APPENDICES

1.00 PRESERVATIVES USED IN REMEDIAL TREATMENTS

Copper naphthenate an organometallic compound of copper and naphthenic acid.

Colour	Bright green
Acute toxicity:	LD_{50} >5000 mg/kg, dermal LD_{50} >2000mg/kg
Efficacy:	Broad range activity against wood decay fungi and wood destroying insects.
Solubility:	Readily soluble in hydrocarbon solvents, very low solubility in water. Relatively stable and leach resistant in wood.
Use:	Used here and overseas with oils to treat utility pole, in light organic solvents as a preservative (LOSP) for timber uses not in contact with the ground, probably best known as the brush -on preservative"Metalex"green.

Oxine Copper an organometallic compound of copper, also known as copper-8-quinolinolate

Colour	Pale green
Acute toxicity:	Oral LD50 4000mg/kg
Efficacy:	Broad range activity against wood decay fungi and wood destroying insects.
Solubility:	Very insoluble in water and most organic solvents. Oil soluble and water-soluble formulations have been developed. The water-soluble formulation is corrosive to metals. Stable and leach resistant in wood.
Use:	Principally in water-soluble formulations as an antisapstain treatmentforfreshlysawntimber.Usedinoil-basedformulations as a preservative treatment for above ground applications overseas. The fungicide in CD50. Copper quinolinate is the only timber preservative that is OK for food-preparation surfaces

Busan. Various formulations of 2 (thiocyanomethylthio) benzothiazole (TCMTB) an organic biocide.

Acute toxicity:	Oral LD_{50} 1590 mg/kg
Efficacy:	Broad range activity against wood decay fungi and wood destroying insects.
Solubility:	Readily soluble in hydrocarbon solvents, very low solubility in water. Emulsifiedformulationsgenerallyused. Relativelystable and leach resistant in wood.
Use:	Emulsion formulations used for antisapstain treatment of freshly sawn wood and occasionally as a surface applied

preservative. Busan Pole-Gel is used in bandages for the treatment of groundline decay in utility poles.

Polyphase . An organic biocide 3-iodo-2-propynyl butyl cabamate (IPBC).

Acute toxicity: Oral LD_{50} > 1580 mg/kg, dermal LD_{50} >2000mg/kg

Efficacy: Broad range activity against wood decay fungi but not effective against wood destroying insects.

Solubility: Readily soluble in hydrocarbon solvents, very low solubility in water.

Use: Principally used as a mouldicide in coatings, as a component in antisapstain formulations for treatment of freshly sawn wood and as a fungicide in LOSP formulations for treatment of wood in above ground applications. The active ingredient in Woodlife II.

Boron. Various compounds based on borax and boric acid which form boric acid in the wood.

Acute toxicity: (disodium octaborate tetrahydrate) Oral LD_{50} >3000 mg/kg, Dermal LD_{50} >5000mg/kg

Efficacy: Broad range activity against wood decay fungi and wood destroying insects.

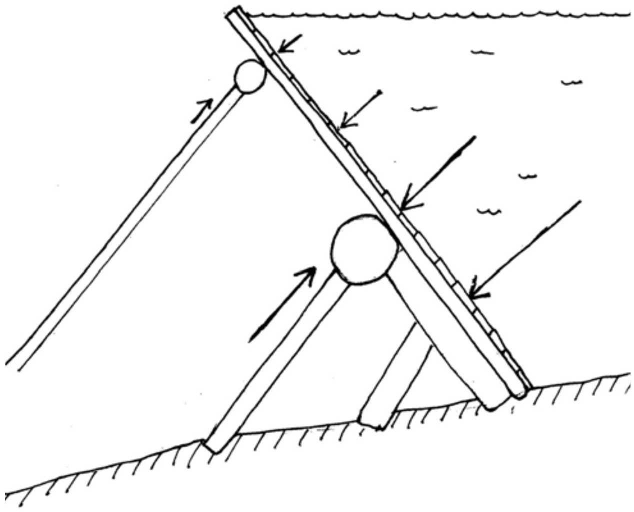
Solubility: Soluble in water. Will diffuse readily into the sap wood of most timber species and will also leach out in wet conditions.

Use: Widely used for the treatment of framing timbers in New Zealand and in remedial and insect preventative treatment of structures in other countries.

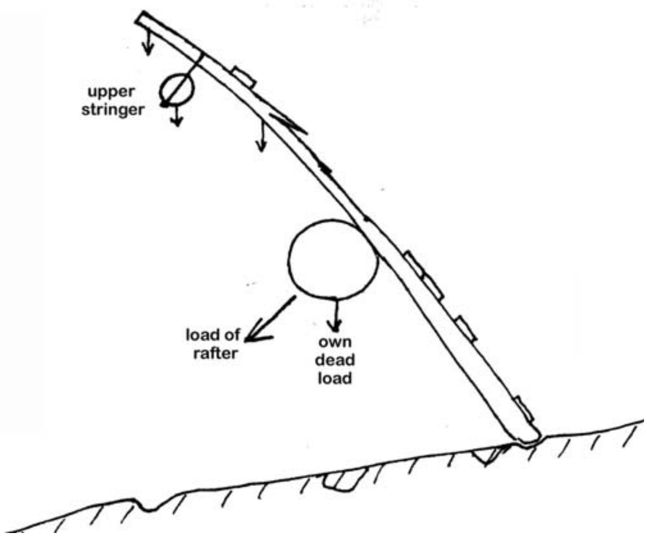
2.00 Kauri driving dams

Kauri driving dams pose special problems in timber preservation. The following notes and diagrams are concerned with so-called rafter dams, in which the rafters are upstream of the stringers and carry the horizontal planking. The same principles apply to stringer dams, in which the stringers are upstream of the rafters and carry vertical planking.

Fig. 28: Driving dam loads



a) Full



b) Empty

Driving dams were designed to withstand a powerful lateral force - the hydrostatic pressure generated by the water on the upstream side of the dam. Inclined backlegs were built downstream to oppose the hydrostatic pressure, and the plane of the dam was inclined upward and outward to prevent the combination of hydrostatic pressure and opposing resistance of the backlegs lifting the dam out of its footings [fig. 29]. Unfortunately the backlegs were generally made from inferior timber, and most of them have now rotted beyond recovery. The now-empty dams today constitute highly asymmetrical structures ill-designed to withstand the vertical dead loads they are subjected too [fig. 28].

This situation is aggravated by the condition of the upper stringers. In service these had to withstand less hydrostatic pressure than did the main stringer, so originally had much less diameter than the main stringer, even though they had to span a greater width of valley than the main stringer [fig. 30a]. To achieve the necessary length the dam builders had to leave more of the butt-wood and head-wood than is desirable [fig. 32]. Much of the head-wood was sap, and has now rotted away completely, while the butt wood is prone to butt-rot, so that upper stringers nowadays are badly rotted at both ends and are not even carrying their own deadweight, let alone helping to hold up the rest of the dam [fig. 30b].

The normal situation now is that the weight of the upper stringers is being carried by the rafters, which means they are being bent downstream and are likely to snap, while the aggregate weight of the upper stringers plus the rafters and any planking is mostly being carried by the main stringer.

The main stringers originally carried by far the greatest hydrostatic load and, in addition, had to withstand all the stresses from the gate suddenly opening and logs smashing their way through whenever the dam was tripped. They were therefore made from massive logs of good quality, with butt wood and head-wood removed. Even so they are now starting to show the strain of carrying the deadweight loads for which they were not designed. An examination of most

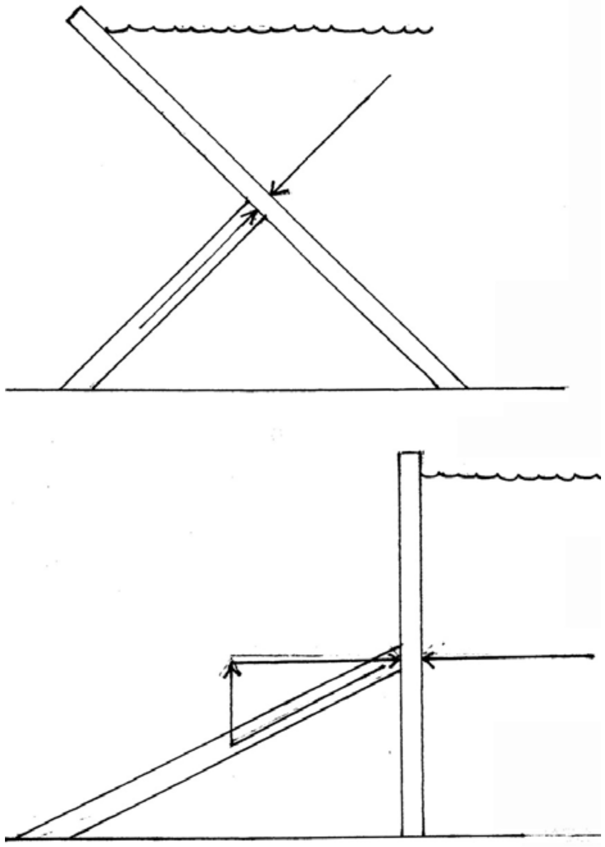
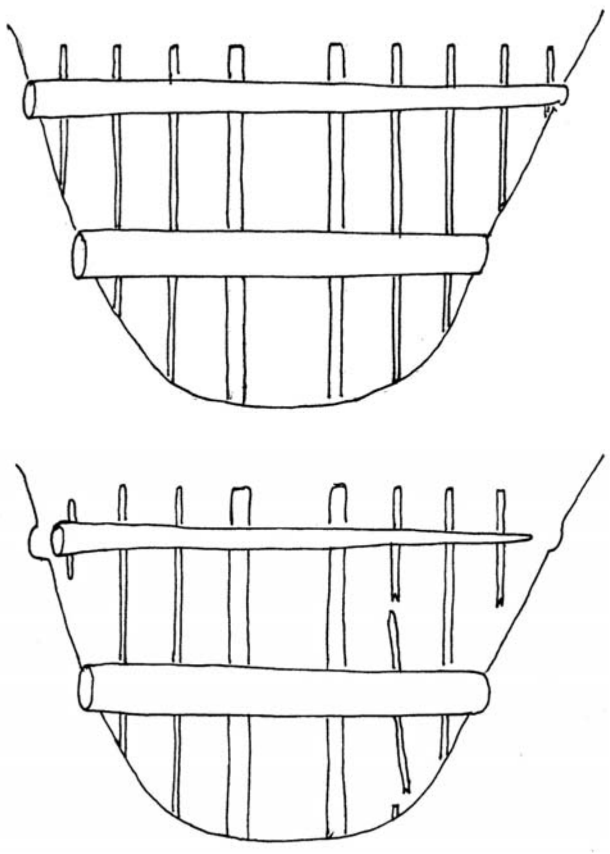


Fig. 29: Dam hydraulic pressure



Figures 30a &30b: Damn stringers

of the still standing and recently collapsed dams in the upper Kauearanga valley shows that after flood and landslip damage the principal mode of failure in kauri dams is rupture of the main stringer, generally by a long diagonal splintering fracture. Once the main stringer fails the entire dam is lost.

The most urgent need by far in any stabilisation operation with kauri dams is to relieve the main stringer of as much deadweight as possible and then to start pre-serving as much of the main stringer fabric as possible. The quickest, easiest and cheapest way to relieve dead load is to prop the main stringer from underneath. A better way of doing it, in keeping with the original design of the dam, is to install new backlegs for both the main stringer and whatever remains of upper stringers. Back-legging the upper stringer will also relieve the bending loads on the rafters, and will thereby remove some load off the main stringer. (On stringer dams the backlegs will support the rafters directly and the stringers indirectly.) Old power poles may be available to use as backlegs, otherwise H4 roundwood poles will do - they have the big advantage of being lighter.

The gate planks, hanging from unsupported middle of the main stringer, are a real killer. Even worse the line of big staples that hold the wire ropes to which the gate planks are attached provides the potential line of weakness for splintering to occur. There needs to be vertical propping up of the stringer, either using the gate planks themselves, or putting in a couple of unobtrusively-positioned acro-props.

The next most urgent task is to provide as much internal preservative protection for the main stringer as is possible. Rot will probably be worst at the butt end, where the stringer is likely to be hollow for some distance.

A hollow stringer can still have considerable strength. Hollow cylinders in theory are nearly as strong as solid cylinders, and have much less intrinsic deadweight. With a hollow log it is much more important to prevent reduction in the outside diameter of the log than to prevent enlargement of the diameter of the internal void.

The theoretical loss of strength due to rot on external surfaces compared to rot on internal surfaces is as follows:

% reduction of external diameter	remaining % original strength
10	73
20	51
30	34
40	22
centre rot as % of original diameter	
10	100
20	100
30	99
40	97
50	94
60	87
70	76
80	59

In other words a hollow equal to 70% of the outside diameter causes less loss of strength (24%) than does the loss of a mere 10% of the outside diameter itself (27% strength loss). The principal aim of preservative application therefore must be to prevent loss of external diameter, along the entire length of the stringer, but particularly at the ends. This is the case whether or not internal rot or a hollow is known to be present. It will involve the following:

1. Very liberal application of surface preservative to all accessible surface. Since depth of penetration is particularly important and since main stringers are almost by definition located in situations of perpetual dampness it may be preferable to use Polegel rather than KCN.
2. A carefully thought-out scheme for inserting diffusible preservatives. [See section 9.]

The existence of a large volume of internal rot or of a hollow can be detected by a combination of visual inspection, sounding exploratory drilling, and ultrasound scanning. Internal rot should be treated by insertion of diffusing preservative. A large hollow should be treated with foamed preservative. It will be necessary to somehow block off the open end of the hollow at the butt, which may not be easy, given that the butt end will be inserted in a slot in the bedrock. Given the importance of getting a good preservative loading, some leakage and environmental contamination will probably have to be accepted.

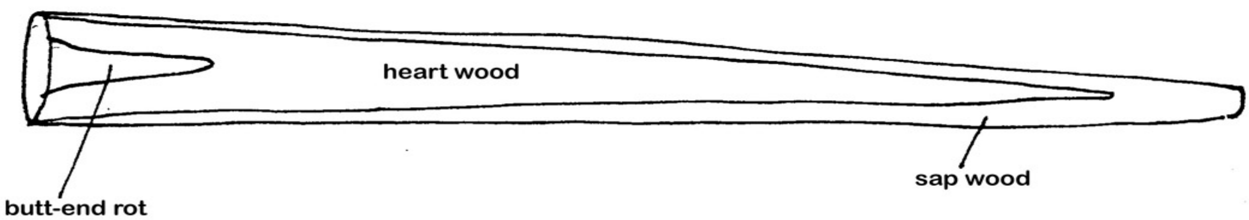


Fig. 31: Butt end rot in dam stringers

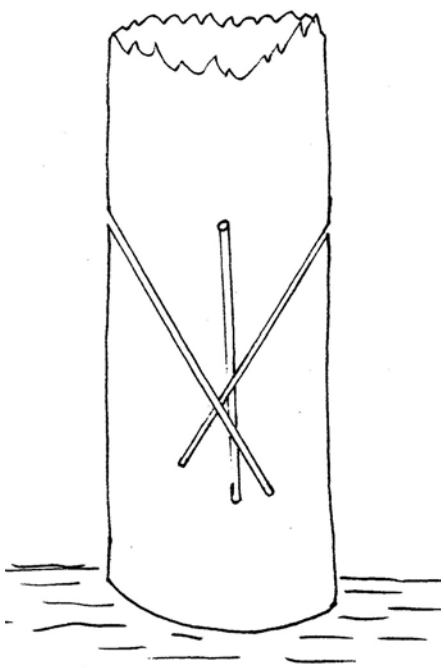


Fig. 32: Inserting diffusible preservative

After treating with foamed preservative consideration might be given to filling the cavities with rigid polyurethane foam (marketed in aerosol cans as "Space Invader"). This would strengthen the stringer, and provide an internal barrier against leakage inwards of diffusible preservatives circulating in the surrounding wood. A rigid foam fill would remove the necessity for periodic re-treatment with foamed preservative.

The other special problem situation with kauri dams is the lower ends of the rafters. These are generally sitting on bedrock, and are suffering end-grain rot in perpetually damp conditions. Pole bandaging in many cases is virtually impossible and is unlikely to be effective even if it were possible. The only thing that can probably be done to alleviate the situation is to bore holes diagonally into the timber near the lower end and fill with diffusible preservative, fig. 32.

[[Add material on jubilee clamping]]

3.00 TIMBERS

These are brief notes relating to the durability and use of the main species likely to be included in historical structures. More comprehensive references include New Zealand Timbers, exotic and indigenous, the complete guide: N.C.Clifton (GP Books, 1990) and Wood in Australia, Types, Properties and Uses: Keith R. Bootle (McGraw-Hill, 1983).

3.1 NEW ZEALAND KAURI (AGATHIS AUSTRALIS)

Widely used in all types of construction. Now classified as only moderately durable in ground contact (durability class 3), similar to rimu, matai and macrocarpa.

3.2 TOTARA (PODOCARPUS TOTARA, P. HALLII)

One of the most durable of New Zealand's timbers (durability class 1), totara was widely used for railway sleepers, fencing, foundation piles and poles as a result. It was also used in sheathing of buildings but its brittleness restricted its use in structural situations.

3.3 SILVER PINE, YELLOW SILVER PINE (LAGAROSTROBOS COLENSOI, LEPIDOTHAMNUS INTERMEDIUS)

The very durable heartwood (durability class 1) from these relatively small trees was widely used for railway sleepers, foundation piles, poles and fence posts.

3.4 KAWAKA, KAIKAWAKA (LIBOCEDRUS PLUMOSA, L BIDWILLII)

Originally used for much the same purposes as totara the lower durability of these species (durability class 3) later limited their use to less demanding uses such as exterior sheathing for buildings, roof shingles and boat planking. They were of even lower strength than totara and seldom used for structural components.

3.5 OTHER INDIGENOUS SOFTWOODS

Rimu (Dacrydium cupressinum), matai (Prumnopitys taxifolia) and miro (Prumnopitys ferruginea) were widely used in general construction. The heartwood of all of these species is only moderately durable (durability class 3), and where rimu or miro were used it is likely that non-durable sapwood would have been included. Kahikatea (Dacrycarpus dacrydioides), although having a reputation as being durable in wet conditions, is non-durable and is best known for its non-tainting sapwood, widely used in packaging such as butter boxes and particularly susceptible to attack by wood borers.

3.6 THE NEW ZEALAND BEECHES (NOTHOFAGUS FUSCA, N. MENZIESII, N. SOLANDRI, N. TRUNCATA)

Red beech (N. fusca) and hard beech (N. truncata) are durable hardwoods (durability class 2) and were widely used for railway sleepers, mining timbers, fencing and heavy construction. Silver beech (N. menziesii) usually has a lower proportion of heartwood which is less durable (durability class 3) and was occasionally used for sheathing but mainly in internal uses and furniture. Mountain beech (N.solandri var. cliffortioides) and black beech (N. solandri var. solandri) were used where they were locally common for much the same purposes as red and hard beech. Although their heartwood has the same durability rating as red and hard beech, they have a reputation for being less reliable.

3.7 PURIRI (VITEX LUCENS)

This very hard and durable timber was used for railway sleepers, piles, fencing and heavy construction such as bridges. Its irregular grain made it difficult to work and it frequently contained large holes left by the puriri moth larvae. Puriri was only available in the northern part of the country and in small quantities.

3.8 OTHER INDIGENOUS HARDWOODS

It was common for locally available species, not known for their durability, to be used in tramways, bridges, buildings and other structures that were expected to have a relatively short life e.g., until an area of bush had been logged. Hardwoods such as kamahi (Weinmannia racemosa), hinau (Elaeocarpus dentatus), rata (Metrosideros umbellata, M. robusta) mangeao (Litsea calicaris) and pukatea (Laurelia noveau-zelandiae) were often used in these structures and in the equipment needed to remove logs or other products from the forests.

3.9 DURABLE AUSTRALIAN HARDWOODS (REGAL HARDWOODS)

These very durable hardwoods (durability class 1) were imported for heavy construction wharves, bridges, transmission poles, crossarms and other uses where the requirements for high strength and very high durability could not be met by locally available species. They included the ironbarks (Eucalyptus paniculata, E. crebra, E. siderophloia), grey gums (E. propinqua, E. punctata), grey box (E. hemiploia), tallow wood (E. microcorys), white mahogany (E. acmenioides), red bloodwood (E. gummifera) and for marine piles, turpentine (Syncarpia glomulifera). While there was a requirement to label logs when they were felled, many consignments contained several species. This, and the fact that redundant timbers were often reused when structures were repaired, means that most structures will contain a mixture of species from the above group.

3.10 OTHER AUSTRALIAN HARDWOODS

Large quantities of general purpose Australian hardwoods were imported for structural uses where high strength was required but where the durability requirements were less critical e.g., railway sleepers, transmission crossarms, heavy construction. These were usually in durability class 2 or the upper end of class 3. They included jarrah (E. marginata), karri (E. diversicolor), blackbutt (E. pilularis), Sydney blue gum (E. saligna) and southern mahogany (E. botryoides). More recently these species, excluding jarrah and karri, have been imported as round transmission poles and marine piles with the sapwood preservative treated.

3.11 NEW ZEALAND GROWN EXOTIC SPECIES

Excluding preservative treated radiata pine there are other locally grown species with moderate durability that could be used to replace damaged or decayed timber in historic structures. All of these species are of limited availability so obtaining timber of the required quality and dimensions may be difficult or slow. The Eucalyptus species listed only grow well in the northern part of the country hence are probably not available in the south.

The cypresses, macrocarpa (Cupressus macrocarpa), Mexican cypress (C. lusitanica) and Lawson cypress (Chamaecyparis lawsoniana) are all in the same durability class as kauri and rimu. Macrocarpa and lusitanica heartwood is similar in color and texture to kauri and could be worth considering when repairing kauri structures.

Locally grown eucalyptus species with durability ratings of class 2-3 include white stringybark (E. globoidea), yellow stringybark (E. muelleriana), Sydney blue gum, southern mahogany and blackbutt. Sydney blue gum is probably the most widely planted of these but supplies are scattered and probably restricted to the North Island.

4.00 TRADITIONAL PRESERVATIVES

4.1 CREOSOTE

Creosote, patented in 1831, would easily be the most used timber preservative in New Zealand up until about 1950. The NZR began creosoting sleepers made of a variety of native timbers from 1886 onwards. Some sleepers creosoted prior to 1912 were still in service as late as the 1950s. The New Zealand Forest service showed quite early on that creosoted radiata fence posts would last 25 years in the ground.

A by-product of the coal gas industry, it is much less easily available than it was, but it is still imported and retailed in small packs. If it is known that a particular historic structure was originally treated with creosote and/or coal tar there is no reason why it should not continue to be coated in creosote, in the interests of historic authenticity. Stockholm tar [section 3.12], will make an excellent substitute for coal tar.

Creosote is an excellent fungicide and preservative. It has high fungal toxicity, it soaks into wood very readily, and it is insoluble in water and therefore does not leach out. Depth of penetration can be determined from direct observation without any need for indicator reagents. It confers little water repellency (but neither do most other preservatives).

It is hard to see why creosote has dropped so far out of favour in recent times. The usual reasons given are its unpleasant smell, its allegedly caustic effect on human skin, and the messy, dirty, sticky surface it imparts to wood for the first year or two after application. It is impossible to apply oil-based paint to creosoted wood. (There is no information about compatibility with acrylics)

It seems to be an accident of history that creosote went out of general use. In the 1950s, as quality native timbers began to run out, New Zealand was forced into a crash programme of finding ways of using the lower quality native timbers and radiata pine. A preservative was needed which was compatible with paint. This led to reliance on first pentachlorophenol (PCP) and later copper-chrome-arsenic (CCA) pressure treatments. Boron diffusion was developed for borer control. These seemed better on aesthetic or cosmetic grounds than messy, smelly old creosote which therefore fell into disfavour, even for fence posts and railway sleepers. By the time the environmental and health hazards of PCP (a polychlorinated hydrocarbon of the same ilk as DDT and dioxin) and CCA were appreciated, creosote was no longer being produced, as coal gas was giving way to Kapuni and then Maui natural gas. The NZR disposed of its stockpile of creosote in the 1970s. PCP was banned, and total reliance was placed on CCA. When pressure for more environmentally-friendly preservatives developed in the 1970s the FRI chose to investigate quaternary ammonium salts (or “quats”) as a CCA substitute rather than re-investigate creosote. The quats were not up to the job, and so we are stuck with CCA, and arsenic and chromium levels must be slowly building up in New Zealand farmland as CCA-treated posts start to decay.

There is still a standard specification for creosote - NZSS 401, "Coal-tar creosote for the preservation of timber".

Creosote has a reputation as being unhealthy stuff to work with, but this is based on its smell and appearance more than anything else. According to a 1950 Forest Service publication (which possibly overstates the case!) "... creosote is one of the least hazardous substances used in industry, and ... the handling of creosoted timber is not a dangerous occupation". The NZFS quoted American and British works which dismissed fears that creosote caused serious skin inflammation or cancer.

As far as possible health hazards are concerned, the general obnoxiousness of creosote is the best thing it has going for it. It is self-policing, so to say. It smells and looks so bad that no-one takes any chances about getting it on or in their body, and if by mischance they do they will take immediate steps to get it off or out. Warm water and soap are all that are needed for external first aid. Vomiting (which will probably come naturally without any emetic other than the creosote itself) is the appropriate response to ingestion. Working with it in an unventilated enclosed space is unthinkable. To cut down on the fumes application of creosote is best done in cool weather. One disadvantage of creosote is that it considerably increases the flammability of recently treated timber.

Creosote is still being manufactured overseas as a bi-product of coke-making for the iron and steel industry. It is retailed in small packs in New Zealand and no doubt is available in 200 litre drums.

Small scale tests are underway on Tauranikau dam and on the subfloor framing of the author's 1940s untreated radiata house.

4.2 TAR

Coal tar was widely used to coat early timber structures, and remnants of tar coating will often be found on structures undergoing stabilisation. The tar was, however, being used more as a form of paint which kept water out of the wood, and it was never regarded as a penetrating fungicidal preservative.

There is a temptation to re-coat historic structures with coal tar in the belief that it has preservative properties, and in the interests of historic authenticity. This will not work, for three reasons:

(a) coal tar has minimal fungicidal effect,

(b) coal tar, a bi-product of town gasworks, is no longer readily available,

(c) a fresh coat of coal tar will not adhere to old weathered damp wood any more than conventional paint will.

If something that looks and smells like tar is wanted, it is suggested that the structure be first treated with creosote, (which consists of fungicidal oils distilled from coal tar) and then with Stockholm tar. Stockholm tar is distilled from wood, and has modest fungicidal and water-repellent properties. It tends to penetrate and adhere to old timber more readily than coal tar, but less readily than does creosote. Tests in Sweden showed that it gives good protection against fungal rot, although it is not a good water repellent.

A small scale test is underway at Tauranikau.

4.3 OLD SUMP OIL

There are still people around who are adamant that old sump oil is as good a wood preservative as you will ever find. It was the preservative of choice for unpainted weatherboard sawmill houses on the West Coast until the 1950s. Oil from diesel engines is supposed to better than oil from petrol engines. Tests in Sweden showed it to have a surprisingly high fungicidal effect, although it conferred little water repellency. The old New Zealand Forest Service recommended old sump oil as a carrier for copper naphthenate. A small scale test is underway at Tauranikau.

4.4 RED LEAD

Red lead oxide in boiled linseed oil was another traditional surface coating for both timber and steel structures. It has good fungicidal and insecticidal properties, although of course it is now regarded as hazardous to health and to the environment. Where it is still present it should be left. If it is still sticking to the wood after waterblasting then it isn't doing any harm, and it may be doing some good, and it will not impede the entry of modern preservative.

4.5 PENTACHLOROPHENOL

5.00 SOURCES OF SUPPLY

This Appendix lists the various materials and services needed for historic timber preservation in more or less the same order as they are mentioned in the main text. A supplier for each item is given. Contact details about the suppliers are in a second list. Often this is the wholesaler or manufacturer, who should be contacted to find the most convenient local stockist.

5.1 MATERIALS AND SERVICES

5.2 SUPPLIERS

Preliminaries

Sodium sulphide
Increment borers
Identification of wood
Surface preservatives
Copper naphthenate concentrate
Copper naphthenate emulsion
Creosote (ordinary)
Creosote emulsion

Internal preservatives etc.

Boron foam
Boron paste
Boron rods
Polyurethane foam, 750 ml aerosol cans
Plugs, plastic, for closing diffusible insertion holes

Groundline and waterline preservatives

Bandages
Bituminous mastic
Petrolatum tape
Geotextile
Plastic membrane for in-water piles
Marine-grade densotape
Concrete grout for casting round in-water piles
Polegel cartridges
Polegel, 20 l pails

Special situations

Butynol

Rust-inhibiting grease

Blue 7

Fish-oil

Lead sheeting

Fish oil

Boron powder

Other treatments

Polyvinyl butyral consolidant solution

Polyvinyl butyral resin

Acetone

Epoxy consolidant Ever-dure

Water repellents

Shrink tape

Permethrin

Colour standard chart.

Assays for copper-based preservatives

Assays for boron-based preservatives

spot test for copper

Spot tests for boron

Spot test for boron and copper

COPPER NAPHTHENATE FOOTNOTES

6 The tests at Waikino have shown that CNE is reasonably cheap on a per-square-metre basis.

7 Assays of bridges treated several years ago in Waioeka gorge indicate that CNE provides surface protection equal to that of H3 radiata for at least 8 years. Similar assays of Busan-treated structures have given less conclusive (though not necessarily unsatisfactory) results.

8 As a copper based preservative the effectiveness of treatment is very easily tested by assay, at about $15 a sample. Busan assays, by contrast cost at least $120 each. There is a simple spot test for copper, but none for Busan.

GLOSSARY

An asterisk indicates that the term, although used in this manual, is not in general usage. Preferred terms are explained. Alternative terms and synonyms are listed, with a cross-reference to the preferred term.

abutment:	The end of a bridge, where the bridge, or its land-span, rests on the ground. See figures 1-4.
Acro-prop:	A galvanised tube, generally about 3 m long with length adjustable by means of a threaded end-piece, used for supporting scaffolding, form work during construction etc.
assay:	Laboratory determination of the amount or proportion of a particular substance in a sample.
baluster:	Vertical post supporting a handrail. See fig. 2.
bay:	A bridge truss is made up of several bays, each bay consisting of the rectangle lying between two sets of truss rods. See fig. 1.
beam, floor:	On NZR Howe truss bridges, transoms were called floor beams.
beam, main:	The longitudinal beams stretching from pier to pier and carrying the decking (on a road bridge) or sleepers (on a rail bridge, where they are also called rail beams), figures . 3, & 22. When the beams rest on transoms (as in truss and suspension bridges) they are referred to as stringers.
beam, rail:	See beam, main
beam, straining:	A beam underneath a bridge main beam and between opposing understruts. See fig. 3b.
block, “A”:	A compression block set into the top chord of a Howe truss to transfer thrust from the strut to the several flitches of the chord. See figures 1 & 21.
block, packing:	A piece of timber filling in a space between two other timbers. See packing.
block, reaction:	Apparently another name for an “A” block.
block, saddle:	The block which transfers stresses between the truss rod, the top chord, and the truss brace of a Howe truss. See figures 1 & 21.
block, thrust:	Equivalent to an “A” block, but set into the bottom chord. See figures 1 & 27.
bolt, strap:	A bolt with a flattened end, used for example to fasten a cap to a pile top.
boron:	Fifth element in the periodic table, hence has a very small atom which diffuses readily. Used as a fungicide insecticide and fire retardant in timber, generally as mixtures containing disodium octoborate, which breaks down with water to form boric acid.

brace (or bracing):	A secondary element of a structure which stiffens the primary elements.
brace, beam*:	A diagonal brace between a pier and a main beam which provides support to the beam. See fig. 3.
brace, longitudinal:	A horizontal beam running between adjacent piers to stiffen the piers. See fig. 3.
brace, sway:	
brace, transverse:	A length of timber or (on NZR bridges especially) an old railway line which braces the piles or studs of a pier. Both horizontal and diagonal braces are needed. See fig. 3.
brace, truss:	The external brace connected to a transom outrigger to provide lateral stiffening to the truss. Also known as a wind brace. See fig. 2 & 21.
brace, wind:	a horizontal diagonal brace under the decking or over the carriageway to prevent a bridge span swaying in the wind.
Busan:	Brand name for a range of fungicides made in the US by Buckman Laboratories, based on the fungicide TCMTB.
Busan 30L:	A timber preservative in which the active fungicidal ingredient is TCMTB at 30% concentration. It is water-miscible.
cap, pile:	A horizontal timber which sits across the tops of piles or studs and supports the corbels. See fig. 22.
CCA:	Copper-chromium-arsenic, the preservative used in pressure treatment of radiata pine for fenceposts etc. Often referred to as “tanalising”.
CD50:	Copper-8-quinolinolate. An oil dressing for cedar weatherboards etc., containing copper quinolinate as a preservative, sold by Churton Distributors of Auckland.
checks, checking:	Longitudinal cracks and fissures opening up on timber surfaces in response to weathering.
chord:	The main horizontal longitudinal components at the top and bottom of a truss. The top chord is under compression and is generally made up of several flitches. The bottom chord is under tension and is often made of two steel plates. See fig. 1.
CNE*:	Abbreviation for copper naphthenate emulsion. An emulsified fungicide formulation designed to improve sustained, deep penetration into wood.
CNL*:	Copper naphthenate liquid. A wood preservative containing copper naphthenate in a liquid formulation.

consolidant:	A dilute solution of a synthetic resin which soaks into timber then sets hard, thus strengthening the timber as well as reducing its permeability to moisture.
copper naphthenate:	A fungicide. See CNL and CNE.
copper quinolinate:	A fungicide, the active ingredient in CD50.
corbel:	A timber on top of a pier which spreads the support provided by the pier to the main bridge beams. See figures 20 & 21.
counter:	See strut, counter.
creosote:	A fungicidal wood preservative distilled from coal tar.
CSIRO:	Commonwealth Scientific & Industrial Research Organisation, Australia.
Densotape:	A synthetic fibre tape liberally coated with petrolatum and corrosion inhibitor. Moulds to fit odd shapes, hardens slowly on exposure. Used within DOCprincipally to wrap turnbuckles, shackles etc. on suspension footbridges.
DMAD:	Dimethylamide modified fatty acids. A powerful solvent which helps preservative penetrate into wood.
extractives:	Substances deposited in the cells of heartwood such as gums, resins, tannins etc. Some are natural fungicides and confer durability. Called extractives because they are easily extracted with solvents.
falsework:	Temporary framework to hold up a bridge while it is under repair.
fibre saturation point:	(FSP) The moisture content at which the wood cell walls become saturated. Above this moisture content water accumulates incell lumens (space or void in the cells).
fishplate:	Any steel strap bolted between two components to hold them in a alignment (especially the plates used to connect consecutive rails in a railway). See fig. 12.
flitch:	A long timber much deeper than it is wide. Chords and struts on a Howe truss are made up of several flitches separated by spacers. See figures 1 & 2.
FRI:	The former Forest Research Institute of the New Zealand Forest Service. Now called Forest Research (FR).
fungicide:	A chemical which kills fungi. More particularly in this manual, one which kills rot fungi. Some fungicides are much more efficient than others, but a good fungicide does not necessarily make a good wood preservative, and a good preservative does not necessarily contain the most efficient fungicide.

grain, side*: Timber surfaces which are parallel to the grain are here referred to as side-grain surfaces.

grainend: The grain exposed in the transverse section of timber.

hardwood: Timber from a broadleafed tree, e.g., eucalypt, native beech or oak. The timber is not necessarily hard (balsa is a hardwood). Hardwoods are characterised micro-scopically by large vessels which provide good longitudinal permeability for fungicide. (see also softwood)

Howe truss: A truss for supporting bridge spans specially suited to wooden construction. It is characterised by diagonal struts under compression and vertical tie rods under tension. See fig. 1.

H1: Radiata pine treated by the boron diffusion process to protect it against boron attack, for use in situations protected from the weather. (Specification for the treatment of timber which is used out of contact with the ground and continuously protected from the weather, primarily against attack by wood boring beetles.)

H3: Radiata pine treated with sufficient CCA to protect it from rot in situations exposed to weather but not to ground contact. (Specification for the treatment of timber which is used out of contact with the ground but may be exposed to the weather.)

H4: Radiata pine treated with sufficient CCA to protect it from rot for 20 years or more in contact with the ground. (Specification for the treatment of timber which is used in fresh water or in contact with the ground or in situations favourable to decay. Expected life in normal ground contact, more than 25 years.)

H5: Radiata pine treated with sufficient CCA to protect it from rot for 50 years or more in ground contact - used for house piles etc. (Specification for the treatment of timber which is used in contact with the ground in critical structural situations or where an extremely high decay hazard exists. Expected life in normal ground contact, 50 years.)

joggle pin: A heavy steel pin inserted into a hole drilled between two parallel timbers, and designed to prevent longitudinal movement of one timber relative to the other. See fig. 27. A joggle block is a wooden block serving the same purpose.

join, butt:	A join in which the endgrain surfaces of two timbers are in contact.
join, lap:	A join in which timbers are overlapped, or in which the timbers lie alongside the other, so that along-grain surfaces are in contact.
join, scarf:	A join mostly used during repairs, see fig. 10. They are also widely used in new construction and come in various shapes and sizes, e.g., half scarf, angle scarf.
Koppers:	Koppers Arch Wood Protection, a manufacturer of timber preservatives.
lift:	A trestle is said to be made up of several lifts when the vertical timbers used are not sufficient to reach the total height needed, so that vertical timbers have to be joined end to end via a spreader.
LOSP:	Light Organic Solvent Preservative (timber). A preser-vative such as copper naphthenate carried in white spirits or turps.
Metalex:	Brand name for a 4% copper naphthenate solution widely used in New Zealand .
meths:	Methylated spirits, mostly made up of ethyl alcohol.
moisture content:	(MC) The amount of moisture in wood measured as a percentage of oven-dry weight. Can range in outdoor conditions from 10% to over 100%.
MoW:	The former Ministry of Works (earlier the Public Works Department).
NZR:	New Zealand Railways (pre-corporatisation).
outrigger, deck*:	A deckplank extending out beyond the deck to provide support for a baluster brace. See fig. 2.
outrigger, transom:	Extension of a transom beyond the deck to provide support for a truss brace. See fig. 2.
Osmose:	Timber protection company now controlling the former FERNZ Timber Protection and Protim companies.
packing:	Any timber in addition to the normal structural elements used to achieve the correct spacing of those elements.
pier:	The supporting structure for the spans of a multi-span bridge, made up of piles etc.
pile:	A long timber, generally roundwood, driven (by striking the top end with a heavy weight) into the ground or into riverbed. See fig. 3. Compare with pole and post pile, brace: Synonym for raker pile.

pile, cut-water: A pile driven into the riverbed upstream of a bridge pier to protect the pier against flood-borne logs etc. See fig. 3.

pile, raker: A pile driven at an angle to provide support and bracing to a bridge pier. See fig. 3.

Pole: A large vertical timber held erect by being set (not driven) into the ground. Compare with pile and post.

Polegel*: Busan pole preservative gel, a diffusible formulation with 15% TCMTB.

post: A shorter vertical timber set into the ground, to support a fence or sign etc. Compare with pile and pole.

psi: Pounds per square inch.

radial: In a transverse section of timber, any line running from the centre of the original log towards the bark. Compare with 'tangential'. See fig. 15.

regal eucalypts: A group of Australian red coloured eucalypt species known for their hardness and durability. Includes, ironbark, grey gum, tallow-wood, red bloodwood etc. More generally but less precisely referred to as Australian hardwoods. Jarrah is not included here as it is only class 2 durability although jarrah is a term often used to describe red coloured eucalypt wood.

repellent, water: Substances such as waxes and resins to which water molecules are not attracted.

rod, tie: A long rod which tensions a structure either by a turnbuckle in the middle or a thread and nut at one end. A truss rod is a special form of tie rod. A cross tie (or wind brace) is a horizontal transverse tie rod bracing a pair of trusses, generally under the decking.

rod, truss: The large vertical tie rods in a Howe truss.

rot, brown: The most common rot in the structures dealt with in this manual. Characterised by soft patches brown in colour and with a fissured cuboidal texture. Caused by fungi which consume (white) cellulose fibres but not (brown) lignin.

rot, butt-end*: Internal rot generally resulting a large central cavity at what was originally the lower end of the growing tree. Often develops in the live, standing tree, and not always removed when long timbers were needed. Regal eucalypts are prone to butt-end rot. See fig. 20.

rot, centre: See pipe rot.

rot, end grain: rot proceeding into a timber from the end grain.

rot, internal:	Any rot which is not on the surface, includes pipe rot, centre rot, and butt-end rot. See figures 8 & 20.
rot, groundline*:	Rot occurring where a post enters the ground. Also called collar rot. See fig. 20.
rot, gutter*:	Rot forming a channel along the upper surface of a bridge beam or stringer, caused by water entering spike holes, See figures 24 & 25.
rot, pipe:	Rot forming along the pith core of a eucalypt, often while the tree is still alive. When it progresses into the sur-rounding heart wood it becomes centre rot. See figures 16 & 20.
rot, soft:	Rot, characterised by softening or corkiness of wood, caused by microfungi resident in wood cell walls rather than lumens, and therefore hard to treat. Not easily visible, but can lead to timbers suddenly snapping the way a carrot can be snapped. Regal eucalypts are prone to soft rot, especially at the groundline.
rot, surface:	Rot happening at the surface, particularly on side-grain surfaces, where it is easy to treat.
rot, white:	Rot which results in whitish fibrous soft patches. Caused by fungi which consume mainly lignin but leave some cellulose.
rot, top-end*:	Rot occurring at the unprotected top ends of poles, posts etc., where rain has easy access to end grain.
shim:	A thin spacer of metal or wood.
sill:	A horizontal timber resting on the ground or on a concrete footing, providing support to timber super-structure. See figures 1 & 3.
sodium hypochlorite:	The active ingredient in household bleach, toxic to surface mould fungi. Also very toxic to freshwater fish, therefore not to be used near waterways.
softwood:	The wood of pines and related trees, characterised by large numbers of tracheid cells which may provide good longitudinal permeability for preservative. The timber is not necessarily soft. Totara and kauri are softwoods (see also hardwood).
span:	All the structure between two piers. A land span has one span resting on a pier and the other end on an abutment. See fig. 4.
spreader:	Usually a block or short beam which maintains the correct separation between two main beams. Also a horizontal timber in a trestle which

	connects the tops of a lower lift of piles or studs and supports the bases of an upper lift. See fig. 3.
Stockholm tar:	Tar derived from the destructive distillation of wood, sold mostly in this country for veterinary use. Formerly used for preserving hemp rope etc. in marine situations.
stringer:	Any horizontal timber running longitudinally, e.g., the beams laid between transoms supporting the deck on a suspension bridge.
strut:	Another term for a brace. In particular the longitudinal diagonal compression braces of a Howe truss. These all, except for counter struts, slope up towards the middle of the span. Ordinary struts (i.e., excluding king and queen struts) are called centre struts.
strut, counter:	A strut which provides additional strengthening to the middle bay(s) of a truss. Made of a single flitch which passes between the two flitches of a centre strut.
strut, king:	The sloping end post of a truss, which transfers most of the compression in the top chord to the king thrust block. The king struts are made of heavier timber than the other parts of the truss. See fig. 1.
strut, queen:	The strut next to the king strut, and made of somewhat lighter timber. See fig. 1.
strut, under:	A diagonal longitudinal strut providing support to the quarter-length point of a beam from a pier. See fig. 3.
stud:	A vertical timber in a supporting role, other than timbers driven into the ground, which are piles.
stud, raker:	A stud performing similar function to a raker pile. See fig. 3.
tangential:	In a transverse section of a log the tangential direction is that perpendicular to a radius, i.e., parallel to the growth ring. See fig. 15.
TCMTB:	2-(thiocyanometylthio) benzothiazole, an organic fungicide effective in particular against mould, sapstain and soft rot.
tie, cross:	See rod, tie.
Tim-bor:	A powder formulation of boron salts used in commercial diffusion treatment of radiata.
TPC NZ :	New Zealand Timber Protection Council Inc. Sets standard for commercial treatments.
trestle:	A pier made up of piles and/or studs, together with caps, sills etc.

transom:	A transverse timber in any structure (c.f. stringer). More particularly the transverse timber supported by piers or suspension bridge hangers and supporting the deck beams, railbeams or stringers. On NZR bridges they were called floor beams. See fig. 2.
truss rod:	A vertical metal tie rod, the feature which distinguishes Howe trusses from other trusses.
turps:	mineral turpentine, as used in oil-based paints.
viaduct:	A high bridge built to span a valley, rather than just span a river.
waling:	Horizontal plank-like timbers on a bridge which provide bracing and/or protect piers against the impact of flood-borne debris. See fig. 3.
wheel guard:	Timber at the side of a bridge deck to prevent vehicles hitting the truss. See fig. 2.
wood, dozy:	Wood which has just started to rot, so that its appearance has hardly changed although the wood is significantly weakened and soft.
wood, heart:	The inner part of a log, much less permeable and generally more durable than sap.
wood, sap:	The younger, live wood on the outside of a tree. See heart wood.