions, would be equally effective in attaining the desired objective.

4.2 Regulatory Controls

Provincial regulatory limits for worker protection are found in the Appendix. Most regulatory criteria established by worker protection agencies are based on the Threshold Limit Values (TLVs) and Biological Exposure Indices recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH recommended limits for ammonia, copper and arsenic are summarized in Table 4.5 (38). ACGIH comments with respect to worker exposure to ammonia, copper, and arsenic follow.

Skin and eye contact: The ACGIH does not provide a recommended limit for ammoniacal copper arsenate, as such. For skin and eye contact with individual components of ACA, the ACGIH provides the following comments (33, 38):

- A TLV of 25 ppm ammonia has been selected to protect against irritation to eyes and the respiratory tract and to minimize discomfort among uninured (unaccustomed) workers. A short-term exposure limit of 35 ppm is suggested.
- Copper salts act as irritants and can produce itchy eczema on skin, and conjunctivitis or ulceration on the eye. However, a TLV for copper salts is based on inhalation.
- Adequate skin and eye protection is required during the handling of all acids, including arsenic acid. ACGIH recommended limits for arsenic acid are based on "inhalation" TLV.

In cases where ACGIH recommended limits (e.g., copper and arsenic) are based only upon "inhalation" as the route of exposure, these limits may not adequately take into account other routes of exposure. The ACGIH has suggested that in such cases "biological exposure indices may be useful as a guide to safe exposure" (38).

Inhalation: The ACGIH has defined TLVs for many substances based on exposure by inhalation and/or by skin exposure. The ACGIH limits for copper and arsenic are based solely on exposure by inhalation. The TLVs are stipulated by the ACGIH as those "airborne concentrations of substances to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effects". The TLVs for ammonia, copper, and arsenic (38) are defined in Table 4.5 with the following provisions from the ACGIH:

- "the limits are intended for use in the practice of industrial hygiene as guidelines for good practices or recommendations in the control of potential health hazards and for no other use" (i.e., proof or disproof of the cause of an existing disease or physical condition).
- "the limits are not fine lines between safe and dangerous concentration".
- "in spite of the fact that serious injury is not believed likely as a result of exposure to the Threshold Limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical."

- "when two or more hazardous substances, which act upon the same organ system, are present, their combined effect, rather than that of either individually, should be given primary consideration."

Since ACA wood preservation facilities exclusively use ACA-waterborne solutions, the limits defined by the ACGIH would apply primarily to ammonia vapours, suspended aerosols, dusts, or to gases generated during welding. Aerosols are not usually generated at ACA facilities in quantities that would cause worker health problems. Incidents of aerosol exposure would be more probable at improperly maintained facilities (e.g., from leaking seals) or at inadequately designed facilities (e.g., from vacuum pump discharges to work area). Dust generation is most probable during cleaning operations; the International Labour Organization strongly suggests the use of wet or vacuum methods for cleaning up many chemical spills, to prevent dispersion as airborne dust.

Ingestion: Oral intake of ACA must be avoided. Ingestion of ACA-containing liquids is unlikely if workers follow the safety precautions outlined in Table 4.4. Upper limits of ingestion are not prescribed by regulation since it is generally expected that no such intake will occur. Reported fatal single dose levels for components of ACA, include:

- 30 mL of 25% ammonia solution (28); and
- 1.5 to 3.5 g Cu as Cu(+1) (39).

No oral toxicity values for As(+5) to man are defined. Reported fatal doses for "arsenic" and "arsenic (+3)" have ranged from 20 to 300 mg (16, 28). The Registry of Toxic Effects (39) suggests that As(+5) is more toxic to rats than As(+3); however, it is known that laboratory animals react to arsenic differently than do humans. The lethal toxicity to man of As(+5) as used in ACA, therefore, remains unknown.

The effect of ingested ACA upon an individual depends on many factors, such as body weight and initial health of the individual. Toxicology studies have indicated lethal doses of 1000 to 1500 mg ACA (8% concentrate) per kilogram of body weight in test animals (12). Assuming similar human sensitivity to ACA, ingestion of approximately 70 to 100 g of ACA concentrate would be lethal. However, calculations based solely on arsenic concentrations suggest that lethal human doses of ACA could be 10 times less (e.g., 5 g).

4.3 Biological Monitoring of Exposed Workers

Routine biological monitoring of workers exposed to ACA can be achieved by various means including:

- determination of arsenic levels in urine (32); and
- elemental analysis of hair for arsenic, and copper concentrations (35, 40)

It is important that any biological monitoring program be carried out and interpreted by qualified occupational hygienists or physicians. If there is concern regarding confidentiality and/or sample handling procedures, it is suggested that these concerns be addressed and resolved by a joint management-worker committee.

TABLE 4.1 FIRST AID FOR EXPOSURE TO AMMONIACAL COPPER ARSENATE OR AMMONIUM HYDROXIDE

Exposure	First Action	Second Action
Eye Contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Get medical attention.
Skin Contact	• Flush contaminated area immediately by use of flowing water. • Subsequently remove soaked clothing or articles in contact with the skin. • Continue to flush contaminated skin for at leat 15 minutes.	• Get prompt medical attention if the skin becomes inflamed (redness, itch or pain).
Inhalation	• Immediately remove the exposed person to fresh air (coughing and sneezing occurs almost immediately after excessive inhalation of ammonia fumes).	• Apply artificial respiration if breathing has stopped. (Do not use mouth to mouth method.) • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• Promptly drink a large quantity of salt solution or lime water. Never give liquids to an unconscious person.	• Call an industrial physician or the Poison Control Centre immediately for subsequent advice.* (Stomach pumping by medical personnel is desirable.)

* First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

TABLE 4.2 FIRST AID FOR ARSENIC ACID EXPOSURE

Exposure	First Action	Second Action
Eye Contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin Contact	• Flush contaminated area immediately by use of flowing water. • Subsequently remove soaked clothing or articles in contact with the skin. • Continue to flush contaminated skin for at least 15 minutes.	• Get prompt medical attention if the skin becomes inflamed (redness, blisters, itch or pain).
Inhalation	• Immediately remove the exposed person to fresh air.	• Apply artifical respiration if breathing has stopped. • Keep the affected person warm and quiet. • Get immediate medical attention.
Ingestion	• Promptly drink a large quantity of saltwater solution (one tablespoon of salt per glass of warm water). Induce vomiting until the vomit fluid is clear (13).** Never give liquids to an unconscious person. • After the vomit fluid is clear, drink two tablespoons of epsom salt or milk of magnesia in water, followed by plenty of milk or water.	• Call an industrial physician or the Poison Control Centre immediately for subsequent advice.* (Stomach pumping by medical personnel is desirable.)

* Inhalation effects are more probable if arsenic acid contacts active metals such as zinc; the subsequent reaction can produce toxic arsine gas.

** First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

TABLE 4.3 FIRST AID FOR COPPER OXIDE EXPOSURE

Exposure	First Action	Second Action
Eye Contact	• Immediately flush eyes with flowing water, occasionally lifting the upper and lower lids. • Flush eyes for at least 15 minutes.	• Use boric acid solution and cortisone ophthalmic drops. • Get medical attention.
Skin Contact	• Thoroughly wash the contaminated skin.	• Get prompt medical attention if the skin becomes inflamed.
Inhalation	• Immediately remove the exposed person to fresh air (coughing and sneezing occurs almost immediately after excessive inhalation of copper dust).	• Get immediate medical attention.
Ingestion	• Ingestion of copper is highly improbable. If ingestion does occur drink large quantities of water and induce vomiting. Never give liquids to an unconscious person.	• Call an industrial physician or the Poison Control Centre immediately for subsequent advice.*
Chronic Symptoms Requiring Medical Referral	• Ulceration of the skin or mucous membrane (breaks in the skin, disintegration of tissue, pus formation). • Abdominal pains and other persistent symptoms of illness.	

* First aid personnel should periodically verify up-to-date response measures with chemical suppliers and/or industrial physicians.

TABLE 4.4 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH AMMONIACAL COPPER ARSENATE SOLUTIONS

General Precautions	
Objective	Recommendations
Assure that workers are familiar with all aspects of ACA usage	• Provide documentation and training to educate workers about the chemical properties, hazards of exposure, and emergency procedures associated with ACA use. • Implement preventative measures to minimize ingestion, inhalation, and skin or eye contact with ACA solutions and their ingredient chemicals.
Assure that first aid can be applied when required	• Install and regularly check emergency eyewashes and showers. • Provide all required first aid equipment for responses as indicated in Table 4.1 to 4.3. • Ensure that first aid is always available by qualified (trained) personnel. (Trained personnel may include supervisors and managers) • Ensure familarity of first aid personnel with updated emergency procedures. • Identify medical contacts who are readily available during all working hours.
Personal Hygiene	
Encourage personal hygiene practices which minimize potential exposure to ACA and/or ingredient chemicals	• Do not carry, store or consume food or drink in working areas. (e.g., areas where ACA solutions are stored or used, or where freshly treated wood is stored). • Do not carry or smoke cigarettes in working areas. • Wash hands thoroughly before leaving working areas and before eating, drinking, smoking, or using the toilet facilities. • Do not expose cuts or abrasions to ACA solutions or ingredient chemicals. • Change contaminated clothing immediately if splashed with ACA solutions. Change clothing daily if any incidental contact with the treatment chemical. Wash contaminated clothing separately from other clothing. • Wear impermeable footwear in all working areas.

TABLE 4.4 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH AMMONIACAL COPPER ARSENATE SOLUTIONS (cont'd)

Specific Precautions During ACA Treatment

Objective: To outline safe workplace practices for each activity during the treatment process.

Activity	Recommendations
Unloading bulk ammonium hydroxide	• Wear protective apparel including face shields, impermeable gauntlets, coveralls, impermeable aprons, and impermeable shoes or boots. • Prohibit foot or vehicle traffic between the point of delivery and the transport vehicle. • Place "DANGER-AMMONIA UNLOADING" signs at each end of the transport vehicle during unloading operations. • Ensure that at least two individuals trained in handling ammonia are present at all times during unloading operations (i.e., at least one person other than the truck driver and may include foremen, supervisors, and management employees). • Ensure that all connections are secure and leak tight. • Provide an emergency eyewash and shower in the unloading area.
Unloading drums of arsenic acid and copper oxide	• For arsenic acid, provide chemical goggles, impermeable gauntlets, full length impermeable aprons/suit. Provide canister-type full-face masks for spill response. • Prohibit foot or vehicle traffic in the delivery area. • Provide adequate equipment for safe, controlled drum handling. • Do not drop drums.
Preparing ACA work solutions	• Wear full face protection mask with ammonia canister, impermeable gauntlets, coveralls, impermeable aprons, and impermeable shoes or boots for all operations involving direct exposure to ACA solutions and chemical ingredients. • Thoroughly clean and hose down the work area following solution preparation. • Dispose of debris and empty containers according to Table 8.1. • Thoroughly clean protective equipment after use. (Reuse all rinse waters for work solution preparation.) • Provide an emergency eyewash and shower in the immediate area.
Sampling Procedures	• Wear eye protection and impermeable gloves when sampling ACA solutions (including full face mask with ammonia canister). • Wear impermeable gauntlets when taking borings from freshly-treated wood. • Wash gauntlets, and goggles immediately after completing sampling. • Wash the outside of sample containers immediately after sampling solutions. • Wash hands thoroughly after all sampling operations.

TABLE 4.4 SAFETY PRECAUTIONS FOR PERSONNEL WORKING WITH AMMONIACAL COPPER ARSENATE SOLUTIONS (cont'd)

Specific Precautions During ACA Treatment (cont'd)

Objective: To outline definitive workplace practices for each activity during the treatment process.

Activity	Recommendations
Cleaning treating cylinders or bulk storage tanks	• Follow all standard precautions for vessel entry (as per provincial health and safety regulations). • Flush vessels as required to establish safe entry conditions, or use an approved self-contained breathing apparatus prior to entry. • Wear NIOSH approved respirators (or breathing apparatus as above), impermeable gauntlets and aprons (rubber or polyethylene coated) and rubber boots during all vessel entries. Select respirators in consultation with ACA suppliers or provincial work safety agency. • Always have a standby attendant present and provisions for continuous outside communication. • Collect and store contaminated waste material in sealed and labeled drums. • Wash all protective equipment immediately after use (reuse all rinse waters for preparing treating solutions). • Shower after completion of clean up tasks.
Removing treated charges from cylinders	• Wear gauntlets during door openings and when moving loads of freshly-treated wood. • Avoid breathing preservative mists. Wear an approved respirator if airborne concentrations are unknown or, at or above TLVs*.
Handling treated lumber	• Wear impermeable** gloves. • Wear impermeable** gloves, apron and boots if there is potential for getting wet by ACA solution.
Handling and maintaining contaminated equipment	• Thoroughly flush equipment with water prior to handling. (Reuse rinse waters for preparing work solutions.) • Wear an impermeable** apron and boots if there is potential for getting wet by ACA solution.
Welding	Welding can produce toxic fumes. In addition to the precautions for handling and maintaining contaminated equipment: • Obtain the specific approval of the plant supervisor before welding. • Block or disconnect lines from tanks before welding. • Completely drain and thoroughly rinse tanks or lines prior to welding operations. • Ensure that equipment is completely dry from cleaning solvent residues. • Wear a respirator or provide effective, local exhaust ventilation during welding to prevent potential exposure to toxic fumes. • Assure good general ventilation of the work area. • Comply with all provincial workplace safety requirements (Appendix).

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* An initial workplace monitoring program as suggested in Table 8.3 will have determined the need for respirator use. The results of the program are assumed to be indicative of conditions in subsequent facility operations, unless procedural or design changes have occurred.

** Heavy-duty, lined polyvinyl chloride, vinyl coated neoprene, NBR, or rubber (13).

TABLE 4.5 LEVELS OF CONCERN FOR AMMONIACAL COPPER ARSENATE EXPOSURE IN THE WORKPLACE

Route of Entry	Basis for Recommendation	Recommendations/Comment
Skin and eye contact	• ACA and ammonia are corrosive • Arsenic is a potential skin carcinogen	• Protective measures should be used by for workers in contact with ACA concentrate (Table 4.2). • Avoid direct contact of skin and eyes with all ACA solutions and ingredients (10). • Sensitive individuals (see Table 3.7) should take special care to avoid exposure. Comment: Current material safety data sheets should always be readily available to workers.
Inhalation	ACGIH Threshold Limit Value Time Weighted Averages (TWA): Arsenic* and soluble compounds: 0.5 mg As/m^3 air Copper (dusts and mists): 1.0 mg/m^3 air Ammonia: 18 mg/m^3 air (25 ppm) Arsine: 0.2 mg/m^3 air (0.05 ppm) * U.S. OSHA has set a limit of 0.01 mg As/m^3 of air	• Full face protection and good ventilation should be used during chemical unloading and open mixing operations. • Provide respiratory protection, eye protection and good ventilation: - during ammonium unloading and mixing operation and when removing charges; - when welding contaminated equipment; - during any activity which might generate arsine vapours (e.g., from exposure of ACA reducing agents); and - when ACA mist or spray is present. • Self-contained breathing apparatus should be used for fire-fighting activities where ACA is present. Comments: - permissible concentrations of arsenic refers to vapours: arsenic could be present in aerosols or dusts; - arsine gas can be formed from exposure of arsenic salts or ACA to reducing agents; and - current material safety data sheets describing safety precautions should always be readily available to workers.
Ingestion	The literature reports an arsenic lethal dose range of 0.1 to 1 g for adults. The lowest reported lethal dose (28) is equivalent to 6 to 7 g of 5% ACA solution.	• Prevent the ingestion of any quantity of ACA or of any ingredients of ACA.

5 SITE SELECTION

5.1 Purpose

Preliminary assessment of an industrial site involves both an evaluation of technical site characteristics (i.e., hydrogeology, topography and soils) and socio-geographic factors (i.e., land use and availability, and proximity to transportation routes). Technical features that should be considered during site selection for an ACA wood preservation facility for the purposes of environmental protection are highlighted in this section. It is recognized that, in most cases, certain site characteristics may have constraining technical features. Early recognition of less desirable site features will enable the development of a compensating facility design and subsequently facilitate site approval.

Criteria for site assessment discussed in this section may also indicate the aspects of existing treatment plant facilities that need to be modified or changed to assure protection of human health and the environment.

5.2 Assessment Factors

Use of ACA treatment chemicals at a plant site introduces the potential for contamination of groundwaters and surface waters. The extent of potential contamination is, in turn, dependent on the chemical, physical and biological properties of the treatment chemical, plant design and operating practices as well as site-specific characteristics including: soil type, geology, hydrology, climate, topography and drainage.

Site characteristics and how they can affect the eventual impact of chemical releases are described in this section. These factors are important in designing the features of a treatment plant that will:

- minimize the possibility of off-site contamination via groundwater and surface waters; and
- minimize chronic on-site contamination to protect worker health during operation and to make decommissioning efforts easier in the event of partial or complete facility closure.

The assessment factors for a preliminary site evaluation rely upon readily available information. Table 5.1 lists the site features that must be considered in an environmental impact assessment.

TABLE 5.1 SITE FEATURES AFFECTING THE DESIGN OF AN ACA PRESSURE TREATMENT FACILITY

	Suggested Degree of Mitigating Design/Operational Measures	
Site Features	Slight	Severe
Soil Texture	loam, silt loam, silty clay loam, clay loam, sandy loam	gravel
Permeability (cm/hour)	<0.5	>50
Topography (% slope)	0 to 9	>30
Soil Depth to Bedrock (cm)	>200	<60
Depth to Groundwater (cm)	>200	<60
Flooding	None	Frequent (>once/20 year)
Drainage	Slow	Very rapid
Distance to surface waterbody (lake or river)	Depends on interaction with other site features (e.g., permeability of soil)	Directly adjacent

5.2.1 Regional Geology. Geologic information about many areas of Canada may be obtained from federal and provincial surveys. Information that should be obtained includes:

- Texture of unconsolidated material - Fine-grained material is more likely to retain chemical contaminants than coarse material.
- Depth to bedrock - Shallow soils imply a limited ability to retain spilled chemicals.
- Aquifer recharge and discharge zones - Potential for hydraulic connections to regional groundwater flow patterns and discharge to sensitive surface waterbodies should be considered.
- Discontinuities such as faults, fissures, joints, fractures - Discontinuities may cause "short-circuiting" of a contaminant plume.

5.2.2 **Soils.** Soil properties should be assessed to evaluate the potential for leaching and retention of treatment chemical constituents. Physical and chemical characteristics of soil to consider are: depth, permeability, texture, water-holding capacity, shrink-swell potential, chemical properties such as cation exchange capacity (CEC), and anion exchange capacity (AEC). Soil depth and soil types are routinely indicated on soil maps (and often on geology maps). Although the available maps may not indicate the exact soil composition of a small site (e.g., 2 ha), they can be used for preliminary assessment purposes.

In addition to the soil evaluation parameters described, the evaluation should consider that soils with high anion exchange capacities, high levels of iron and aluminum oxides, and/or high levels of calcium compounds will enhance the retention of arsenate anions. High cation exchange capacity, high clay content, and high organic matter content will enhance the retention of the copper cation and ammonia.

5.2.3 **Geotechnical Description.** Subsurface hydrogeology can be inferred from regional geologic and soil technical published maps and reports. This information is adequate at the preliminary site assessment stage. Site-specific hydrologic data will be required if one or more of the following conditions is identified during preconstruction assessment:

a) the site is located over a shallow unconfined aquifer;
b) the site is located over an aquifer used for a potable or irrigation water supply;
c) the aquifer has hydrologic connections with other aquifers in the area and/or regional groundwater flow patterns.

The type and specificity of additional information required will have to be defined in consultation with the appropriate regulatory agency.

5.2.4 **Topography.** Topographical information is easily obtained from published government maps. In general, steep sites should be avoided due to runoff problems and erosion; however, topography can be modified by facility design. Slope gradients between 1 to 10% should present few problems. Upland flat and terraced landforms are desirable locations for treatment facilities. Floodplains are acceptable if they lie above the 100-year flood level, otherwise special design provisions must be implemented.

5.2.5 **Climate.** Climatic variables such as precipitation (form, historical 1-hour and 24-hour maxima, and annual total amount), temperature regime and wind patterns influence both chemical loss during storage of treated wood and leaching in the subsurface. Information for such variables is generally available from Environment Canada. However, definitive criteria are difficult to evaluate for rating climatic influences. Precipitation is an indicator for leaching potential in soils, but this parameter can also be alleviated by selection of sites with soils of low permeability.

5.2.6 Proximity to Sensitive Uses. Sites located adjacent to waterbodies (e.g., lakes, rivers, marine waters) or above aquifers used for drinking or irrigation water supplies, food manufacturing plants and beverage processing plants, should be cautiously considered for use by the wood preservation industry. If such a site is selected, then exceptional design requirements and operational and monitoring procedures will be required. Desireable minimal distances of ACA facilities from sensitive waterbodies depend on factors such as: soil type, regional geology, topography and climate. If a selected site is adjacent to waterbodies used by migratory fish, then the intended plans will have to be reviewed by Environment Canada, and Fisheries and Oceans Canada. Local zoning generally attempts to separate industrial use areas from residential areas. As a result, awareness of zoning designation generally precedes site selection.

5.3 Site Selection Procedures

Following a compilation of data for various potential sites, the developer is then faced with a decision-making process for site selection. Site selection on the basis of environmental protection will also depend on economic evaluations. Based solely on economic factors, a less environmentally acceptable site might be most desirable. However, additional design and operational considerations to accommodate those less acceptable environmental features must be added to the cost of locating a wood preservation facility at the site.

All factors previously described should be considered in the assessment. Various techniques may be used for the selection of sites of the basis of environmental acceptability, (e.g., criteria ranking, matrices, decision trees, or mathematical modelling). Assessment techniques among regulatory agencies may vary considerably, necessitating consultation with local and provincial regulatory agencies as well as federal agencies if required.

Examples of site characteristics requiring very little environmental mitigation as well as those requiring significant environmental mitigation are listed in Table 5.1. Deviations from the most desirable characteristics suggest various degrees of mitigating design/operational measures.

- Slight mitigating design/operational measures are necessary for those site features that are well suited to the location of a treatment facility. The site will require only low cost maintenance and monitoring to assure environmental protection.
- Moderate mitigating design/operational measures present more of a problem, but in general sites requiring such measures are acceptable.
- Severe mitigating design/operational measures such as special innovative designs may partially overcome the constraints of a marginally suitable site. Design costs are likely to be high. Extensive monitoring efforts will be required adding to the cost of locating a treatment facility at such a site.
- "Very severe" mitigating/operational measures pose such a threat to environmental protection that the site may be economically impractical.

The range of site features shown in Table 5.1 were selected on the basis of siting criteria suggested by various investigators (41, 42).

6 DESIGN

Approaches for the design and operation of ACA wood preservation facilities for protection of workers and the environment from harmful effects are suggested in this section. Recommendations are based on "best practices" currently in use. The design aspects are intended to achieve the following general objectives:

a) to prevent or reduce direct contact of personnel with ACA wood preservative chemicals;

b) to reduce releases of ACA to the environment to the greatest degree possible by providing secure containment of ACA solutions; and

c) to enable prompt response and effective corrective measures to assure worker safety and environmental protection after abnormal events (e.g., tank rupture)

Means of achieving these design objectives at ACA wood preservation facilities are presented in Tables 6.1 to 6.7. The recommended design features in these tables may not be the sole options available to attain the stated objectives. Alternative approaches may exist which would be equally effective or more suitable to site-specific conditions. If a more suitable alternative approach can be demonstrated to be equally effective in attaining the desired objective, an appropriate design feature that has not been included in the recommendations could be used at a specific facility.

Figure 6.1 presents an overview of subject areas for the design recommendations listed in Tables 6.1 to 6.7. The figure is based on the handling and use of ACA at wood preservation facilities, and is cross-referenced to indicate the appropriate table for each subject area. It is intended that all new wood preservation facilities be designed to achieve the specific objectives listed in Tables 6.1 to 6.7. Existing facilities should review their abilities to comply with the objectives and gaps, if present, should be alleviated using the suggested features or alternative but similarly effective features.

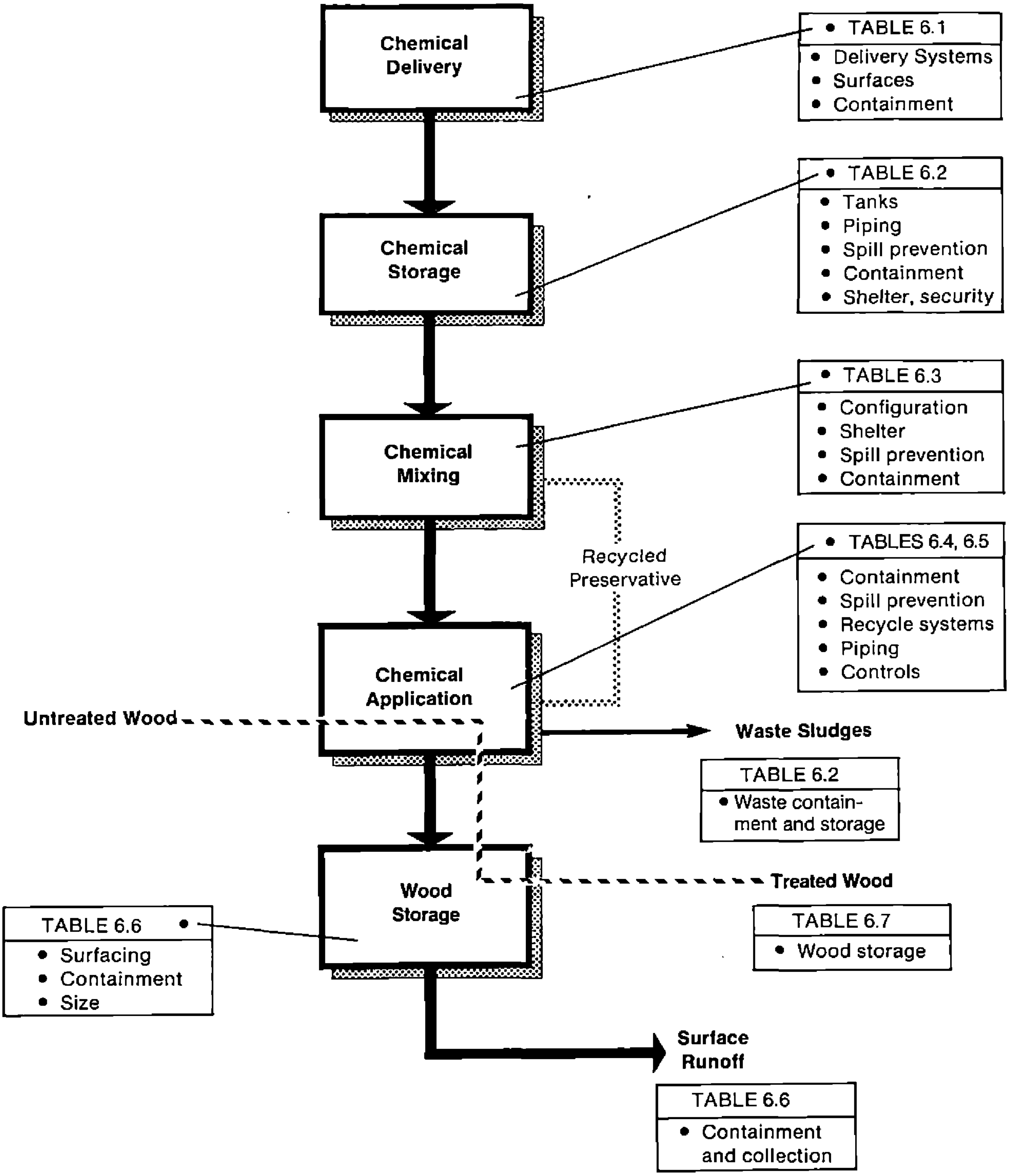

FIGURE 6.1 OVERVIEW OF DESIGN RECOMMENDATIONS FOR ACA FACILITIES

TABLE 6.1 RECOMMENDED DESIGN FEATURES FOR CHEMICAL DELIVERY AREAS

Delivery Format	Design Feature	Recommendation
Bulk Liquid ° Aqua ammonia (Delivered by Truck, or Rail Tanker)	**Objective:**	To provide an off-loading area which enhances spill prevention and containment of spills and to prevent the release of harmful air emissions.
	Off-loading pad	• Provide an impervious pad which drains to a containment area. • Design to prevent settling or cracking of the pad.
	Surfaces	• Seal surfaces to enhance cleanability.
	Joints	• Provide liquid tight joints (if applicable).
	Drip control	• Provide local drip catchment to minimize contamination of the containment system. • Provide for wash down of minor drips or spills with recovery of washwater (or infiltrating precipitation) for reuse.
	Access	• Attempt to locate off-loading area away from high yard traffic routes. • Restrict access during delivery.
	Delivery system piping	• Install permanent delivery systems with rigid, accessible and visible delivery lines (lines should not be buried). • Protect delivery systems from mechanical damage. • Provide mechanically secure connections between the tanker and delivery hookup point (with flexible connectors between aqua-ammonia tankers and rigid delivery piping). • Clearly identify all delivery lines. • Use top delivery to concentrate storage tanks.
	Backflow prevention	• Install backflow preventors on delivery lines.
	Security	• Install locking valves on delivery lines, restrict access.
	Overflow prevention	• Provide maximum visibility of the delivery system from the point of off-loading. • If visibility is limited, use audible alarms to detect tank overflow during delivery.
	Emergency response	• Provide accessible storage for spill response equipment, absorbant (lime) and personnel protection equipment. • Install a phone or manual alarm switch near the off-loading area. • Provide emergency ventilation for ammonia vapour control (in enclosed spaces).

TABLE 6.1 RECOMMENDED DESIGN FEATURES FOR CHEMICAL DELIVERY AREAS (cont'd)

Delivery Format	Design Feature	Recommendation
Containerized liquid ° arsenic acid concentrate (drums)	**Objective:**	To provide an off-loading area which enhances spill prevention and containment.
	Off-loading pad/shelter	• Provide an off-loading area near the storage area.
	Containment	• Assure provision for containment of worst event spill (e.g., 4 drums or 1 pallet load).
	Surfaces	• Select an off-loading site with low surface permeability or provide a sealed surface.
	Container handling	• Design for safe, convenient manipulation of containers.
	Emergency response	• Provide accessible storage for spill response equipment and personal protection equipment.

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS

Storage Format	Design Feature	Recommendation
Bulk ACA Liquids ° aqua ammonia ° working solutions ° contaminated surface runoff ° drip return	**Objectives:**	• To provide positive spill prevention features. • To provide spill containment capability for 150% of the largest on-site bulk storage tank (in multiple tank containment areas) or 100% plus 15 cm additional containing wall for single tanks in isolated containment.
	Tanks	• Engineer materials of construction, dimensions in consultation with chemical suppliers. • Provide tanks in sound physical condition, with no rust or serious physical damage. • Mount tanks on containment pad surfaces. • Mount tanks in stable positions and anchor securely. • Locate tanks within a dyked area. • Provide shelter (e.g., roof) from infiltration water or have provision for retention and reuse of the water. • Protect from mechanical impact, vandalism. • Protect against freezing (as required for external tanks). • Provide inspection points for detecting leaks in insulated tanks. • Vent tanks to the exterior (never vent to the workplace); - protect vents against release of entrained liquids or overflow (e.g., direct overflow piping to sumps or containment areas).
	Spill containment	• Install, impervious, structurally sound floors. • Provide structurally sound dykes, seal all joints. • Provide a dyked containment volume. • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration). • Consider providing means for detecting subsurface leakage from containment systems (where warranted by site-specific conditions; e.g., where the site overlays sensitive groundwater systems). • Provide for directing all spills, washes and infiltrating water to tankage (contaminated liquids must be treated to applicable limit before discharge). • Provide effective capability for transferring spilled liquids from containment areas. • Provide surface drainage to prevent pooling of minor spills and washdowns. • Design to minimize tracking of fluids from containment surfaces. • Provide water sprays and/or ventilation to control ammonia vapours.

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS (cont'd)

Storage Format	Design Feature	Recommendation
Bulk ACA Liquids (cont'd) ° aqua ammonia ° working solutions ° contaminated surface runoff ° drip return	**Piping**	• Design according to applicable codes.
		• Use rigid, permanent piping throughout.
		• Provide visible, accessible piping with a simple layout (to facilitate early leak detection and easy repair).
		• Maximize above floor piping or open containment channels for subgrade piping.
		• Properly engineer piping systems for material, dimensions (do not use brass or aluminum fittings).
		• Identify piping systems and valves (e.g., by labelling and/or colour coding).
		• Provide mechanical impact protection for vulnerable exposed piping.
		• Provide freeze protection for piping (as required).
	Drip containment	• Provide local collection/containment (isolated from larger containment areas (at drip points (e.g., under pumps, valves, flanges, etc.).
		• Provide adequate ventilation to control ammonia vapours.
	Spill prevention/ detection	• Install reliable, accurate level indicators on all tanks.
		• Provide mechanical impact protection on glass sight gauges (including for containing and stopping release from broken gauge tubes).
		• Install shut-off valves on all rupturable lines and tank gauges.
		• Install permanent overflow piping from tanks directly to a definitive contained area.
		• Install reliable, independent high-level alarms on tanks (visual and audible alarm).
		• Interlock high-level alarms to tank feed pumps (auto shut-off).
		• Install manual alarm buttons (call for help) at potential major spill points.
		• Consider installation of 24-h monitoring alarms (with remote) for immediate detection of major spills.
	Backflow prevention	• Install backflow preventors on all waterlines at plant entry.
		• Use top entry of waterlines to tanks (as secondary backflow protection).
		• Waterlines must comply with all applicable local codes.
		• Design to protect against inadvertant transfers to/from interconnected tanks.

TABLE 6.2 RECOMMENDED DESIGN FEATURES FOR CHEMICAL STORAGE AREAS (cont'd)

Storage Format	Design Feature	Recommendation
	Vapour control	• Install control equipment as required to comply with applicable air emission limits for ammonia vapours. If scrubbers are used, design for recycle and reuse of scrubber fluid.
Bulk ACA Liquids (cont'd) ° aqua ammonia ° working solutions ° contaminated surface runoff ° drip return	**Shelter**	• Preferred location for ACA tankage (all solutions) is in a well-ventilated (open sites) tank farm near the process area. • If possible, roof exterior tank farms to minimize the quantity of infiltrating precipitation.
	Security	• Provide security precautions to prevent vandalism or access to unauthorized persons.
	Emergency response	• Provide accessible storage for spill response equipment, absorbants (sawdust for work solutions, drip return, runoff) and personnel protection equipment. • Provide appropriate measures for rapid, effective fire control with containment of liquid fire-fighting residues and treatment to required limits before discharge. • Provide for emergency ventilation in enclosed spaces. • Install a phone and manual alarm switch near the off-loading area.
Drummed Liquids ° arsenic acid concentrate	**Objective:**	To provide secure storage with containment for the worst-event spill.
	Location	• Provide safe, easy access to the mixing area.
	Shelter	• Provide storage in an enclosed, secure area, segregated from other chemicals.
	Ventilation	• Provide adequate ventilation for both routine and also emergency requirements.
	Containment	• Store in paved, curbed or dyked area with no floor drains. - Provide containment capacity for the worst-event spill (no less than 4 drums). - Provide for effective cleanup (including recovery of washdown water) if a spill were to occur.
	Surfaces	• Seal surfaces and joints to facilitate cleanability and surface impermeability.
	Emergency response	• Provide accessible storage for spill response equipment, absorbants and equipment for personnel protection as identified in Table 4.4 and Section 10. • Provide appropriate measures for rapid, effective fire control with containment of liquid fire-fighting residues and treatment to required limits before discharge.
Drummed Solids ° copper oxide pellets	**Shelter/Containment**	• Provide a secure, enclosed paved area.
Drummed Wastes ° filter cartridges ° sludges ° contaminated debris	**Shelter/Containment**	• Provide a paved area for storing all drummed wastes pending removal to approved disposal (Section 8.1). • Provide a covered area or tarps for drummed wastes.

TABLE 6.3 RECOMMENDED DESIGN FEATURES FOR CHEMICAL MIXING SYSTEMS

Chemical Form	Design Feature	Recommendation
ACA ° aqua ammonia ° working solutions ° drip return ° contaminated surface runoff	**Objectives:**	• To provide a mixing system with effective spill prevention features. • To provide a mixing system which minimizes worker contact with ACA.
	Configuration	• Use permanent, closed systems (rigidly piped, tank to tank).
	Location/Shelter	• Locate mixing and working solution tanks in an enclosed, heated area, particularly if sub-freezing temperatures are encountered during operation.
	Spill prevention	• Install high-level alarms to prevent mixing tank overflow. • Interlock high-level alarms to tank feed pumps. • Provide equipment to enable safe, controlled manipulation of ingredients drums. • Provide equipment for transferring drum contents with minimum worker contact and minimum spill potential.
	Spill Containment	• Provide all applicable features for "spill containment of bulk liquids" (Chemical Storage Area, Table 6.2).
	Drip Containment	• Provide local drip collection at all potential drip points.
	Splash Protection	• Discourage open transfer operations, if unavoidable, provide reliable splash protection.
	Emergency Response	• Provide features described in "Emergency Response" (Table 6.1).

TABLE 6.4 RECOMMENDED DESIGN FEATURES FOR TREATMENT PROCESS SYSTEMS: GENERAL REQUIREMENTS

Design Feature	Recommendation
Objectives:	• To minimize and contain all releases of ACA. • To recover and recycle releases which do occur.
Spill Containment	• Provide spill containment capability for 150% of the largest on-site bulk storage tank or cylinder (in multiple vessel containment areas) or 100% plus 15 cm additional ccontaining wall for single vessels in isolated containment. • Locate treatment cylinders and process tanks in an area with: - Continuous, structurally sound paved floors or, slabs or sections with sealed joints, - Sealed surfaces for cleanability and impermeability, - Reinforced dyke walls and sealed joints, - Graded surfaces for ready drainage of wetted surfaces, - Walkway grates (or alternative design) to minimize worker exposure and prevent tracking of chemicals from containment areas. • Engineer containment for long-term integrity (leak-proof for infiltration and exfiltration). • Provide permanent, isolated drainage/transfer systems to direct all spills, washes and infiltrating water to tankage or containment. Reuse contaminated liquids or treat contaminated liquids to applicable limits before discharge. • Isolate control and transfer equipment to avoid damage from spilled liquids in containment areas.
Process Control Area	• Segregate the operator control area from retort and tank spill containment areas. • Locate the process control area for maximum visibility of treatment systems.
Ventilation	• Provide adequate routine and emergency ventilation to control ammonia vapour levels in all work areas.
Process Emissions to Air	• Vent all air emissions (including tank vents, and vacuum pump exhausts) to the building exterior. - Install control equipment as required to comply with applicable air emission limits for ammonia (see Section 8.1.5). - Install traps on otherwise uncontrolled vents (to remove entrained liquids).
Fire Controls	• Provide fire controls as decided on site-specific basis in consultation with the local fire department.

TABLE 6.5 RECOMMENDED DESIGN FEATURES FOR TREATMENT PROCESS SYSTEMS

Design Feature	Recommendation
Objectives:	• To provide fail-safe operation of the treatment system. • To minimize the potential for ACA spills.
Treating Cylinder	• Treatment cylinder and pressurized components must meet all pressure vessel certifications required by the provincial ministry responsible for such certification. • Install an effective protection device to prevent door openings when the cylinder is pressurized or filled with preservative. - Provide independent backup protection. - Install independent indication/alarm interlocks between the cylinder door and the control point (where the door is not visible from the control point). • Design to facilitate drainage of excess preservative.
Piping and Recycle Systems	• Design an overall system which is effective at containing and recycling all chemicals with minimum potential for release and dispersal and minimum infiltration of water. • Select and install piping as per Table 6.2.
Sumps	• Provide leakproof design (e.g., impermeable surfaces, sealed joints). • Provide overflow protection if sump is not in containment area (e.g., install independent high-level alarms).
Process Controls	• Design for simple, unambiguous operation (regardless of the degree of automation). • Establish a clear relationship betweeen process controls and process functions in order to minimize operator error.

TABLE 6.6 RECOMMENDED DESIGN FEATURES FOR FRESHLY-TREATED WOOD DRIP AREAS

Design Feature	Recommendation
Objective:	To minimize losses of preservative chemicals from treated wood by: • providing proper conditions for preservative fixation in freshly-treated wood, and • controlling the generation and disposal of contaminated runoff waters.
General Design	• Integrate consideration of design requirements for: - Shelter from precipitation, dust, debris, - Efficient drip and runoff collection and containment, and - Surface drainage and return of fluids to process with minimum dispersal from tracking by personnel and vehicles.
Fixation Time*	• Provide for storage of all freshly-treated wood in a specially designated area, with assured recovery of dripped material and precipitation. Holding time should be sufficient to allow adequate fixation of preservative chemicals (as determined by consideration of wood types, treatment processes, operational practices and other practices and other relevant factors).
Containment	• Provide for paved charge unloading and drip areas, sloped to enable collection and storage of all runoff and infiltrating precipitation (for reuse or controlled discharge under terms of existing regulatory standards). • Where storage of runoff waters would be difficult, roofing would be a consideration.

* Data for ACA fixation rates are unavailable and should be determined. Fixation of ACA depends on ammonia loss, which in turn is dependent upon climatic conditions (e.g., temperature, humidity, air exchange rates).

TABLE 6.7 RECOMMENDED DESIGN FEATURES FOR DRY TREATED WOOD STORAGE AREAS

Design Feature	Recommendation
Objective:	To minimize and control releases of contaminated surface waters from treated wood storage areas.
Storage Areas	• Where practical, store all dry treated wood under roof or wrap. • Segregate treated wood storage areas from others and segregate contaminated from uncontaminated runoff water to minimize the need for water treatment and/or recycling. • Locate unsurfaced ground storage areas away from surface waterbodies. • Routinely monitor contaminant levels in storage area runoff.

7 OPERATION

In addition to the design objectives described in Section 6, an ACA facility should develop operating procedures to protect both workers and the environment from potentially harmful exposure to ACA solutions. The operating procedures would:

a) minimize direct contact of personnel with wood-preserving chemicals;
b) minimize releases of wood-preserving chemicals to the environment; and
c) facilitate clear and accurate definition of responsibility and action when emergency response is required.

Recommended operating practices are presented in Tables 7.1 to 7.4 and include:

- general practices (Table 7.1);
- procedures for handling and storing wood preservation chemicals (Table 7.2);
- practices for operating process systems (Table 7.3); and
- practices for maintenance, cleanout, and shut down of preservation systems (Table 7.4).

The recommendations provided in these tables may not be the sole options available to attain the objectives. Alternative approaches may be equally effective or more suitable in view of site-specific conditions. When programs are developed for a particular facility, the recommendations may be modified if it can be demonstrated that an alternative approach, more suitable to plant specific conditions, would be equally effective in attaining the desired objective.

Consistent with the stated intent of this document, it is recommended that all existing and new wood preservation facilities meet the specific objectives outlined in Tables 7.1 to 7.4, by implementing the recommended practices or their equivalents. Detailed operating procedures for each facility should be incorporated into a written operations manual that is available to all affected personnel. Responsibility and accountability for implementing procedures should be clearly assigned to supervisory personnel and to workers.

TABLE 7.1 RECOMMENDED GENERAL OPERATING PRACTICES FOR AMMONIACAL COPPER ARSENATE PRESSURE TREATMENT FACILITIES

Operation	Recommendation
Personnel	**Objective:** To enhance worker protection by providing education, and medical surveillance.
	• Train all foremen, on-scene supervisors, operators, and handlers in good work practices. • Provide pre-employment medical check-up and annual on-going medical surveillance (see Section 4). • Provide periodic review and update of education and training.
Procedures	**Objective:** To assure that worker responsibilities are well understood, and that site-specific procedures are available in hardcopy for reference.
	• Prepare (and have readily available) explicit written instructions for all aspects of chemical use, facility operation, maintenance and emergency response. • Identify and communicate precautions for all other on-site handlers of treated wood (including quality control personnel, sorters, and transporters).
Signing	**Objective:** To assure clear and accurate signing in all wood preservation use areas.
	• Identify the contents of all tanks. • Identify the function of each tank (e.g., "concentrate tank", "work tank"). • Prominently display personnel safety precautions and first aid procedures. • Prominently display emergency response procedures. • Prominently display emergency telephone numbers for medical aid, facility management, local environmental control agencies.
Personal Hygiene and Safety Precautions	• Follow precautions outlined in Section 4 (Table 4.2).
Housekeeping	**Objective:** To maintain a clean, orderly site.
	• Define and practice regular housekeeping standards (suggest daily). - Contain all contaminated debris. - Do not accumulate empty drums and containers (provide secure designated storage or dispose of according to Table 8.1). • Visually inspect for, record and report leaks at routines defined in the facility's procedure manual. • Contain and repair all leaks.

TABLE 7.1 RECOMMENDED GENERAL OPERATING PRACTICES FOR AMMONIACAL COPPER ARSENATE PRESSURE TREATMENT FACILITIES (cont'd)

Operation	Recommendation
Record Keeping	**Objectives:** • To provide a secondary level of control for chemical losses. • To enable a rapid assessment of potential hazards, in the event of a catastrophic incident (e.g., tank rupture, fire).
	• Maintain accurate daily records for: - chemical delivery, use and inventory, and - equipment condition and maintenance. • Record and compare bulk tank volumes before and after facility shutdowns in excess of two days. - If changes in volume are apparent, check for tank leaks and/or irregular practices. • It is a practice at some pressure-treating facilities to compare actual versus estimated chemical retention by wood. (If actual exceeds estimated quantities, efforts are made to determine if leaks or poor operating practices exist.)
Spill Response	**Objective:** Maintain a state of readiness to implement the plan in case of a chemical spill.
	• Establish a spill contingency plan (Section 10).
Fire Fighting	**Objective:** To maintain a state of readiness in case of fire emergency.
	• Establish a fire contingency plan (Section 10) and undertake action to maintain a state of readiness to implement the plan in case of fire emergency (including routine checks of the pressure and proper function of firefighting equipment and drills with all affected personnel). • Liaise with the local fire department, with regard to chemicals in storage and use, and emergency procedures. • When a fire alarm call is made, notify firefighters of chemical quantities in stock and verify the status quo of storage locations. • Require self-contained breathing apparatus for all personnel exposed to smoke (Only trained fire-fighting personnel should be allowed at the fire scene). • Make advance preparation to contain and properly dispose of contaminated fire residues, to the greatest degree possible. - Runoff water, soot and ash from fire areas are presumed to be contaminated and provision should be made to contain as much as possible. - Analyse fire residues and involved ground soils (as applicable) to determine the need for and scope of special cleanup and disposal activities. - Dispose of contaminated firefighting waters as "contaminated runoff" (Table 8.1). - Dispose of solid treated wood fire residues as "contaminated solid wastes" (Table 8.1).

TABLE 7.2 RECOMMENDED OPERATING PRACTICES FOR CHEMICAL HANDLING AND STORAGE

Operation	Recommendation
Unloading Chemicals	**Objective:** To assure the safe unloading of bulk aqua ammonia and other preservative chemicals.
	• Assure that the delivery of preservation chemicals is undertaken by personnel who are trained in emergency response procedures for (as required by Transport of Dangerous Goods Regulations (TDGR)).
	• Assure that personnel with recognized first aid training are present during unloading (personnel can include the truck driver).
	• Assure that ready access to emergency advice and aid is available during all chemical unloading periods.
	• Restrict access to the unloading area during chemical transfer operations. Prohibit pedestrian or vehicle traffic.
Preparation of Wood Preservation Solutions	**Objective:** To assure worker safety during handling of ACA concentrate and work solutions.
	• Follow the personnel safety precautions for all procedures (Table 4.2).
	• Avoid inhalation, ingestion, or skin or eye contact with ACA concentrate or work solutions.
	• Thoroughly rinse empty arsenic acid and copper oxide containers (if applicable). - Recycle rinse water. - Return containers to suppliers or reuse sound containers for storage of wastes. - Dispose of unusable containers only in landfills specifically approved for such disposal (Section 8.1).
Storage of Wood Preservation Chemicals	**Objective:** To assure that ACA solutions are safely stored.
	• Assign responsibility for storage areas to trained personnel.
	• Label storage tanks with the identification of contents by chemical name, type of solution, and concentration (e.g., aqua ammonia, ACA Work Solution (1 to 4%)).
	• Post chemical identity placards, fire or spill emergency response procedures, personnel safety precautions and first aid procedures at storage room entrances.
	• Check and maintain the integrity of storage tanks and storage containers. - Clean up all leaks or spills and implement remedial actions immediately. - Vent arsenic acid drums as required (consult the supplier).
	• Provide secure storage areas; restrict access to authorized personnel.

TABLE 7.3 RECOMMENDED OPERATING PRACTICES FOR PROCESS SYSTEMS

Operation	Recommendation
Routine Checks	**Objective:** To define procedural practices which will enhance environmental and worker safety.
Work Solutions	• Regularly check and record quantities of treatment solution in storage. • Test and record solution strengths at regular intervals.
All Process Components	• Visually check the complete system for leaks. - Take immediate action to stop leaks. • Check sludge levels in retorts. - Clean out as required, in accordance with facility policy. - Observe personnel safety precautions (see Table 4.2).
Tank Vents	• Test tank vents to assure the absence of blockage (suggest once/month).
Charges	• Secure loads to avoid uncontrolled floating. • Stack loads to allow good drainage of preservative from all wood surfaces after treatment.
Treating Cylinder	• Check door seals for damage. - Replace door seals at regular intervals or as required if damaged. • Check cylinder doors for proper seal after loading charges. - Ensure that all bolts on doors are securely fastened or that the hydraulic collar has moved to its regular endpoint.
Recycle Systems	• Check filters. - Clean or replace if necessary.
Trams	• Clean soil and debris from trams to prevent contamination of the preservative. • Thoroughly clean trams if alternative preservative treatments are used.
Checks During Treating	**Objective:** To monitor the treatment system so that potential/actual problems are identified quickly.
System Integrity	• Closely monitor process systems for leaks during initial stages of treatment. • Check for leaks or abnormal conditions throughout pressurized system. • Compare recording instrument readings with indicating gauges and thermometers. • Note malfunctions of recording devices, thermometers, gauges (including level floats) and arrange for prompt repairs. • Carefully observe pressures during treatment to make certain that maximum limits are not exceeded (maintain records of treatment cycles, tank gauge readings and chemical consumption). • Define (in writing) operator actions for abnormal situations of concern (e.g., response to equipment breakdown).

TABLE 7.3 RECOMMENDED OPERATING PRACTICES FOR PROCESS SYSTEMS (cont'd)

Operation	Recommendation
Post-treating Checks	**Objective:** To prevent worker contact with treatment solution and with freshly charged loads.
Retort Opening and Charge Removal	• Ensure that retorts cannot be opened when liquid and/or pressure remains. • Wear impermeable gauntlets during handling of freshly treated charges. • Pull charges only when the superficial excess preservative has sufficiently drained. • Avoid exposure to ACA or ammonia mists, aerosols or vapours. • If airborne concentrations are unknown or, at or above TLV's, wear an approved respirator (full-face mask is recommended).
Load Jams	• Follow standard regulatory safety procedures for tank entry. • Do not enter retorts until purged with fresh air. - If retort TLV levels exceed regulatory values, or if concentration is unknown, the attendant must wear a self-contained full-face respirator mask, impermeable coveralls, boots and gauntlets. - If TLV levels are less than regulatory limits, wear NIOSH approved respirator, impermeable coveralls, rubber boots and gauntlets (select respirator in consultation with ACA supplier or provincial labour agency). • Assure presence of a standby attendant. • Shower immediately after tank entry.

TABLE 7.4 RECOMMENDED PRACTICES FOR MAINTENANCE, CLEANOUT AND SHUTDOWN OF TREATMENT SYSTEMS

Operation	Recommendation
Equipment Maintenance	**Objective:** To assure that equipment is maintained in a manner that will minimize releases of ACA solution and minimize worker exposure to ACA and its by-products.
	• Maintain all equipment in good operating condition.
	• Prepare explicit written maintenance procedures with assigned responsibility and accountability.
	• Follow all personnel safety precautions during maintenance procedures (Table 4.2).
	• Drain and/or clean wood preservation chemicals from equipment prior to maintenance. - Flush equipment thoroughly with water; recycle rinse waters to work solutions. - Thoroughly purge all ammonia vapors and provide effective ventilation.
	• Use extreme caution if contaminated equipment must be welded (toxic fumes can be generated). - Thoroughly clean surfaces to be welded. - Wear an approved belt-mounted respirator when welding arsenicals. - Provide good ventilation in the work area. - Contain all sparks and remove flammable materials from the repair area.
Cleanout	**Objectives:** • To prevent accumulation of ACA solutions and sludges within the treatment system. • To assure worker safety during clean out operations.
	• Observe personnel safety precautions during all procedures (Table 4.2).
	• Wash down drip pads regularly to prevent accumulation of ACA. (The washdown frequency should be determined by site-specific factors including the probability of worker exposure, vehicle traffic, and washdown by rain.) - Reuse wash water for work solution preparation.
	• Routinely inspect sludge levels in storage and mix tanks and cleanout if necessary. Determine sludge levels of concern (requiring removal) in consultation with ACA suppliers or technical personnel. - During cleanup, inspect gauge floats or similar equipment within tanks.
	• Routinely inspect treating cylinders for sludge accumulation and clean if required. - Purge cylinders with fresh air sufficient to permit entry. - If airborne concentrations are unknown, at, or above TLVs, the attendent must wear self-contained breathing apparatus, gloves, rubber boots and impermeable coveralls. - If airborne concentrations are below TLVs, wear respirators (do not exceed the ammonia concentration limit of the cartridge), impermeable gloves and boots, and impermeable coveralls. - Provide a constant standby attendant and continuous outside communication. - Follow standard safety procedures for entry of confined spaces. - Prevent skin contact with sludges. - Remove sludges with equipment used only for cleanout purposes. - Collect, drain, and store contaminated material in sealed drums pending disposal (Table 8.1). - The attendant should shower immediately after cleaning retorts or tanks.
Alarms	• Test all alarms and safety devices at regular intervals (or as specified by the manufacturer).

TABLE 7.4 RECOMMENDED GENERAL PRACTICES FOR MAINTENANCE, CLEANOUT AND SHUTDOWN OF TREATMENT SYSTEMS (cont'd)

Operation	Recommendation
Long-term Shutdown	**Objective:** To assure orderly shutdown prior to long-term closure.
	• Thoroughly clean all equipment which has been in contact with waterborne solutions. • Collect all wash-waters generated by cleanup operations (Table 8.1). • Hold solutions in closed tanks for prolonged shutdown. - Drain all open tanks or sumps. - Assure that temperatures in storage areas are above freezing levels or provide adequate freezing protection for all stored liquids. • In case of permanent shutdown, reuse of treatment solutions at another facility is preferred to disposal.

8 PROCESS EMISSIONS

8.1 Control, Treatment, and Disposal

Potential process emission sources at ACA-wood preservation facilities were described in Section 2.2 and Figure 2.3. The main categories of process wastes or emissions which may be encountered at ACA facilities, and recommended disposal methods, are presented in Table 8.1.

8.1.1 Liquids Containing ACA. Liquid process wastes (i.e., >1% total oxides) are not normally discharged from ACA plants. Liquid solutions (such as drips and washwaters) containing ACA are routinely collected and reused as make-up waters in preparing new treatment solutions. If unusual circumstances (such as prolonged plant shutdown) prevent on-site reuse, transport to another ACA facility (for reuse) should be arranged. The chemical supplier may be able to suggest another facility using ACA. Disposal should be considered only as a last alternative.

If disposal is unavoidable, specific approval must be obtained from the appropriate regulatory agency. If no suitable means of disposal are readily available, the solutions should be sealed in leakproof metal containers (see Table 3.2 to assure compatibility with metal used for containers), labelled and stored in a secure area.

Contaminated storm runoff should be minimized. Various approaches can be used including: proper wood treatment process operation (i.e., assure solution quality, proper material placement on trams, and appropriate treatment cycles and final vacuum); roofed areas for treated product storage; adequate fixation prior to storage in the open environment; and containment of storm runoff waters. In areas of high rainfall, complete containment may not be economically feasible. If the release of ACA-contaminated runoff does occur, then guidance (and possibly specific approval) may have to be obtained from the appropriate provincial environmental regulatory agency. Control specifications may depend on factors such as the concentration of contaminants, the volume and frequency of the discharges and the sensitivity of the receiving environment. The discharge of ACA-contaminated runoff into waters inhabited by fish is subject to the provisions of Section 33(2) of the Federal Fisheries Act, because ACA is considered a deleterious substance in this case (Appendix).

8.1.2 Solids with High ACA Concentrations. For the purposes of this document, solids with "high ACA concentrations" include sludges from sumps and cylinders, and disposable cartridge filters used to filter recycled waters. Recovery of the components (copper and arsenic) would be ideal, but this option is not commercially feasible in Canada at this time. The preferred means of disposal for ACA-contaminated sludges and cartridge filters is solidification and burial in an approved, secure (hydrogeologically isolated) chemical landfill. It is the responsibility of the waste generator to obtain and comply with approvals required by the jurisdiction in which the disposal site/facility is located.

Solids with high concentrations of ACA should be drained and stored in leakproof containers while awaiting disposal. Large quantities of such solids should be stored in a specially designed area that is curbed and lined with impermeable material. The area should be roofed or covered by a plastic leakproof tarpaulin to protect the wastes from precipitation. Any seepage or leachate generated at the site should be contained.

Incineration of ACA-contaminated materials is not recommended because this causes the formation of toxic by-products.

8.1.3 **Miscellaneous Solid Wastes.** Miscellaneous solid wastes (e.g., empty arsenic acid and copper oxide drums, cuttings from ACA-treated lumber) from ACA wood preservation plants may be disposed at designated sanitary landfills as approved by the provincial regulatory agency. The ingredient drums should be rinsed with water prior to disposal, and the rinse water should be used for the preparation of work solutions.

8.1.4 **Air Emissions.** Air emissions at ACA facilities are normally localized; effects, if any, would be confined within the boundaries of the facilities. Air emissions from ACA facilities include:

- vapours from ammonia storage tank vents,
- vapours from ACA mixing and storage tank vents,
- vapours from vacuum pump discharge,
- vapours from opening of retort cylinder doors, and
- vapours from freshly treated charges.

Monitoring of mists (10) in the vicinity of several ACA retort cyclinder door openings has shown arsenic and copper concentrations below published ACGIH threshold limit values (38). Ammonia emissions in the vicinity of ACA retort cylinder door openings and in the vicinity of freshly treated wood have been reported at concentrations above occupational health limits. For example, Todd and Timbie (10) measured airborne ammonia concentrations of up to 250 ppm within localized areas of one ACA facility.

These concentrations were much above occupational health limits of 35 ppm for a 15-minute exposure and 25 ppm for an 8-hour exposure. Concern about ammonia releases and control measures at an ACA facility also has been expressed in an Environment Canada report (8).

8.2 Emission and Site Monitoring

Site monitoring and assessment is required at ACA facilities, in accordance with the design and operating objectives described in this document, to verify that wood preservative chemicals are being properly managed at the site and to ensure environmental and worker health protection. Assessment records also will allow an orderly assessment of site decommissioning requirements if a plant is shut down.

Environmental monitoring requirements for most ACA facilities would normally be developed in consultation with the appropriate provincial environmental regulatory agency. Additional consultation would be required with Environment Canada if the facilities have a potential to impact on federally managed resources (e.g., facilities located on or adjacent to Indian lands, or facilities located adjacent to waters used by anadromous fish such as salmon). Worker health monitoring requirements would be developed in consultation with a provincial workers' compensation board and/or department of labour.

The level of detail and scope of these monitoring activities depends on site characteristics, facility design, and the requirements of the regulatory agencies. Components of a site environmental and worker health monitoring program are suggested in Table 8.2.

TABLE 8.1 RECOMMENDED DISPOSAL PRACTICES FOR WASTES CONTAMINATED WITH AMMONIACAL COPPER ARSENATE

Waste Category	Examples	Recommendation
Liquid ACA Solutions	• ACA concentrates and ACA work solutions • Drips from freshly treated lumber • Wash waters	• Reuse as make-up for work solutions (standard practice at ACA plants).
Contaminated Solid Wastes	• Debris and bottom sludge from storage tanks and sumps • Debris and sludges from recycle filters (if applicable) • Any wood waste or wood debris which has contacted ACA concentrate	• Drain drum and dispose of in a secure chemical landfill with prior approval of the regulatory agency. • Do not burn ACA-contaminated wastes (toxic gases and ash may be formed).
Miscellaneous Solid Wastes	• Empty concentrate drums	• Rinse thoroughly and dispose of in designated sanitary landfills subject to approval by the regulatory agency.
	• Scraps, cuttings and shavings from ACA treated lumber • Solid fire residues	• Dispose of in sanitary landfills (subject to approval by the provincial regulatory agency).
Contaminated Storm Runoff	• Any storm runoff or contaminated liquid discharge that contains arsenic at concentrations exceeding 0.05 mg/L, or whose discharge results in concentrations of copper in the receiving environment exceeding 0.005 mg/L, or whose discharge results in ammonia in the receiving environment exceeding 0.020 mg/L.	• Prevent or minimize contamination of storm runoff. • Contain and reuse contaminated runoff as make-up for work solutions. • Monitor surface water discharges (in consultation with the provincial regulatory agency) to assess contaminant concentrations.
Fire-fighting Water Runoff	• As above (contaminated storm runoff)	• Contain and reuse contaminated runoff as make-up for work solutions (to the greatest possible extent). • If reuse is not practical, consult with the provincial regulatory agency to determine acceptable disposal.

TABLE 8.2 RECOMMENDED ROUTINE ENVIRONMENTAL MONITORING

Item	Recommendation
Authority/Reporting	• Develop a site-specific monitoring plan in consultation with the appropriate regulatory agency. • Define reporting requirements. • Re-evaluate the plan if the facility expands or changes design or operating practices.
Soils	• Consider implementing a soil monitoring program (with emphasis on unsurfaced grounds) including: - all areas where preservative chemical is routinely stored, processed or handled; - all freshly-treated lumber storage areas; - all treated wood storage areas; and - drainage ditches or areas exposed to surface runoff (including overflow from drip pads and paved areas). • Define sampling frequency (e.g., annual), sample type (e.g., surface, core), and required analyses (e.g., constituents, detection levels, quality control) in consultation with the regulatory agency.
Surface Waters	• Consider implementing a monitoring program for adjacent water bodies: - Define monitoring frequencies and required analyses (e.g., constituents, detection level, quality control) in consultation with the regulatory agency - Define concentrations of concern
Groundwaters	• Consider implementing a groundwater monitoring program using permanent monitoring points down-gradient of unpaved process areas and treated lumber storage areas. - Define well construction. - Define sampling frequencies and required analyses (e.g., constituents, detection levels, quality control). • Give special attention to on-site wells used for drinking water.
Air Emissions	• Identify air emission sources by use of data provided in workplace exposure study (Table 8.3). • Monitor air emission as required by air local emission permits.
Liquid Waste Streams	• Identify liquid waste discharges (including stormwater runoff) and determine: - concentrations of preservative constituents, and - estimates of total mass rates of emissions. • Thereafter, monitor as required for all discharges governed by permits.
Solid Wastes, Sludges	• Maintain current and complete records for all solid wastes stored on-site (pending disposal). • Undertake all reporting and disposal activities in accordance with applicable regulations.

TABLE 8.3 RECOMMENDED ROUTINE MONITORING WORKPLACE

Item	Recommendation
Authority/Reporting	• Develop a facility-specific plan in consultation with the regional workers' compensation board office. • Define reporting requirements.
Contact Exposure	• Identify existing and potential sources of skin exposure by periodic walk-through inspections.
Air Inhalation Exposure	• In consultation with the regulatory agency responsible for worker safety, define the design of an initial monitoring program (e.g., sampling techniques, frequency of sampling, etc.). • For the purpose of defining worker health protection measures, provide an initial evaluation of peak and average levels of preservative constituents in air at significant points of worker exposure including areas such as: - cylinder doors (openings); - kiln interiors; - all vents to exhausts which discharge to enclosed work areas; - receiving areas for all vents/exhausts which discharge to areas frequented by personnel; - all enclosed preservative process areas; and - areas adjacent to freshly-treated wood storage. • Provide for subsequent monitoring if required by regulatory agency. • Make personnel samplers available for spot monitoring (as required) if high emission levels are suspected.
Biological Monitoring	• Conduct initial screening medical exams to identify sensitive individuals (Section 4). • In consultation with the regulatory agency, define a schedule for: - medical exams to confirm the absence of symptoms or signs of exposure to preservative constituents; and - biological monitoring of workers for preservative constituents (e.g., arsenic concentration in urine).

9 TRANSPORTATION OF AMMONIACAL COPPER ARSENATE SOLUTIONS AND WASTES

Except in the case of permanent shutdown of an ACA wood preservation facility, it is not expected that ACA solutions would be transported. The transportation of arsenic acid, ammonia and ACA-containing wastes is regulated under the Federal Transportation of Dangerous Goods Act (TDGA). The Act does not apply to the transportation of lumber and forest products treated with preservatives (43). The regulation of intra-provincial movement of dangerous goods is a provincial responsibility.

Transported dangerous goods must be classified according to the regulations. Regulatory requirements for aspects such as shipping, documentation, placarding and personnel training were published in the February 6 1985, Canada Gazette (44). A brief overview of the regulatory aspects is provided in Table 9.1. More specific transport procedures for ACA ingredients (ammonia, copper and arsenic acid) and ACA wastes are suggested in Table 9.2. The procedures are based on good operating practice, complementing the 1985 Transport of Dangerous Goods Regulations. It is the intent of these control measures to minimize the potential for accidental release in transit and to provide an effective mechanism for safely managing spills if they occur.

TABLE 9.1 TRANSPORTATION OF DANGEROUS GOODS REGULATIONS FOR AMMONIACAL COPPER ARSENATE

TDGA Reference*	Subject	Brief Description
4.4, 4.8	**Shipping Documentation**	Shipping document to be prepared which indicates (in part): primary classification number; special instructions for safe handling, transportation, and storage; 24-h telephone number for information concerning damaged or defective containers; placard requirements.
4.9	**Identification of Active Constituents**	Where dangerous goods are a systemic poison, the technical name of the active constituents shall be included.
4.15 - 4.18	**Shipments of Wastes**	A manifest is required for the shipment of more than 5 kg of solid wastes or more than 5 L of liquid wastes.
4.19	**Empty Containers/Vessels**	Cleaning and purifying of residues from containers and vessels is required until "no hazard exists", containers and vessels to be signed as "empty-last contained arsenic acid.
4.22	**Rail Transport**	Railway crews to be notified of the position within the train of vehicles containing dangerous goods.
4.23	**Location of Documentation during transport**	i.e., documents to be in cab door of truck.
4.24. - 4.26	**Delivery of Dangerous Goods**	Provision of consignee with documentation.
4.27	**Retention of documentation**	Document to be retained for two years.
5.2	**U.S. - Canada shipments**	Compliance with all aspects of the TDGA is required.
5.5 - 5.15	**Labels**	Label requirements are specified.
5.16 - 5.3	**Placards**	Placard requirements are specified.
7.4	**Incompatibility**	Shipment with incompatible goods is not allowed.
7.14	**Transborder consignment of wastes**	Imports and exports require notice in writing to the Director General, TDGD, Transport Canada.
7.16	**Emergency response planning**	Schedule XI is applicable "Poisonous" liquid, N.O.S. (not otherwise specified).
9.2 - 9.3	**Personnel Training**	Handling, transport only by trained personnel.
9.8	**Registration**	Each importer of dangerous goods must register with the Director General, TDGD, Transport Canada.
9.13 - 9.14	**Dangerous Occurrence Reporting**	Dangerous occurrences (i.e., spills) with more than 5 kg or 5 L of solids, solutions or wastes must be reported immediately (see Appendix for reporting authority).

* Transport of Dangerous Goods Act Section No. (6 February, 1985).

TABLE 9.2 RECOMMENDED TRANSPORTATION PRACTICES FOR ACA-CONTAINING SOLUTIONS OR WASTES

Feature	Recommendation
Container Specifications	• Drums or tanks for transporting ACA ingredient materials must be free from mechanical defects.
Container Labelling	• The Transportation of Dangerous Goods Act stipulates specific label requirements. • Affix the proper labels depending on classifications to each container. • Label each container on at least two sides.
Vehicle Placarding	• Affix the proper placards to vehicles carrying 500 kg or more of any material (solutions or wastes) containing ACA ingredients.
Securing Vehicle Loads (i.e, drummed concentrates and wastes)	• Replace drum spouts with leak-proof bungs prior to transit. • Strap drums vertically to pallets. • Strap drums horizontally to each other. • Brace or tie down loads to prevent shifting (do not rely on the vehicle floor or sides to prevent shifting). • Ensure a stable load consistent with the vehicle floor strength. • Secure other load items to prevent drum punctures.
Responsibilities of Truck Driver, Ship Captain or Railroad Crew	• Know the nature of the load. • Carry suitable emergency equipment and be trained in its proper use. • Know and follow correct procedures for the reporting of accidents or spills. - Immediately telephone the 24-h contact identified in the shipping manifest. - If more than 5 kg is spilled, also telephone the emergency contact identified in the Appendix. - Know and comply with any other requirements of the shipper/manufacturer. • Immediately replace lost or damaged placards or labels (carry spares). • Notify the receiver of goods that ACA ingredient materials are in transit. (Note: Some provinces allow only licensed carriers to transport hazardous wastes.)
Loading Procedures	• Ensure that personnel have the means and ability to transfer bulk liquid and move containers safely. • Set vehicle handbrakes securely and place wheel blocks prior to unloading. • Require the presence of a person who knows the hazards of ACA ingredients and who is trained and prepared to respond to spills and other emergencies. • If leakage or spillage occurs, decontaminate the vehicle prior to returning it to service. • Dispose of absorbants and spill cleanup materials as per Table 8.1.
Manifest Requirements	• Transport of Dangerous Goods Regulations require a manifest. See Table 9.1 and the 6 February 1985, Canada Gazette for specific details. • The transport of wastes requires both a manifest and regulatory approval (Table 9.1).

10 SPILL AND FIRE CONTINGENCY PLANNING

It is recommended that facilities that use ACA prepare a detailed contingency plan to ensure that response to spills and fires is safe, rapid and effective. Although it is recognized that details of a contingency plan will be facility-specific, the following sections outline the contents which should be found in a typical spill contingency plan. It is recommended that the individual facility plan be filed with the authority having jurisdiction.

10.1 Spill Contingency Planning

10.1.1 General Requirements. A contingency plan should:

1) have policy, purpose and organizational structure;
2) be geared to the most probable spill size;
3) address the following phases of spill response:
    - discovery and notification,
    - evaluation and initiation of action,
    - containment and countermeasures,
    - cleanup, mitigation and disposal,
    - documentation and cost accounting,
4) clearly assign duties and roles to responsible personnel and organizations;
5) outline equipment requirements for spill control;
6) have procedures for updating the plan on a scheduled basis;
7) outline training requirements for plant personnel in prevention and response;
8) co-ordinate with other chemical spill prevention plans and procedures is appropriate;
9) be submitted to chemical suppliers and the clean-up contractor or consultant for review; and
10) subsequently be submitted to appropriate government agencies including the local fire department and police, for review.

10.1.2 Implementation Capability. A contingency plan should:

1) describe location, capability, and limitations of cleanup and containment equipment;
2) pre-arrange for use of the best available cleanup and containment equipment;
3) identify detailed response options and strategies;
4) provide for training programs and regular practice sessions;
5) detail how communications will be maintained among all parties during response operations;

6) detail steps to be taken as a routine precaution against spills;
7) address human safety issues; and
8) assign selected personnel to respond to public and media calls.

10.1.3 Environmental Protection and Liability Risks. A contingency plan should:

1) identify high-risk areas and operations;
2) discuss expected chemical and physical behaviour of spill materials;
3) identify sensitive environments for protection and place in order of priority;
4) detail specific actions planned for minimizing damage to resources;
5) have explicit standards to define the components of and extent of effective cleanup;
6) have provisions for responding to spills under all anticipated weather conditions; and
7) pre-arrange all response capability needed for the estimated "worst-case" spill.

10.1.4 Examples of Action Steps. Safety of people is of prime concern. If a spill of ammonium hydroxide, ACA solution or arsenic acid occurs:

1) immediately put on appropriate full-face mask (ammonia canister for ammonia or ACA spill, approved cartridge respirator for arsenic acid, e.g., TC21-C);
2) stop the flow of spilled material,
   - use common sense
   - act quickly
   - shut off pumps, close valves, etc. if can be done without risk
   - if applicable, shut down mechanical production systems first (for example, lumber movement) to prevent injury;
3) warn people in immediate vicinity,
   - do not allow unauthorized personnel to enter the area
   - provide proper protective equipment for on-site personnel
   - avoid any contact with skin, eyes, clothing or shoes;
4) contain the spill,
   - always stay upwind
   - act promptly
   - if ammonia spill, use water spray to knock down vapours
   - block off drains, culverts and ditches
   - surround spilled material with earth, peat, straw, sand, booms, or commercial sorbents
   - use liquid recovery type vacuum cleaner (or use of empty cylinder and vacuum pump) for recovery of pools;
5) obtain required assistance from
   - company personnel (advise at earliest opportunity)
   - chemical suppliers
   - fire/police/public works/highways department/contractors (as required);

6) notify applicable government agencies
   - prompt notification is especially important for spills which have entered or may enter receiving waters
   - spills to marine waters require contact with Environment Canada
   - spills to water bodies with anadromous fish, or spills on or adjacent to Indian lands require contact with Environment Canada and provincial emergency program
   - for all other spills, contact Provincial Emergency Program as identified in Appendix;
7) commence recovery, cleanup, restoration action
   - recover pools by use of vacuum systems, and contain recovered liquid for re-use
   - if tanks other than normal work tanks are used for salvage purposes, then assure compatibility of materials, i.e., do not use galvanized or aluminum tanks because of the corrosiveness of ammonia
   - use an inert absorbent to complete cleanup
   - carry out cleanup and disposal in consultation with provincial and federal regulatory personnel.

10.2 Fire Contingency Planning

Although the ingredients of ACA and ACA-solutions are not flammable, precautions should be taken in the event that a fire occurs in the vicinity of ACA solutions, arsenic acid or ammonia. Ammonia gas could be released if ACA or aqua ammonia are heated. Mixtures of ammonia and air in an enclosed space with an ignition source could be explosive. In addition, heating of ACA or drums of arsenic could result in the formation of toxic arsenic vapours.

It is important, therefore, that ACA-wood preservation facilities devise an adequate contingency plan for fire protection.

10.2.1 General Requirements. A fire contingency plan should:

1) initially be developed in contact and consultation with local fire authorities;
2) have policy, purpose and organizational structure;
3) be geared to the most probably affected area;
4) address the following phases of fire response:
   - discovery and notification;
   - evaluation and initiation of action;
   - cleanup, mitigation and disposal;
   - documentation and cost accounting.
5) clearly assign duties and roles to responsible personnel and organizations;
6) include procedures for updating the plan on a scheduled basis;
7) co-ordinate with other fire prevention plans and programs is appropriate;
8) be submitted to the local fire department for review.

10.2.2 Action Steps. Fire contingency plans and defined action steps will be site specific. Nonetheless an overall strategy should include:

1) use of water blanket area;
2) use of water spray to suppress toxic dust and gases, and to keep temperatures of other oxidizable materials below that for ignition;
3) use any fire protection agents except soda-acid;
4) protection for fire-fighters if exposed to dust or if material is heated to gaseous state;
5) containment for contaminated runoff waters; and
6) notification of provincial emergency program if potential exists for runoff waters to enter receiving waters.

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APPENDIX LEGISLATIVE SUMMARY

This section describes the principal federal and provincial legislation (Acts and Regulations) which addresses the use, transportation, and disposal of ammonia, copper and arsenic compounds.

Federal Acts

1) Fisheries Act
2) Environmental Contaminants Act
3) Pest Control Products Act
4) Ocean Dumping Control Act
5) Transportation of Dangerous Goods Act
6) Clean Air Act

Provincial Acts

Alberta	1) Clean Water Act
	2) Clean Air Act
	3) Hazardous Chemicals Act
British Columbia	1) Waste Management Act
	2) Pesticide Control Act
	3) Workers' Compensation Act
	4) Environmental Management Act
Manitoba	1) Dangerous Good Handling and Transportation Act
	2) Clean Environment Act
	3) Workplace Safety and Health Act
New Brunswick	Clean Environment Act
Newfoundland	Department of Environment Act
Nova Scotia	1) Environmental Protection Act, SNS, 1973
	2) Dangerous Goods and Hazardous Wastes Management Act, SNS, 1986
Ontario	1) Dangerous Goods Transportation Act
	2) Environmental Protection Act
	3) Health Protection and Promotion Act
	4) Lakes and Rivers Improvement Act

5) Ontario Water Resources Act
6) Pesticides Act
7) Occupational Health and Safety Act

Quebec

1) Loi sur la qualité de l'environnement (Environmental Protection Act)
2) Loi sur la santé et la sécurité du travail (Occupational Health and Safety Act)
3) Code de la sécurité routière (Road Safety Code)

Saskatchewan

The province has no legislation specific to the use and disposal of chemicals used in the wood preservation industry. The uncontrolled release of preservative chemicals is reportable under the Environmental Spill Control Regulations, 1981, and disposal in municipal landfills is prohibited by the Municipal Refuse Management Regulations' 1986. ACA products are regulated on provincial highways by the Dangerous Goods Transportation Regulations, 1986. Hazardous Substances and Industrial and Hazardous Waste Management Regulations which will address the storage, treatment and disposal of these wastes by industry are in preparation. These regulations should be in place by 1988.

Figure A.1 provides a schematic overview of regulatory agencies and their responsibilities with respect to ACA wood preservation facilities. Table A.1 presents a brief review of the pertinent sections of the Acts and any Regulations that have been promulgated under those acts. Table A.2 provides emergency contacts in cases of contraventions of the above Acts; additional contacts to provide clarification of requirements are provided in Table A.3.

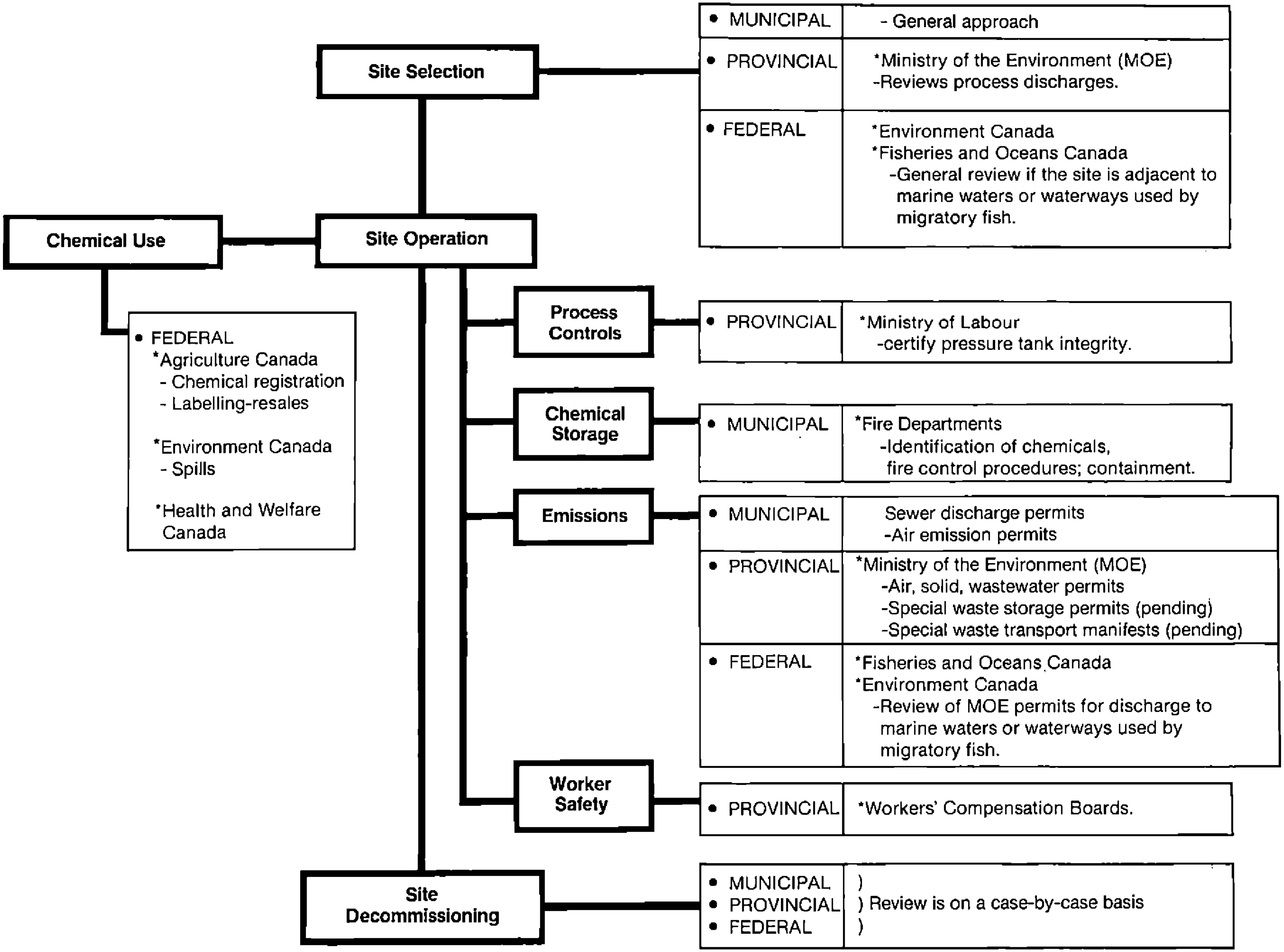

FIGURE A.1 OVERVIEW OF AGENCY MANDATES FOR REGULATING WOOD PRESERVATION FACILITIES

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE

Legislative Act (Responsible Agency)	Relevant Sections	Comments
1. Federal		
1.1 Fisheries Act (Environment Canada and Fisheries and Oceans Canada)	Section 33(1)	If a proposed facility could affect federally managed resources, then Environment Canada (EC) has the authority to review plans for operations and works, to recommend modifications and, if necessary, to prohibit construction.
	Section 33(2)	This Section focuses on the protection of certain fish fish species in marine and fresh waters. It is used by EC and DFO for the prohibition of the discharge of deleterious substances into waterways frequented by fish. Copper, ammonia, and arsenic are deleterious to fish and their habitat. Other subsections of the Act may have application if regulations are developed or if specific information is requested.
1.2 Environmental Contaminants Act (Environment Canada, Health and Welfare Canada)	Section 4(1)	The Act gives the federal government authority to investigate and collect information on commercial chemicals pertaining to all facts of production, use, and release into the environment. Arsenic compounds are currently being investigated to determine the nature and extent of the danger that they pose to human health and the environment.
	Section 8	Pursuant to Section 8 the federal government may develop regulations prescribing the maximum quantity of a substance which may be released and the conditions under which the substance may not be imported, manufactured, processed, offered for sale or used.
1.3 Pest Control Products Act and Pest Control Regulations (Agriculture Canada)	Section 5	The Act regulates products used for the control of pests and organic functions of plants and animals. Examples of products are insecticides, fungicides, mulluscides and herbicides. The Act requires that an importer exporter, manufacturer and distributor of a controlled product must register that product with Agriculture Canada. The Regulations prescribe the registration procedures, the information required to be submitted with an application and they define restrictions on the formulation and composition of the products, packing and labelling, product distribution and product use. ACA wood preservation products are fungicides and must be registered with Agriculture Canada.
1.4 Ocean Dumping Control Act Ocean Dumping Regulations	The Act Section 5	The Act provides the federal government the authority to restrict the dumping of scheduled substances into Ocean waters.
(Environment Canada)	The Regulations Section 5	Arsenic and its compounds would be included under the category of "Restricted Substances" (pesticides and their by-products not included in Schedule 1). Such substances are considered to be potentially harmful and require special care when dumped into the marine environment.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
1.5 Transportation of Dangerous Goods Act and Regulations (Transport Canada)	Section 4 Section 5 Section 26	The Act was proclaimed in 1980 in order to promote public safety in the transport of dangerous goods, such as explosives, flammable materials and toxic chemicals. Sections 4 and 5 define the offences under the Act, and Section 26 provides the federal government the authority to develop regulations and standards. Regulations published in 1985 identify specific requirements for documentation (manifests and waybills), packaging and labelling for nine classes of dangerous goods and wastes.
1.6 Clean Air Act (Environment Canada)	Section 7(1) Section 31	An Act relating to ambient air quality and the control of air pollution. No specific regulations for arsenic.
2. Alberta		
2.1 Clean Water Act (Alberta Environment)		Act provides the legislative basis for the protection of surface and fresh groundwater.
2.2 Clean Air Act (Alberta Environment)		Legislative basis for the protection of ambient air quality and control of air pollution.
2.3 Hazardous Chemicals Act Hazardous Waste Regulations (Alberta Environment)		The disposal of hazardous waste is controlled under this Act and Regulations.
3. British Columbia		
3.1 Waste Management Act (Waste Management Branch of the B.C. Ministry of Environment)	The Act	The Act provides the Waste Management Branch with the legislative basis for overall management of industrial wastes for the protection of the environment. The Act was passed in 1982; however, as of 1987 no regulations had been promulgated.
	Section 3	A permit or approval from the Waste Management Branch is required to discharge a waste into the environment (applies to liquid effluent discharges, air emissions and solid wastes).
	Section 4	Storage of "special wastes" in excess of specified quantities must be authorized by a permit.
	Section 5	The generator or owner of a waste must complete a manifest form and meet other requirements before transporting special wastes.
	Section 10 Section 22	All industries that handle hazardous materials may be required to prepare a contingency plan. The Waste Management Branch can issue an "order" for a company to investigate the risk to the environment posed by its handling of a polluting substance or the environmental effects of a spill, or to conduct remedial and abatement measures.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
3.2 Environmental Management Act - B.C.	The Act	
	Section 5	Declaration of environmental emergency.
	Section 6	Recovery of costs associated with environmental emergency.
3.3 Pesticide Control Act and Regulations (Pesticide Control Branch of the B.C. Ministry of Environment)	The Act	The Act and Regulations are designed to ensure that pesticides are sold and used safely according to label directions in a manner that will not produce an unreasonable adverse effect to the environment.
	The Regulations Section 4	The application of a pesticide on public land must be conducted by a certified pesticide applicator. A certified pesticide applicator has successfully completed a course and examination in a speciality field conducted by the Pesticide Control Branch.
	Section 28	There are no specific regulations for the control of ACA at wood preservation facilities.
3.4 Workers' Compensation Act Industrial Health and Safety Regulations - B.C. (Workers' Compensation Board (WCB))	The Act	The Act designates the WCB as responsible for the prevention of injuries and industrial diseases to workers at their place of employment. The Act empowers the WCB to make regulations that may apply to employers, workers and all persons working in or contributing to the production of any industry within the scope of the Act.
	8.18*	Adequate direction and instruction of workers.
	8.20	Supervisors are responsible for the proper instruction of workers under their direction and must ensure the work is performed without undue risk to the worker.
	12.01	Signs indicating the presence of hazardous chemicals at facilities.
	12.03	Storage of hazardous chemicals and design and labelling of containers.
	12.05	Emergency wash facilities.
	13.01	Exposure to airborne arsenic, copper and chromium, and measures to mitigate excessive exposure.
	13.05, 13.07	Tests to determine unsafe conditions.
	13.09	Protective measures where workers are in a confined space with unsafe atmosphere.
	13.07	Ventilation and testing for confined areas.
	13.37	Design of ventilation systems.
	13.43	Location of exhaust ventilation systems.

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* Only certain regulations are highlighted. Many other regulations are applicable, including 8.02, 8.04, 8.22, 8.32, 8.52, 8.58, 8.72, 8.74, 8.84, 12.11, 13.41, 13.57, 14.01, 17.03, 17.05.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)		Relevant Sections	Comments
3.4	Workers' Compensation Act Industrial Health and Safety Regulations, cont'd	13.47, 13.49	Restrictions on the recirculation of contaminated exhaust air.
		14.16, 14.18, 14.21	Protective equipment for workers handling treatment chemicals or treated lumber.
		14.23	Provisions for respiratory protection equipment.
		68.46	Special procedures for dealing with fires involving arsenic compounds.
		76.29	Chemical spills shall be cleaned up under the supervision of persons who are knowledgeable of the hazards of such spills and the precautions to be taken.
4.	**Manitoba**		
4.1	Dangerous Goods Handling and Transportation Act and Regulations (Environment and Workplace Safety and Health)	Section 8 Section 9 Section 12 Section 31 Section 32	The Act was proclaimed August 1984 and provides the legislative basis covering all aspects of handling dangerous goods including their manufacture, use, storage, transportation and disposal. Sections 31 and 32 cover penalty provisions and offences. Section 40 provides provincial government the authority to develop regulations.
4.2	Clean Environment Act and Regulations - Environment and Workplace Safety and Health	Section 14	A proposal must be filed with the department for the establishment of any operation that will release contaminants into the air, water or soil. Subsequently, the operation will receive a Clean Environment Commission order setting out limits, terms and conditions for the process. In the absence of a central hazardous waste management system and facility, such an order will be required for the operation of a wood preservation facility in Manitoba. NOTE: This legislation is in the process of change - but approval will still be required.
5.	**Ontario**		
5.1	Dangerous Goods Transportation Act (Ministry of Transportation and Communications)		The Act permits the Ministry to enact regulations to supplement those promulgated under the Federal Transportation of Dangerous Goods Act.

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.2 Environmental Protection Act (Ministry of the Environment)		The Act provides the legislative basis for the protection of the environment.
	Sections 12 and 14	The Ministry of the Environment must be notified if a discharge is greater than the permitted level, or is likely to harm the environment.
	Sections 80 and 81	Spills likely to harm the environment must be reported to the Ministry, the municipality and company management. Remedial action must be taken.
	Section 84	Disposal of spilled material may be regulated by the Ministry.
	Section 136(1)	The Ministry may regulate the discharge of a contaminant or the modification of waste treatment facilities.
	Section 136(7)	Any occurrence in compliance with the Ontario Water Resources Act or the Pesticides Act is not a "spill".
Air Pollution (Control) Regulations	Section 9	The Ministry must be consulted if a process upset results in excessive emissions.
	Section 10 Also Section 6	The use of treated wood wastes in a boiler is legally questionable.
Spills Regulations		Sets out procedures for compensation of persons affected by a spill; but only if the Pesticides Act and other applicable federal, provincial and municipal legislation has not been complied with.
Waste Management General Regulation	Section 15	Generators of waste must be registered with the Ministry.
	Section 16, 20-23	Waste must be properly disposed of, and all prescribed manifests kept.
	Schedules 1 and 2	Sludge from the effluent treatment plant is a hazardous industrial waste.
Guidelines for Environmental Protection Measures at Chemical Storage Facilities		Code of good practice for storage tanks.
5.3 Health Protection and Promotion Act (Ministry of Health)		The medical officer of health may inspect, receive complaints and issue orders or directions in case of a health hazard.
5.4 Lakes and Rivers Improvement Act (Ministry of Natural Resources)		The Act provides for the protection of water bodies and for their equitable public and private use.
	Sections 37 and 38	The Ministry of Natural Resources may order a mill not to discharge any refuse, sawdust, chemical, etc.
	Also Section 39	

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.5 Ontario Water Resources Act (Ministry of the Environment)		The Act provides for the preservation of water purity, and governs the operation of water and sewage works.
	Sections 14-16	Discharge of any substance that may impair water quality is prohibited, and an ex parte injunction may be obtained against it.
	Section 18	The Minister may order the maintenance of equipment or chemicals necessary to alleviate impairment of water quality.
5.6 Pesticides Act (Ministry of the Environment)		The Act regulates the elimination of pests, and all use and handling of pesticides.
	Section 4	The use of a pesticide such that excessive harm is caused to the environment is prohibited.
	Section 28	Provides for the enactment of regulations governing the transportation, handling, storage and use of pesticides, the type, labelling and disposal of containers, and decontamination.
	Also Sections 20, 21 and 23	
Pesticides (General) Regulations	Section 24	A pesticide must be kept in the proper container, which must be properly labelled.
	Sections 25 and 26	Empty pesticide containers must be properly disposed of, damaged containers must be replaced or disposed of and spillage cleaned up.
	Section 27	If a pesticide is involved in a fire, theft or other unusual occurrence, the Director (Pesticides, MOE) must be notified.
	Section 98	Pesticides must be kept away from human or animal food.
	Section 99	Pesticides on schedules 1, 2 and 5 must be stored in a room which is vented to the outside, with doors marked "Chemical Storage - Authorized Persons Only" and which is accessible only to authorized persons.
	Also Sections 105 and 106	

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
5.7 Occupational Health and Safety Act (Ministry of Labour)		The Act governs protection of health and safety in the work place.
	Sections 14-17	Employer shall provide necessary equipment, educate workers, disclose all hazards, maintain occupational health service, keep records of chemicals used, including exposure records. The use of new chemicals must be reported, the levels of chemicals must be monitored and kept below a prescribed level. Supervisor must ensure that workers comply with health and safety procedures. Workers must use protective equipment provided, and inform the employer of any unsafe situations.
	Section 20	The Ministry may regulate the use of, and exposure to any toxic substances.
	Section 41 (1) and (2)	Provides for the specific regulation of exposure to chemicals.
	Also Sections 23, 24, and 28-33	
Industrial Establishments Regulations	Section 66 (1)	Piping containing a hazardous substance shall be labelled at valves, fittings, etc.
	Sections 83, 85 and 88	Workers must be provided with equipment protecting them from skin and eye injury, and be trained in its use.
	Setions 128 and 129	Eyewash fountains and deluge showers must be provided.
	Sections 131 and 132	Work place must be adequately ventilated.
	Sections 134 and 135	Workers shall be trained in the use of chemicals, use of protective equipment and emergency procedures. Food, drink and tobacco not permitted near poisonous substances.
	Section 145	All measures necessary to prevent exposure to toxic substances shall be taken.
	Also Sections 14, 15, 26, 27, 71-74, 139, 141(b), and 142	
Regulations Concerning Exposure to Chemical and Biological Agents		

TABLE A.1 SUMMARY OF LEGISLATION REGULATING THE USE OF AMMONIACAL COPPER ARSENATE (Cont'd)

Legislative Act (Responsible Agency)	Relevant Sections	Comments
6. Quebec		
6.1 Loi sur la qualité de l'environnement (Environmental Protection Act) (Ministry of Environment)	Article 1	Contaminants are defined in the following manner: a solid liquid or gas, or any combination of these that could alter in some manner the quality of the environment.
	Article 20	This article states that no person may emit, dispose of, release or discharge, or permit the emission, disposal, release or discharge, into the environment of a contaminant that could affect human life, health, safety, security, welfare or comfort, or cause damage or otherwise compromise the quality of soil, vegetation, wildlife or property.
	Article 21	The Deputy Minister of the Environment must be notified immediately of any incident that causes the presence of a contaminant in the environment.
	Hazardous Wastes Regulation (A.C. 1000-85)	This regulation defines bottom sediment sludges from the treatment of wastewaters from wood preserving processes that use creosote, pentachlorophenol or inorganic components containing arsenic, as being a category of hazardous wastes.
	Solid Waste Regulations (R.R.Q. 1981, C.Q. - 2, r.14)	Any leachate containing contaminants (chromium, copper, phenolic compounds) above the standards prescribed must not be discharged into the hydrographic surface network or into a storm water sewer.
6.2 Loi sur la santé et la sécurité du travail (Occupational Health and Safety Commission) (L.R.Q., chap. S-2.1)		This act establishes mechanisms to permit the participation of workers and employers in the elimination of causes of accidents and occupational illnesses. The act gives to workers the right to take leave if exposure to a contaminant poses a danger to them, as evidenced by signs of health effects.
	Industrial and Commercial Establishments Regulation (R.R.Q. 1981, chap. S-2.1 r.9)	This regulation prescribes general standards of health and safety for industrial and commercial premises. The scope of application includes the state of workplaces, working conditions such as ventilation, lighting, noise and vibration, control of hazardous substances and radiation, equipment and individual protection.
	Regulation on the Quality of the Workplace (R.R.Q. 1981, chap. S-2.1, r.15)	This regulation applies to the presence of dust, gases, fumes and vapours, lighting, temperature, noise, ventilation, etc.
6.3 Code de la sécurité (Highway Safety Code) (Ministry of Transport)	Transport of Dangerous Substances Regulation (C-24.1, r.19.01)	This regulation protects the public during the transport of dangerous goods. Documentation, packing, and signing for dangerous goods are specified.

TABLE A.2 EMERGENCY CONTACTS (ACA Treatment Facilities)

Incident	Contact
Spills to marine waters	Environment Canada - Local office
Spill to freshwaters containing anadromous fish (e.g., salmon) or Spills on federal or indian lands	Environment Canada - Local office and Provincial Emergency Program - Local office
Spills to land during transport (more than 5 kg or 5 L of ACA or ACA wastes, arsenic acid or ammonium hydroxide)	Provincial Emergency Program - Local office
Ingestion of creosote or exposure to high concentrations of ACA, arsenic acid or ammonium hydroxide	Local Hospital and Poison Control Center (additional information)
Fire	Local Fire Department
Emergency response information	• J.H. Baxter and Co. (415) 349-0201 • CANUTEC (24-hour) (613) 996-6666 - call collect

TABLE A.3 GENERAL INFORMATION CONTACTS (ACA Treatment Facilities)

Subject	Contact
Compliance with Federal Environmental Legislation	Environment Canada - Local office
Transport of Dangerous Goods Act (questions of consignors, manufacturers, consignees, warehousers, freight forwarders, brokers, etc.)	Local Regional Inspector Transport of Dangerous Goods Transport Canada
Railway Transport	Local Dangerous Goods Coordinator and Chief, Operations Railway Transport Committee
Transport of Dangerous Goods Road Transport	Local Director, Administrator and Road Safety Motor Vehicle Department
Product Information	J.H. Baxter and Co. (415) 349-0201