APPENDIX D

Historical Information

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CRA ATD Technology for CRA

A Report prepared for
Country Fire Authority

Fiskville Training College Review of Site Assessments and Remediation Options

CONFIDENTIAL

28 November 1996

Client:	Grant James Country Fire Authority

CONFIDENTIAL

Fiskville Training College Review of Site Assessments and Remediation Options

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Date:	28 November 1996

Implications

Total volumes of contaminated soil requiring treatment and/or disposal appear to be in excess of $2000m^3$.

Disposal to off site landfill of the estimated total volume of soil can be expected to cost a minimum of $90,000. On site bioremediation using a simple landfarming or similar process can be expected to cost in the range $50-90,000.

These cost estimates do not include costs of excavation and transport, which may be significant for off site disposal, nor the cost of replacement clean fill.

It is recommended that

- the FLP/FMA area be reviewed, and improvements in prop design, firewater collection, drainage and water treatment be implemented as soon as practicable to prevent further contamination of soil and dam sediment.
- contaminated soils from the FLP/FMA and fire training pits be excavated for on site treatment, and backfilled with clean fill.
- once these improvements have been made, and hydrocarbons are being intercepted and removed from surface waters, Dam 1 may be rehabilitated.
- contaminated soils from the drum burial pits be excavated, and, subject to the presence of drums, be treated on site, or otherwise disposed of off site to appropriate landfill. The trenches should be backfilled with clean soil.
- surface water monitoring be continued at appropriate intervals, including at least one more sampling round before the FLP/FMA improvements mentioned above are implemented.
- the groundwater monitoring wells be dipped and sampled annually.

SUMMARY

Project Focus

This report reviews the environmental status of the Country Fire Authority (CFA) Training College at Fiskville, Victoria The objectives of this report are to:

- identify the areas containing contaminated soils and sediments,
- assess and describe the risks associated with such contamination, particularly any impacts on groundwater and surface water,
- review and evaluate various options for carrying out remediation.

Findings

The environmental investigations reviewed reveal localised soil, sediment and surface water contamination at the Fiskville Training College. This contamination has been principally the result of storage and handling of fuels, fire training activities, and disposal of fuel residues.

Levels of soil contamination at the Fiskville site exceed soil investigation guidelines for total petroleum hydrocarbons at several locations, including

- the Flammable Liquids Pad (FLP),
- the decommissioned fire training pits east of the FLP, and
- the drum burial pits.

Significant hydrocarbon contamination is also evident in sediments in Dam 1, and near the inlet to Dam 2.

Some low level soil contamination with phenols, BTEX and lead was also encountered, but only where TPH concentrations were also above investigation guidelines. Slightly elevated levels of chromium in most soils are considered to represent site background.

No significant groundwater contamination has been identified.

All contaminated soil is accessible for excavation ie is not constrained by storage tanks or buildings. Of the available *on site* remediation alternatives, bioremediation (by landfarming or similar process) should achieve soil remediation objectives at low cost for hydrocarbon impacted soil from the FLP/FMA and fire training pit.

Excavation and removal to a suitable landfill also appears to be an appropriate remediation strategy. Soil from the drum disposal pits may contain drums or other containers, so that on site treatment would be difficult, and disposing of the material off site in this case is likely to be the most appropriate remedial action.

CONTENTS

DETAILS

Project Focus

Introduction

CRA ATD, formerly Minenco Pty Limited (Environmental Services), was commissioned in April 1996 to review the environmental status of the Country Fire Authority (CFA) Training College at Fiskville, Victoria, and evaluate remedial options for the site.

This review encompassed a series of environmental investigations, which are the subject of this report.

Objectives and Scope

The review comprised the following :

- site inspections on 14 May and 2 July 1996,
- scoping site investigations required to characterise site contamination,
- collation and interpretation of the investigation data
- evaluation of remediation options.

The objectives of this report are to:

- summarise the areas identified in the investigations as containing contaminated soils and sediments,
- assess and describe the risks, if any, associated with such contamination, particularly any impacts on groundwater and surface water,
- discuss the basis for any remediation work that may be required,
- review and evaluate various options for carrying out the remediation,
- discuss the timing of the remediation work,
- provide a recommendation as to the most cost effective remedial strategy, in the context of CFA business plans for the site.

Background

Location

The CFA Training College is located at Fiskville, approximately 50 km north of Geelong and 10 km south of Ballan. The site covers an area of approximately 146 ha, and is situated on the western side of the Ballan-Geelong Road.

Land Use

The site is in a rural pasture setting, and is currently used by CFA as a Training College for fire and emergency services personnel from within CFA, and from external organisations. This principally involves fire fighting exercises at a number of "props", using both gas and liquid fuels.

The site has been used for such training for approximately 20 years. Prior to this few buildings existed on the site.

The main areas of the site comprise:

- Flammable Liquid Pad (FLP) and Fuel Mix Areas used for fire training
- Two interconnecting dams, collecting run off from the FLP, and draining to Lake Fiskville
- Fuel storage area
- Light industrial facilities, including stores, workshops and underground diesel storage tanks
- Decommissioned fire training pits east of the FLP
- Drum burial pits south of the western end of the airstrip
- A landfill, west of Lake Fiskville
- Training centre, administration and accommodation facilities.

Surrounding land is essentially rural.

Topography and Drainage

The college is located on a flat to gently undulating plateau, with lakes and wetlands formed in local depressions. Lake Fiskville is situated immediately west of the training complex.

A central north-south ridge forms a break in the site drainage.

The site drains generally towards the south, via Yaloak Creek on the eastern side, and Beremboke Creek to the west. Drainage to the east is towards the Werribee River water supply catchment.

Geology and Hydrogeology

The site lies over Quaternary Olivine Basalts. Surface soils are residual silts and clays, generally no more than 2-3m deep, overlying very stiff, high plasticity residual clays, grading to variably weathered basalt.

Shallow fill, comprising gravel or road base, is found in parts of the site, particularly in the area of the Flammable Liquids Pad. A summary of the site stratigraphy is given in Table 1.

The groundwater table is likely to comprise of an unconfined aquifer within the variable weathered basalt at depths ranging between approx 8 and 15m below existing ground surface level.

Table 1. Generalised Subsurface Profile

Soil Unit	Depth to Top of Layer (m)	Thickness (m)	Description
1	0	0.1 - 0.8	FILL: fine to coarse grained sandy gravel, silty clay or medium plasticity red clay.
2	0.2 - 1.0	0.1 - 0.2	RESIDUAL SILTY CLAY: medium plasticity, grey to grey-brown, may comprise rounded buckshot gravel (2 to 5mm) with clay.
3	0.3 - 1.2	0.5 - 1.8	SILTY CLAY: high plasticity, yellow-grey to yellow-brown, mottled orange-yellow. Residual clay formed on basalt.
4	0.8 - 2	14 - 18	BASALT
5	16 - 18.8	3.2 - 6.0	VOLCANIC ASH

Previous Investigations

Four site investigations were carried out at Fiskville during 1996. The following reports on these individual investigations are reviewed here:

- Diomides & Associates, Environmental Site Assessment (27 June 1996),
- Coffey Partners International, Field Site Appraisal and Sampling (August 1996),
- Coffey Partners International, Groundwater Monitoring Network Installation (October 1996),
- Coffey Partners International, Sediment and Surface Water Sampling (October 1996).

The scope of these investigations is outlined below, for soil, sediment, groundwater and surface water.

Soil

Diomides & Associates was commissioned in May 1996 to investigate the nature and extent of soil contamination. The **Environmental Site Assessment** (Report No DA1108/SD3000, 27 June) included:

- inspection of areas of buried drums containing solvents and other flammable liquids, decommissioned fire training pits, sludge burial pits, areas of ground saturated with petroleum hydrocarbons, contaminated sediment in a dam near the flammable liquid pad,
- drilling of boreholes with solid auger, soil sampling and soil vapour testing carried out in May 1996,
- nine (9) bores drilled to a maximum depth of 2.6m in the FLP area,
- three (3) bores to 1.0m at the drum burial pits near the airstrip,
- four (4) bores to a maximum depth of 2.8m near underground fuel storage tanks in the training centre - administration area,
- soil samples collected at depths of 0.5, 1.0 and 2.5m, and
- 46 soil samples and 12 composites analysed for total petroleum hydrocarbons (TPH), BTEX (Benzene, Toluene, Ethylbenzene, Xylene), polynuclear aromatic hydrocarbons (PAH), phenols, organochlorine pesticides, polychlorobiphenyls (PCBs) and selected heavy metals.

The bore locations are shown in Figures 1 and 2.

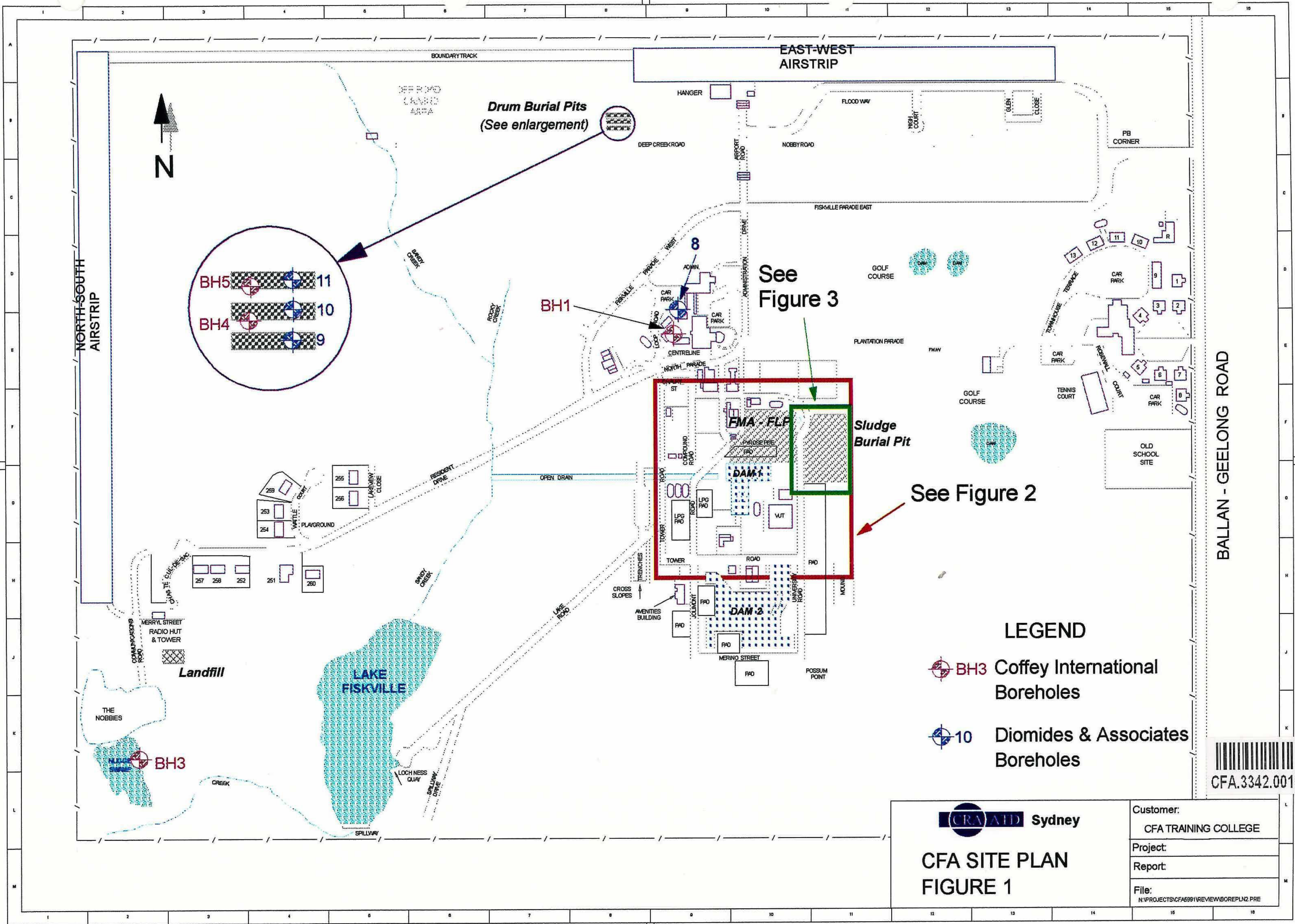
Coffey Partners International. Field Site Appraisal and Sampling (Report No E3517/1-AD, August 1996) included:

- excavation of 20 test pits to a maximum depth of 1.4m in the area of the fire training pits east of the FLP,
- visual and olfactory observations,
- *in situ* soil vapour survey, and
- 10 soil samples analysed for TPH and BTEX

to locate and define the extent of hydrocarbon sludge and contaminated soil from the previous fire training pits. Test pit locations are shown in Figure 3.

Coffey Partners International. Groundwater Monitoring Network Installation (Report No E3523/1-AK, October 1996) included:

- drilling of 8 boreholes to a maximum depth of 25m,
- soil vapour survey, and
- 7 soil samples analysed for TPH, BTEX and selected heavy metals.


EAST-WEST AIRSTRIP
BOUNDARY TRACK
HANGER
FLOOD WAY
PB CORNER
Drum Burial Pits
(See enlargement)
N
DEEP CREEK ROAD
NOBBY ROAD
AIRPORT ROAD
FISKVILLE PARADE EAST
NORTH-SOUTH AIRSTRIP
BH5
BH4
11
10
9
8
BH1
ADMIN.
CAR PARK
CENTRELINE
NORTH PARADE
ADMINISTRATION DRIVE
See Figure 3
GOLF COURSE
PLANTATION PARADE
FMA - FLP
Sludge Burial Pit
DAM 1
DAM 2
OPEN DRAIN
See Figure 2
VUT
LPG PAD
TOWER
ROAD
PAD
MERINO STREET
POSSUM POINT
CROSS SLOPES
AMENITIES BUILDING
TRENCHES
LAKE ROAD
SANDY CREEK
ROCKY CREEK
RESIDENT DRIVE
LAKEVIEW CLOSE
PLAYGROUND
WATTLE COURT
MERRYL STREET
RADIO HUT & TOWER
COMMUNICATIONS ROAD
Landfill
THE NOBBIES
BH3
CREEK
LAKE FISKVILLE
LOCH NESS QUAY
SPILLWAY DRIVE
SPILLWAY
TENNIS COURT
OLD SCHOOL SITE
BALLAN - GEELONG ROAD
LEGEND
BH3 Coffey International Boreholes
10 Diomides & Associates Boreholes
CRA AID Sydney
CFA SITE PLAN
FIGURE 1
Customer:
CFA TRAINING COLLEGE
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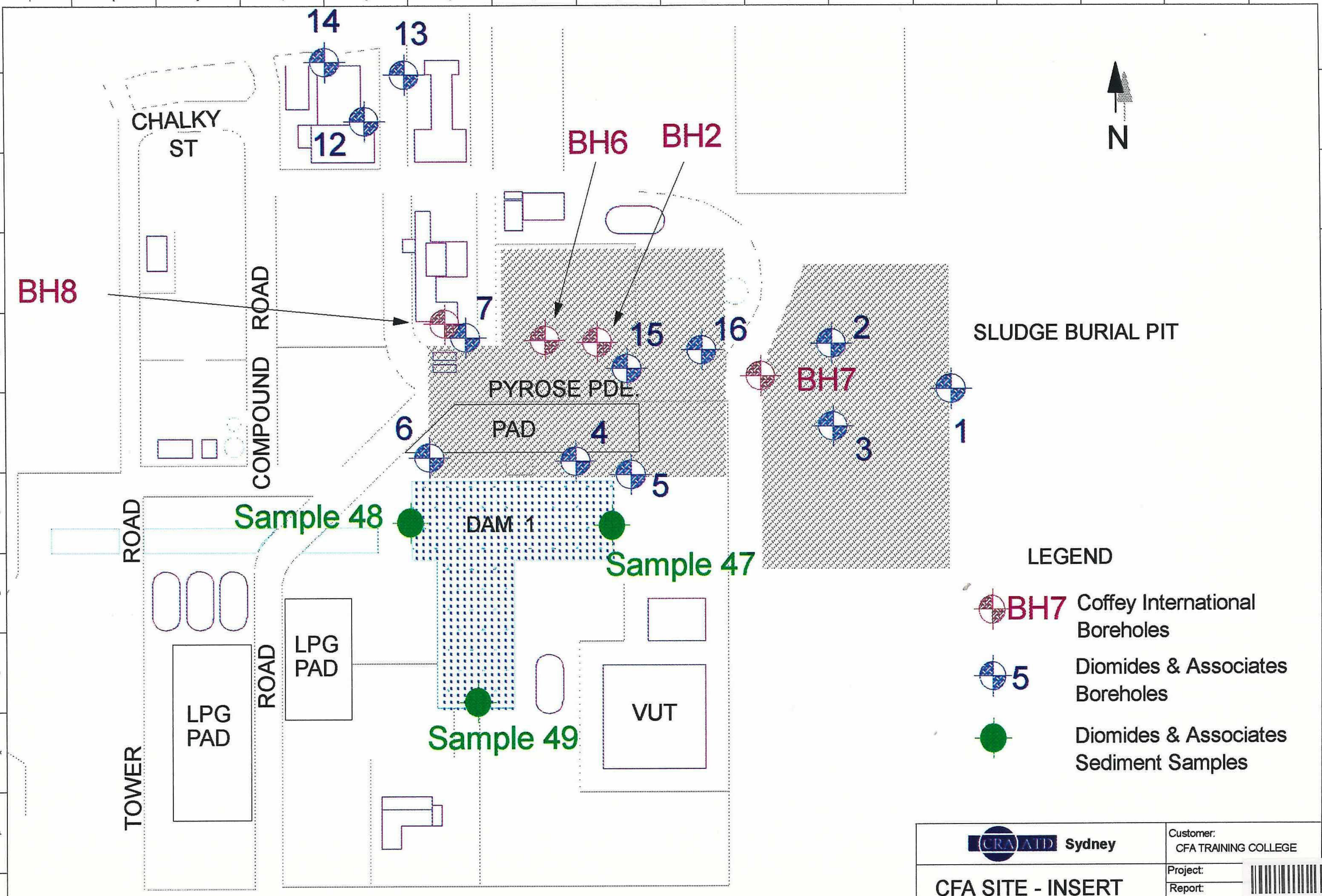

CRA ATD Sydney

Customer: CFA TRAINING COLLEGE

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Report:

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CFA SITE - INSERT

FIGURE 2

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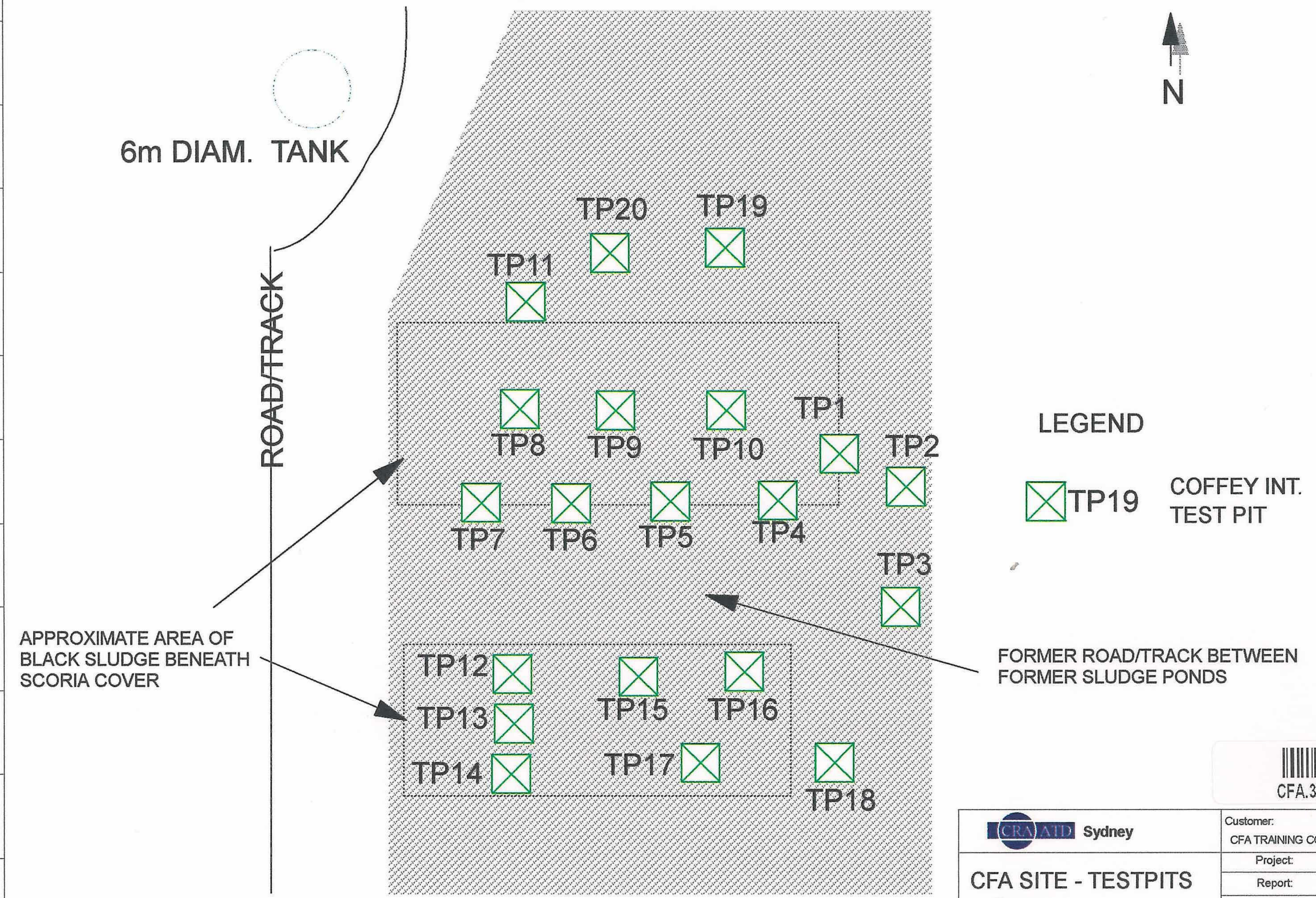

CRA ATD Sydney

CFA SITE - TESTPITS
FIGURE 3

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Project:
Report:
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Sediment

Diomides & Associates. Environmental Site Assessment. (Report No DA1108/SD3000, 27 June) included:

- 3 sediment samples retrieved from Dam 1, analysed for total petroleum hydrocarbons, BTEX, polynuclear aromatic hydrocarbons and selected heavy metals.

Coffey Partners International. Sediment and Surface Water Sampling (Report No E3523/2-AD, October 1996) included:

- 3 sediment samples retrieved from Dam 2 on 26 September 96, analysed for total petroleum hydrocarbons, phenols and selected heavy metals.

Surface Water

Diomides & Associates. Environmental Site Assessment. (Report No DA1108/SD3000, 27 June) included a single water sample from Dam 1, analysed for TPH, BTEX, PAH, phenols, organochlorine pesticides, PCBs and selected heavy metals.

Coffey Partners International. Sediment and Surface Water Sampling (Report No E3523/2-AD, October 1996) included surface water samples collected on 26 September 96 from

- Dam 1 inlet
- Dam 2 inlet
- Dam 2 outlet
- Lake Fiskville - Sandy Creek inlet
- Lake Fiskville - Inlet from Dam 2
- Lake Fiskville outlet
- Creek draining from Lake Fiskville, down-gradient and downstream from landfill.

Groundwater

Coffey Partners International. Groundwater Monitoring Network Installation (Report No E3523/1-AK, October 1996) included drilling and construction of four (4) deep (17 - 25m) and four (4) shallow (approx 2m) groundwater monitoring bores, targeted at known or suspected sources of soil contamination, from 9 to 11 September.

Groundwater samples were collected on 26 September, and analysed for water quality parameters, TPH, BTEX and selected heavy metals.

Findings

Assessment Criteria

Soil and sediment

The significance of analytical results can be assessed against health or environmental investigation guidelines, or against background concentrations of the analytes (Table 2). Health and environmental investigation levels are set on the basis that concentrations below these levels are unlikely to present unacceptable risks to human health or the environment.

No background data exists for hydrocarbon and other organic contaminants and so results of these analyses are compared with published guidelines only.

Because of the limited data set, the presence of a large number of non-detect results and the localised nature of contaminated areas, no statistical analysis has been attempted.

Health and Environmental Investigation levels

Health and environmental investigation guideline values for Australia have been published by ANZECC [1], and these are recognised by Victorian EPA, and should be used as the basis for determining whether investigation of the significance of any contamination is required. The environmental guideline values are set for protection of environmental receptors, for example effects on plants. Where concentrations in soil exceed these values, further investigation may be required.

In the absence of guideline values for specific contaminants, ANZECC recommend Dutch B levels be used. However, since the ANZECC guidelines were published, the Dutch guidelines have been significantly revised [2], and the previous B level or threshold for further investigation has been deleted. The new Dutch guidelines contain two values:

- a "target" value, above which there is considered to be pollution, and
- an "intervention" value requiring management and/or remediation.

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1 Australian and New Zealand Environment and Conservation Council and NHMRC (1992). Australian and New Zealand Guidelines for the Assessment and Management of Contaminated Sites.

2 Netherlands Ministry of Housing, Spatial Planning and the Environment (1994). Environmental Quality Objectives in the Netherlands.

Australian health risk based investigation guidelines have also recently been published[3]. These propose values for various "exposure settings" eg residential, recreational and commercial/industrial land uses. The main areas of environmental concern at the Training College could be considered to be used for commercial/industrial purposes, although since large unsealed areas exist and site activities can involve contact with soil and surface water, these guidelines may not be appropriate for use here. No specific guidelines are set for rural or agricultural land.

Background

Background concentration ranges for some analytes in Australian soils have been published by ANZECC and elsewhere [1,4].

Water

Water quality guidelines from several sources have been used for evaluating results of analyses of surface water[2,5,6] and groundwater[7].

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3 Imray, P. and A. Langley (1996). "Health-Based Soil Investigation Levels." National Environmental Health Forum Monographs, Soil Series No. 1.

4 Olszowy et al (1995). Trace Element Concentrations in Soils from Rural and Urban Areas of Australia. South Australian Health Commission, Contaminated Sites Monograph Series, No. 4.

5 ANZECC (1992). Australian Water Quality Guidelines for Fesh and Marine Waters.

6 EPA Victoria (1988). State Environment Protection Policy (Waters of Victoria) No. S13.

7 EPA Victoria (1994). Draft State Environment Protection Policy (Groundwaters of Victoria) Publication 288.

Table 2. Soil, Water and Sediment Reference Criteria [a]

	ANZECC (1992) A level - Background	SAHC (1995) Rural Background	Dutch (1994) Target Value [c]	ANZECC (1992) B level - Environmental	Dutch (1990) B level	SAHC (1995) Health Risk [d]	Dutch (1994) intervention value [c]	VicEPA (1988) Surface Water	ANZECC (1992) Aquatic systems
TPH			50		1000		5000	none [b]	
PAHs	0.95 - 5		1		20	100	40		0.003
benzene	0.05 - 1		0.05	1	0.5		1		0.3
toluene	0.1 - 1		0.05		3		130		0.3
ethylbenzene			0.05		5		50		
xylenes			0.05		5		25		
phenol	0.03 - 0.5		0.05		1	42500	40		0.05
arsenic	0.2 - 30	<5 - 53	29	20	30	500	55	0.5	0.05
cadmium	0.04 - 2	<0.5	0.8	3	5	100	12	0.1	0.0002
chromium	0.5 - 110	<5 - 56	100	50	250	500	380	0.3	0.01
copper	1 - 190	<5 - 412	36	60	100	5000	190	0.2	0.002
mercury	0.001 - 0.1	<0.1	0.3	1	2	75	10	0.005	0.0001
nickel	2 - 400	3 - 38	35	60	100	3000	210	0.5	0.015
lead	<2 - 200	<5 - 56	85	300	150	1500	530	0.1	0.001
zinc	2 - 180	<5 - 92	140	200	500	35000	720	0.5	0.005
pH								6 - 9	6.5 - 9
BOD								40	

[a] Soil criteria in mg/kg dry weight. Waters as mg/L.
[b] No visible oil and grease
[c] Values for standard soil
[d] Health risk based criteria for commercial/industrial exposure setting

Site Contamination

Soil and sediment contamination, predominantly petroleum hydrocarbons, has been found on the CFA Training College site.

The following sections discuss soil, sediment, surface and groundwater data collected at the site.

Soil

The initial soil contamination investigation was conducted by Diomides and Associates in May 1996.

Levels of TPH, PAH, BTEX, phenols, lead, chromium and zinc in soil samples are shown in Table 3 and Table 4. No organochlorines (PCBs or pesticides) were detected in any sample.

Results from Coffeys test pits in the area of the fire training pits east of the FLP are summarised in

Table 5. Soil samples were also taken from boreholes 1, 2 and 4 (Figures 1 and 2) by Coffeys in September 1996. The results are shown in Table 6.

The findings of these investigations for different areas of the Training College site are summarised as:

- **Fire Training Pits.** A 0.1 to 0.8m thick layer of surface fill comprises silty clay, silt and gravel. A thin (less than 10cm) layer of black hydrocarbon sludge is found at a depth of 0.1 to 0.6m. High TPH levels, up to 88,000mg/kg are found in soil sampled from 0.6 to 1.0m. Hydrocarbon contamination appears to have penetrated a short distance into the underlying clay soil layer. Elevated lead levels (710mg/kg) were found in one sample only, with all other heavy metals staying below ANZECC and Dutch intervention values.
- **Flammable liquids fire pad (FLP).** This large area contains obvious superficial soil contamination with fuel residues from fire training activities. Bores located within the FLP area or near Dam 1 revealed crushed rock fill contaminated with hydrocarbons between depths of 0.1 to 0.5m. Total petroleum hydrocarbons at depth 0.2 - 0.7m exceeded the Dutch B value (1000mg/kg), but none was more than the intervention value. BTEX, PAH, and selected heavy metals in this area all registered below Dutch intervention values. A composite sample taken in this area showed slightly elevated chromium levels exceeding ANZECC guidelines.

Table 3. Soil Analyses Results - May 1996

Sample (Bore)	Location	Depth (m)	TPH (mg/kg)	BTEX (mg/kg)	PAH (mg/kg)	Lead (mg/kg)
ANZECC Guidelines						300
Dutch B Value			1000	12	20	
Dutch intervention value			5000	1*	40	530
Sa1 (1)	Fire Training Pit	0.7	<140	<2	<5	13
Sa2 (1)	“	1.0	<140	<2	<5	39
Sa3 (1)	“	2.5	<140	<2	<5	36
Sa4 (2)	“	0.1	<140	<2	<5	60
Sa5 (2)	“	0.5	60	<2	<5	11
Sa6 (2)	“	1.0	<140	<2	<5	12
Sa7 (3)	“	0.1	<140	<2	<5	38
Sa8 (3)	“	0.5	14132	4.8	<5	710
Sa9 (3)	“	1.0	<140	<2	<5	13
Sa10 (4)	FLP	0.1	**1070**	<2	<5	24
Sa11 (4)	“	0.5	<140	<2	<5	20
Sa12 (4)	“	1.0	<140	<2	<5	12
Sa13 (5)	“	0.5	**1585**	<2	<5	16
Sa14 (5)	“	1.0	<140	<2	<5	14
Sa15 (6)	“	0.3	76	<2	<5	30
Sa16 (6)	“	0.8	<140	<2	<5	28
Sa17 (6)	“	1.2	<140	<2	<5	28
Sa18 (7)	FMA	0.5	152	1	<5	19
Sa19 (7)	“	1.0	<140	<2	<5	11
Sa20 (7)	“	2.5	<140	<2	<5	24
Sa21 (8)	UST, Admin	0.5	<140	<2	<5	15
Sa22 (8)	“	1.0	<140	<2	<5	13
Sa23 (8)	“	2.1	<140	<2	<5	20
Sa24 (9)	Drum Burial Area	0.1	<140	<2	<5	18
Sa25 (9)	“	0.5	**2548**	<2	<5	12
Sa26 (10)	“	0.1	**1185**	<2	<5	16
Sa27 (10)	“	0.5	289	<2	<5	15
Sa28 (10)	Drum Burial Pits	1.0	7040	62	13	11

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

Table 3. (cont.) Soil Analyses Results - May 1996

Sample (Bore)	Location	Depth (m)	TPH (mg/kg)	BTEX (mg/kg)	PAH (mg/kg)	Lead (mg/kg)
ANZECC Guidelines						300
Dutch B Value			1000	12	20	
Dutch intervention value			5000	1*	40	530
Sa29 (11)	"	0.1	<140	<2	<5	24
Sa30 (11)	"	0.5	320	<2	<5	18
Sa31 (11)	"	1.0	<140	<2	<5	9.9
Sa32 (12)	USTs, Centre Ave	0.5	<140	<2	<5	5.8
Sa33 (12)	"	1.0	<140	<2	<5	13
Sa34 (12)	"	2.5	<140	<2	<5	11
Sa35 (13)	"	0.5	<140	<2	<5	13
Sa36 (13)	"	1.0	<140	<2	<5	14
Sa37 (13)	"	2.5	<140	<2	<5	26
Sa38 (14)	"	0.5	<140	<2	<5	21
Sa39 (14)	"	1.0	<140	<2	<5	12
Sa40 (14)	"	2.5	<140	<2	<5	12
Sa41 (15)	FLP	0.2	97	<2	<5	18
Sa42 (15)	"	0.6	120	<2	<5	24
Sa43 (15)	"	1.1	190	<2	<5	13
Sa44 (16)	"	0.5	102	<2	<5	18
Sa45 (16)	"	1.0	83	<2	<5	14

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

Table 4. Soil Composite Analyses Results - May 1996

Composite (Bore)	Location	Phenols (mg/kg)	Zinc (mg/kg)	Chromium (mg/kg)
ANZECC Guidelines			200	50
Dutch B Value		1		
Dutch intervention value		40	720	380
Composite A10 (2,3,4,6,15)	Fire Training Pit & FLP	<0.1	30	75
Composite A50 (2,3,4,6,15)	"	<0.1	50	110
Composite A100 (2,3,4,6,15)	"	<0.1	18	95
Composite B50 (1,5,7,16)	Fire Training Pit, FLP	<0.1	16	68
Composite B100 (1,5,7,16)	& FMA	<0.1	16	86
Composite B250 (1,5,7,16)	"	<0.1	20	140
Composite C50 (8,12,13,14)	USTs	<0.1	20	72
Composite C100 (8,12,13,14)	"	<0.1	16	41
Composite C250 (8,12,13,14)	"	<0.1	12	92
Composite D10 (9,10,11)	Drum Burial Area	1.9	29	45
Composite DV (9,10,11)	"	1.3	16	76

Table 5. Soil Analyses - Fire Training Pit Area (June 1996)

Test Pit	Depth (m)	BTEX (mg/kg)	TPH (mg/kg)
ANZECC Guidelines		1 *	
Dutch B Value		20	1000
Dutch Intervention Criteria		1 [a]	5000
TP1	0.3	<0.08	470
TP5	0.8	<0.08	<80
TP6	0.3	<0.08	**2890**
TP6	0.8	<0.08	<80
TP8	0.6	1.26	**85610**
TP8	1.0	<0.08	**87910**
TP12	0.7	3.17	260
TP12	1.1	<0.08	<80
TP13	1.0	<0.08	<80
TP14	0.2	<0.08	**2934**

* Benzene 1mg/kg (ANZECC B), Toluene 130mg/kg, Ethylbenzene 50mg/kg,, Xylenes 25mg/kg

Table 6. Soil Analyses Results - September 1996

Bore	Location	Depth (m)	TPH	BTEX	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC B				1 *	20	3	50	60	1	60	300	200
Dutch intervention value			5000	1 *	55	12	380	190	10	210	530	720
BH1	Training Centre UST	1.5-1.6	26	<0.08	<2	<1	24	5	0.02	9	7	9
BH1	"	2.0-2.1	553	<0.08	<2	<1	52	10	0.02	16	22	12
BH2	FLP	1.0-1.1	38	<0.08	<2	<1	46	7	0.05	15	8	9
BH2	"	1.5-1.6	80	<0.08	<2	<1	42	6	0.02	9	9	9
BH4	Drum Burial Pits	1.0-1.1	<80	<0.08	<2	<1	55	9	0.05	13	10	13
BH4	"	2.0-2.1	88	<0.08	<2	<1	40	6	0.15	16	7	11

* Benzene 1mg/kg, Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

All data expressed in mg/kg dry weight

- **Fuel Mix Area.** This smaller area also contains some obvious superficial soil contamination with fuel. Samples of soil taken at this location at depths of 0.35-1.5m showed detectable levels of total petroleum hydrocarbons and BTEX, but none exceeding investigation guidelines. No PAH, phenols or heavy metals exceeded investigation guidelines. A composite sample taken from the fire training pit, flammable liquids pad and fuel mix areas showed slightly elevated levels of chromium, exceeding ANZECC Guidelines.
- **Drum Burial Pits.** While no drums were encountered during the investigations, soil samples were retrieved with total petroleum hydrocarbons levels exceeding the Dutch B value from Bore 9 at a depth of 0.4-0.9m, and exceeding the intervention guideline at Bore 10 (1.0m). Ethylbenzene levels also exceeded the intervention guideline. Composite samples taken in the area showed elevated phenol and chromium levels exceeding the Dutch B values. Two samples from Coffeys bore BH4 only showed elevated levels of chromium, slightly exceeding the ANZECC guidelines.
- **Underground Storage Tanks.** Samples from Coffeys bore BH1 contained detectable total petroleum hydrocarbons, but all TPH, BTEX, phenols, PAH and heavy metals were below ANZECC or equivalent investigation guidelines. Two of the three composite samples showed chromium levels slightly exceeding the ANZECC guidelines.

Sediment

Initial sediment sampling in Dam 1 revealed extensive petroleum hydrocarbon contamination (Table 7). Three samples collected around the dam showed total petroleum hydrocarbons at concentrations exceeding intervention criteria, and up to 15%.

Phenols, BTEX and PAHs were all less than investigation levels. Heavy metals, arsenic, cadmium, copper, mercury, nickel, lead and zinc were all less than ANZECC B levels, while chromium was slightly elevated, at 70mg/kg in a composite sample.

Results of analyses of three sediment samples from Dam 2 are also shown in Table 7.

Sample 2A, closest to Dam 1, contained elevated TPH (C_{10}-C_{36}) at concentrations exceeding Dutch B, and equal to the Dutch Intervention Criteria. Samples 2B and 2C were lower than the Dutch B level.

All sediment samples show heavy metals concentrations below ANZECC B criteria except for chromium, which ranges between 52 and 70mg/kg.

Table 7. Summary of Sediment Analysis

Sample	Location	TPH	BTEX	PAH	Phenols	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC B			1 *	20		20	3	50	60	1	60	300	200
Dutch B		1000			1								
Dutch intervention value		5000	1 *	40	40	55	12	380	190	10	210	530	720
Sa47	Dam 1, East	155300	<2	<5								53	
Sa48	Dam 1, West	123275	<2	<5								79	
Sa49	Dam 1, South	98850	<2	<5								29	
Composite SED					0.9			70					140
2A	Dam 2	5000			0.3	<2	<1	52	14	0.06	25	12	81
2B	Dam 2	130			0.2	<2	<1	66	8	0.04	13	23	29
2C	Dam 2	110			0.2	5	<1	70	6	0.04	18	19	65

* Benzene 1mg/kg (ANZECC B), Toluene 130mg/kg, Ethylbenzene 50mg/kg, Xylenes 25mg/kg

All data expressed in mg/kg dry weight

These findings clearly indicate that petroleum hydrocarbons are accumulating in Dam 1 sediments. These contaminants enter the dam in run off from the FLP/FMA during fire training activities and in wet weather. There is also evidence that contaminants are being transported from Dam 1 to Dam 2.

Surface Water

Results of surface water sampling conducted by Diomides & Associates in May 1996, and Coffey Partners International in September 1996 are shown in Table 8.

Surface water samples were neutral to mildly alkaline, pH 7.1 - 7.9. Dam 1 inlet and Dam 2 outlet exceeded Victorian EPA State Environment Protection Policy criteria for suspended solids.

Water entering Dam 1 also contained elevated BOD and total petroleum hydrocarbons. Elevated TPH concentrations were also present at the inlet and outlet of Dam 2.

Phenol levels were mostly below detection limits, with the exception of samples taken within Dam 1 and Dam 2 in May 1996, where levels exceed the Dutch intervention value, but not the ANZECC aquatic guideline level.

These results confirm hydrocarbon contaminated run off from the FLP/FMA is impacting on the water quality of Dam 1 and Dam 2.

BTEX, PAH, PCBs and organochlorine pesticides were below laboratory detection levels.

Copper concentrations in four out of seven samples tested in September 1996 were above ANZECC guidelines for protection of aquatic ecosystems, but all were below Victorian EPA criteria.

The nickel concentration in the water sample taken at the outlet of Dam 2, while within Victorian EPA guidelines, exceeded the Dutch limit value, and was above the lower limit of the ANZECC guidelines. Lake Fiskville outlet also had detectable levels of nickel, on the lower bound of the ANZECC guideline. Nickel was below laboratory detection limits in all other samples.

Samples taken within Dam 1 (May 1996) and at the inlet of Dam 2 (September 1996) show high levels of zinc, significantly exceeding ANZECC guidelines, but less than Victorian EPA guidelines.

Water at the Lake Fiskville outlet marginally exceeded ANZECC guidelines for lead. Chromium levels in all samples were below ANZECC guidelines.

Other heavy metals (arsenic, cadmium and mercury) were below detection levels in all samples.

Table 8. Summary of Surface Water Analyses Results

Sample	Date	pH	TSS	BOD	TPH	BTEX	PAH	Phenols	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC (Aquatic)		6.5-9.0				0.3 *	0.003	0.05	0.05	0.0002 - 0.002	0.01	0.002 - 0.005	0.0001	0.015 - 0.15	0.001 - 0.005	0.005 - 0.05
ANZECC (Drink)								0.001	0.05	0.01	0.05		0.001		0.05	5.0
Vic EPA SEPP		6 - 9	80	40	**				0.5	0.1	0.3	0.2	0.005	0.5	0.1	0.5
Dutch limit value								0.002	0.01	0.0002	0.02	0.003	0.0003	0.01	0.025	0.03
Dam 1	31/5/96	na	na	na	**1.2**	<0.004	<0.01	0.032	na	na	<0.01	na	na	na	na	**0.24**
Dam 2	31/5/96	na	na	na	<0.3	<0.004	<0.01	0.006	na	na	<0.01	na	na	na	na	<0.01
Dam 1 Inlet	26/9/96	7.5	190	95	**4.9**	na	na	<0.05	<0.005	<0.0002	0.006	**0.013**	<0.0001	<0.01	0.002	<0.005
Dam 2 inlet	26/9/96	7.9	41	11	**0.3**	na	na	<0.05	<0.005	<0.0002	<0.005	**0.01**	<0.0001	<0.01	0.002	**0.21**
Dam 2 outlet	26/9/96	7.9	270	6	**0.5**	na	na	<0.05	<0.005	<0.0002	0.009	0.003	<0.0001	0.037	0.002	<0.005
Lake Fiskville inlet Dam 2	26/9/96	7.6	300	8	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	**0.013**	<0.0001	<0.01	0.004	<0.005
Lake Fiskville Sandy Ck inlet	26/9/96	7.1	35	<7	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	0.004	<0.0001	<0.01	<0.001	<0.005
Lake Fiskville outlet	26/9/96	7.2	45	7	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	**0.013**	<0.0001	0.015	**0.006**	0.014
Creek draining Lake Fiskville	26/9/96	7.2	47	6	<0.4	na	na	<0.05	<0.005	<0.0002	<0.005	0.005	<0.0001	<0.01	<0.001	<0.005

* Benzene only

** Victorian EPA SEPP criterion for surface water “no visible oil and grease”.

All Data expressed in mg/L

na = not analysed

In summary, concentrations of copper, nickel, lead and zinc were elevated in surface waters, at levels exceeding ANZECC aquatic guidelines. However, the distribution is considered not indicative of any specific source, and the concentrations appear to be consistent with local background conditions.

Groundwater

Eight bores (four deep bores to 20m, and four shallow to 2m) were installed by Coffey Partners International with the objective of investigating groundwater quality in areas of environmental concern (drum burial pits, fire training pits, underground storage tanks, flammable liquid pad, fuel mix area, adjacent to Dam 1 and at the landfill. Figures 1 and 2).

Groundwater was intercepted only in two bores:

- BH2, a deep bore located in basalt aquifer in the flammable liquids pad area.
- BH5, a shallow bore located immediately adjacent to the backfilled drum burial trenches.

Where groundwater was encountered it appears to be of limited extent and the water bearing zones of low permeability. Water intersected in BH5 is probably a consequence of locally enhanced recharge occurring in the trench backfill materials.

No permanent groundwater was encountered within the residual clays investigated. Coffey Partners International suggested that from experience of groundwater conditions gathered in the general area, none would normally be expected within the residual basaltic clays.

Table 9 summarises the bore installation data and groundwater analysis results, from samples taken in September 1996.

TPH levels were below detection in BH2, and below the Dutch intervention value in BH5. BTEX, arsenic, cadmium, chromium, mercury, and lead were below laboratory detection limits. Nickel levels were below both ANZECC (Drink and Aquatic) Guidelines and the Dutch intervention value.

Copper levels in BH2 exceeded the ANZECC Aquatic Guideline, but were below the Dutch intervention value. BH5 showed levels below both criteria.

In both boreholes the levels of zinc were above ANZECC Aquatic Guidelines, while not exceeding ANZECC Drinking Guidelines or the Dutch intervention value. The heavy metals detected in BH2 are consistent with expected background levels.

These investigations suggest that the potential for contaminant migration via groundwater systems is very limited.

Table 9. Summary of Groundwater Analyses (September 1996)

Borehole	SWL (m PVC *)	Depth (m)	Screened Interval (m)	pH	TPH	BTEX	Arsenic	Cadmium	Chromium	Copper	Mercury	Nickel	Lead	Zinc
ANZECC Criteria (Drink)				6.5-8.5			0.05	0.005	0.05		0.001	0.1	0.05	5
ANZECC Criteria (Aquatic)				6.5-9.0			0.05	0.0002	0.01	0.002	0.0001	0.015	0.001	0.005
Dutch Intervention Criteria					0.6	1.25	0.06	0.006	0.03	0.075	0.0003	0.075	0.075	0.8
BH1	dry	25	15.0 - 21.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH2	14.8	17	11.0 - 17.0	7.5	<0.4	<0.016	<0.005	<0.0002	<0.005	0.01	<0.0001	0.013	<0.001	0.095
BH3	dry	21	15.0 - 21.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH4	dry	20	14.0 - 20.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH5	0.3	1.8	0.3 - 1.8	7.5	0.4	<0.016	<0.005	<0.0002	<0.005	0.007	<0.0001	0.013	<0.001	0.13
BH6	dry	2.0	0.3 - 2.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH7	dry	2.8	1.3 - 2.8	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
BH8	dry	2.3	1.3 - 2.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* mPVC = m below top of PVC casing.
All concentration data expressed in mg/L
n/a = not applicable (dry well)

Remediation Options

Levels of soil contamination at the Fiskville site exceed soil quality guidelines for total petroleum hydrocarbons at several locations (Table 10):

- the FLP,
- the decommissioned fire training pits east of the FLP, and
- the drum burial pits

In addition, significant hydrocarbon contamination is evident in sediments in Dam 1, and near the inlet to Dam 2,

No significant groundwater contamination has been identified. Removal of contaminated soils and buried wastes will remove future risks to groundwater.

Low level hydrocarbon contamination was found at the UST at the training centre, but in the absence of groundwater does not constitute an unacceptable health or environmental risk.

Some low level contamination with phenols, BTEX and lead was also encountered, but only where TPH concentrations were also above investigation guidelines. Slightly elevated levels of chromium in most soils are considered to represent site background.

Remediation decisions should be made in the context of a site specific evaluation of risks to human health and the environment.

In general, risks associated with the contamination at Fiskville Training College appear to arise from

- worker and trainee exposure to contamination. This is most likely to occur in the FLP/FMA area during training events or normal site operations. The area is largely unsealed.
- surface water run-off and erosion from the FLP/FMA into Dam 1, and off-site via Dam 2.
- exposure during excavation in areas containing buried contamination.

There appears to be little impact on groundwater from any of the identified sources, because of the depth of groundwater in the basalt, and relative impermeability of the residual silty clay soil.

Table 10. Fiskville Training College Soil Contamination Summary

Location	Borehole or Sample No.	Sample Depth (m)	Contaminant	Concentration (mg/kg)	Criteria exceeded (highest) (mg/kg)
Flammable Liquids Pad	BH4	0.1 (fill)	TPH	1070	clean fill (1000)
	BH5	0.5 (clay)	TPH	1580	clean fill (1000)
Fire Training Pits	BH3	0.5 (fill)	lead	710	Dutch Intervention (600)
			TPH	14,000	LLCS (10,000)
	TP 6	0.3	TPH	2890	clean fill (1000)
	TP 8	0.6	TPH	85,610	LLCS (10,000)
	TP 8	1.0	TPH	87,910	LLCS (10,000)
	TP14	0.2	TPH	2930	clean fill (1000)
Drum Burial Pits	BH9	0.5 (clay)	TPH	2550	clean fill (1000)
	BH10	0.1 (fill)	TPH	1120	clean fill (1000)
		1.0 (clay)	TPH	6920	Dutch Intervention (5000)
			BTEX	62	clean fill (7)
	Composite D10	0.1 (fill)	phenols	1.9	clean fill (1.0)
	Composite DV	0.5 - 1.0	phenols	1.3	clean fill (1.0)
Dam 1	sample 47	sediment	TPH	155,000	LLCS (10000)
	Sample 48	sediment	TPH	123,000	LLCS (10000)
	Sample 49	sediment	TPH	99,000	LLCS (10000)

LLCS limit refers to the max concentration of contaminant allowed in soil to be disposed of as Low Level Contaminated Soil

Contaminant migration in groundwater away from the localised sources identified appears unlikely, unless local permeability conditions are enhanced by clay fissuring or man-made features such as service trenches, backfill or surface construction fill placement. No evidence of this has been observed in the investigations to date.

Factors which are usually used as criteria for evaluating various remediation alternatives include :

- effectiveness,
- technical feasibility,
- cost,
- time required to achieve remediation objectives.

Effectiveness is normally defined as a reduction in environmental and health risks.

In order to assess and compare remediation alternatives, a set of evaluation criteria was defined (Table 11).

Table 11. Evaluation Criteria

Criteria	Description
Effectiveness	Reduction in health and environmental risks
Cost	Capital expenditure
	Operation and maintenance of remediation
Site impacts	Disruption of services, equipment on site etc
Implementability	Is it practical for the site
Time	When will the remediation objective be achieved
Acceptability	To EPA, local community
Technical risk	Risk that the remediation method will fail

Remediation Objectives

Remedial action at the Fiskville Training College should be initially focussed at source removal, that is, prevention of further soil and water contamination from fire training and other site activities, particularly in the Flammable Liquids Pad and Fuel Mix areas.

The primary objective of subsequent remediation works should then be the removal of the contaminated soils and buried wastes. Some of the contaminated areas identified are not impacted by present activities, and their remediation is not contingent on improvements in the FLP/FMA.

Remediation of existing areas of soil contamination to a standard such that soil exceeding ANZECC or Dutch B level criteria is removed, and suitably treated or disposed off site, will minimise future risks of surface or groundwater contamination.

Victorian EPA provides guidelines for off site disposal of contaminated soil[8]. These indicate that soil can be disposed of as clean fill where concentrations of contaminants are less than the following:

- total petroleum hydrocarbons (TPH) ($\leq C_9$) 100mg/kg
- total petroleum hydrocarbons (TPH) ($>C_9$) 1000mg/kg
- phenols 1mg/kg
- mono-aromatic hydrocarbons (BTEX) 7mg/kg
- polynuclear aromatic hydrocarbons (PAH) 20mg/kg
- lead 300mg/kg

Where concentrations exeed these values, soil is classified "low level contaminated soil", and must be disposed of, with EPA approvals, to an appropriately licenced landfill.

Remediation Options

A number of potential approaches exist for remediation of the contaminated areas identified at Fiskville Training College, including excavation and treatment or disposal, and *in situ* techniques (Table 12).

Ex situ soil treatment alternatives include bioremediation, soil washing and thermal treatment. All contaminated soil is accessible for excavation ie is not constrained by storage tanks or buildings. Of the available *on site* remediation alternatives, bioremediation (by landfarming or similar process) could achieve soil remediation objectives at low cost for hydrocarbon impacted soil from the FLP/FMA and fire training pit.

8 EPA Victoria (1991). Information Bulletin WM91/01

On site treatment of selected material would provide CFA an opportunity to demonstrate application of best environmental practice.

In situ remediation techniques provide no advantages over excavation in this case.

Excavation and removal to a suitable landfill also appears to be an appropriate remediation strategy. Off site disposal is usually adopted where treatment technologies are likely to be ineffective or take too long to achieve remediation goals, and is often the least costly approach, especially if soil volumes prove to be small.

Different approaches may be adopted for different contaminated areas. These are discussed below.

Remediation of FLP/FMA

The principal contaminants in the FLP/FMA area are petroleum hydrocarbons, derived from liquid fuels used in fire training. TPH concentrations in soil samples range up to 1600mg/kg, but higher concentrations can be expected in surface fill. The area affected by superficial contamination is extensive. There is crushed rock fill and soil contaminated with hydrocarbons to a depth of probably no more than 0.8m. There is also an accumulation of petroleum hydrocarbons in sediments in Dam 1, and near the inlet of Dam 2.

Volatile hydrocarbons may be lost to ambient air, with potential for exposure of site personnel or visitors. Contaminant spread from the affected areas may occur via surface water run-off and erosion. There is no demonstrable impact on groundwater.

CFA intend that the site will continue to be used for fire training using both liquid fuels and gas. In the absence of significant groundwater contamination, and given the shallow depth of soil contamination, remediation will involve soil excavation, followed by on site treatment or off site disposal.

Any remediation action requires permanent removal of the source. Therefore, improvements in prop design, firewater collection, drainage and water treatment will be required before resumption of training activities, or otherwise as soon as practicable to prevent further contamination of soil and dam sediment. Concurrently, contaminated soil should be removed for treatment and/or disposal.

Table 12. Summary of remediation options available for hydrocarbon contaminated soil/sediment

Remediation Option	Effective	Site impact	Implement-ability	Risk	Cost	Time (months)	Acceptability	Considered Further	Reason not considered further
Excavate & dispose off site	yes	excavations; short term	yes	low	low	1 - 2	good	yes	
Excavate & on site bioremediation	yes	excavations; short term;, requires soil treatment area	yes	low	low	6 - 12	very good	yes	
Excavate & thermal desorption	yes	excavations; short term; requires soil treatment area	yes	low	high	2 - 3	medium	no	high cost
Excavate & soil washing	unknown	excavations; short term; requires soil treatment area	yes	high	high	3 - 6	unknown	no	high risk, cost
In situ bioventing/soil vapour extraction	not for heavy hydrocarbons, clay soil	few, long term	yes	high	low	indefinite	no	no	probably not effective - unacceptable treatment time
In situ soil flushing	not for heavy hydrocarbons, clay soil	few long term	yes	high	moderate	indefinite	no	no	probably not effective - unacceptable treatment time
Intrinsic remediation (deferred action)	unknown	none	yes	high	low	indefinite	no	no	high risk

On site treatment by landfarming or similar bioremediation process will be feasible for this soil, since no contaminants other than hydrocarbons are present.

Fire Training Pit area

Contamination in this area is again shallow, and in a limited area defined by the previous pit locations. The total affected area is estimated at $1200m^2$.

The volume of sludge is estimated at $20\text{-}50m^3$. In some locations sludge has been mixed with soil. Some contamination may have migrated a short distance into the underlying clay soil.

Contaminants comprise weathered and partially combusted fuel residues, occurring in a relatively thin (less than 100mm) black sludge layer. Concentrations of TPH occur exceeding Victorian EPA low level contaminated soil and Dutch intervention values, and up to 8.7%w/w. One sample from borehole 3 also contained 710mg/kg lead. No other significant contaminants have been found at this location.

Remediation of this area could be undertaken by excavating the two pits, and either disposing of soil off site, or retaining on site for treatment by landfarming or similar bioremediation process.

With the possibility of high lead levels in the sludge (which will not be removed by bioremediation), some further assessment of lead will be required after excavation to confirm the appropriateness of such treatment.

This soil would not be suitable for off site disposal as low level contaminated soil, due to the high concentrations of total petroleum hydrocarbons, exceeding VIC EPA guidelines.

Drum Burial Pits

Three pits near the air strip were used for disposal of drums containing solvent and other residues. No drums were encountered during the investigations. Nevertheless, soil samples from these pits at depths up to 1m showed concentrations of TPH and BTEX exceeding the intervention guidelines. Samples also showed phenol and chromium levels exceeding the Dutch B values.

This contaminated soil appears to be inhibiting revegetation of the three backfilled trenches.

Remediation of this area could be undertaken by excavating the three trenches to the underlying basalt, and backfilling with clean soil. The excavated soil may contain drums or other containers. If this is the case, on site treatment would be difficult, so that disposing of the material off site is likely to be the most appropriate remedial action.

This soil appears to be suitable for off site disposal as low level contaminated soil, since concentrations of contaminants meet Victorian EPA guidelines.

Dam Sediments

Sediments in Dam 1 and Dam 2 contain petroleum hydrocarbons at concentrations exceeding intervention value and should be removed for treatment or disposal.

As with the contaminated soils, the main alternatives are off site disposal or on site treatment. However, off site disposal of sediments with concentrations of more than 10000mg/kg TPH requires disposal to secure landfill as prescribed waste.

Water in Dam 1 is currently also contaminated with petroleum hydrocarbons. It can be anticipated that following improvements to prop design, firewater collection, drainage and water treatment, inputs of hydrocarbons to Dam 1 would be significantly reduced, and water quality in Dam 1 should therefore improve over time. Were Dam 1 to be drained for remediation of the sediment, it may be acceptable to dispose of the water by irrigation on site, and may not require other treatment before disposal.

Remediation of Dam 1 should not be commenced until remediation of the FLP/FMA and improvements to prop design, firewater collection, drainage and water treatment have been completed to prevent hydrocarbon contaminated water from entering the Dam.

When this occurs, removal and remediation of contaminated sediments in Dam 1 should be the main priority. A limited amount of sediment from Dam 2, near the Dam 1 overflow should also be removed.

The volume of sediment requiring treatment/disposal is unknown at present. One advantage of on site treatment for contaminated soils is that the facilities and general procedures established can also be used later for sediment remediation.

Remediation Costs

Remediation costs for off site disposal are a direct function of the volume of soil requiring disposal. Preliminary estimates of contaminated soil volumes are given in Table 13 (not including sediment in Dams 1 and 2).

Table 13. Estimated soil volumes

Location	Area (m^2)	Average depth (m)	Volume (m^3)
FLP	3000 - 5000	0.5	1500 - 2500
FMA	100	0.3	30
Drum burial pit	200 - 500	1	200 - 500
Fire training pits	1200	0.3 - 0.5	360 - 600

Disposal to landfill (not including haulage) can be expected to cost in the range $28 - $45 per tonne depending on the landfill and waste type. For the total volume of soil estimated above, and assuming a bulk density of 1.6 tonnes/m^3, the cost would then be at least $90,000.

Bioremediation techniques are usually quoted as costing in the order of $30-50per m^3. For the volumes of soil anticipated, treatment costs are not highly sensitive to the volume of soil to be treated, and the process is such that CFA should be able to implement and manage the treatment using site resources and with limited external supervision (essentially restricted to initial design, construction supervision, and monitoring and auditing functions). In this case, on site treatment using a simple landfarming or similar process can be expected to cost in the range $50-90,000.

Note that these costs do not include excavation and transport of soil, which may be significant for off site disposal, nor the cost of replacement clean fill.

Disposal of contaminated sediments from Dams 1 and 2 is also not included in these estimates.

Implications

The environmental investigations reviewed reveal localised soil, sediment and surface water contamination at the Fiskville Training College. This contamination has been principally the result of storage and handling of fuels, fire training activities, and disposal of fuel residues. No groundwater contamination has been detected, nor has any significant contamination been found associated with underground storage tanks.

Any response by CFA should recognise future risks and liabilities associated with the contamination, as well as current requirements. Remedial actions can be taken consistent with CFA's requirement to continue fire training and related operations at the site.

It is recommended that

- the FLP/FMA area be reviewed, and improvements in prop design, firewater collection, drainage and water treatment be implemented as soon as practicable to prevent further contamination of soil and dam sediment.
- contaminated soils from the FLP/FMA be excavated for on site treatment, and backfilled with clean fill.
- once these improvements have been made, and hydrocarbons are being intercepted and removed from surface waters, Dam 1 may be rehabilitated.
- the fire training pits be excavated for on site treatment, and backfilled with clean soil
- contaminated soils from the drum burial pits be excavated, and subject to the presence of drums, be treated on site, or otherwise disposed of off site to appropriate landfill. The trenches should be backfilled with clean soil.
- surface water monitoring be continued at appropriate intervals, including at least one more sampling round before the FLP/FMA improvements mentioned above are implemented.
- the groundwater monitoring wells be dipped and sampled annually.