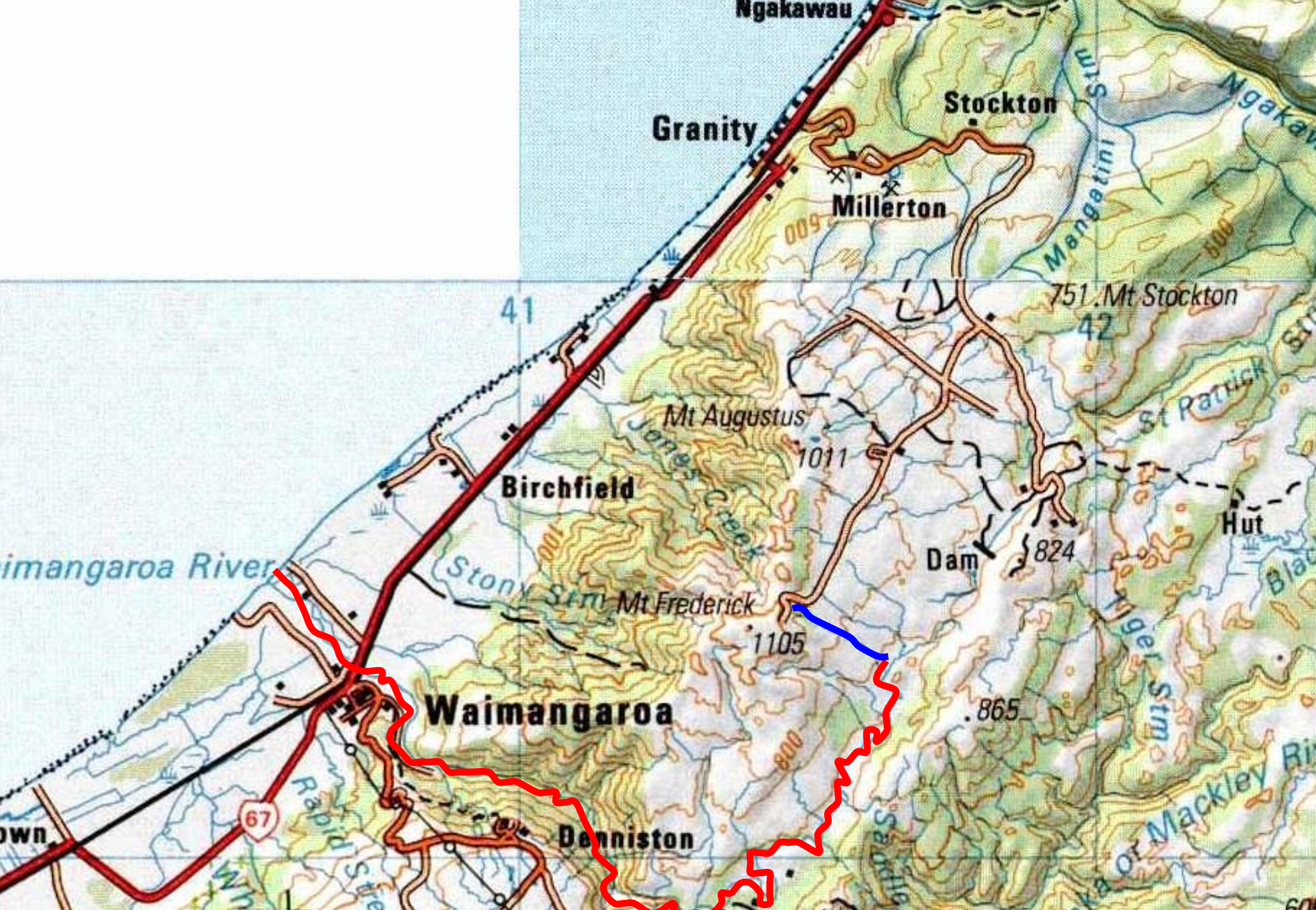
Acid Mine Drainage Treatment at Herbert Stream, Stockton

- Location and background
- Flow rate and chemistry
- Use of passive treatment flow chart
- Field trials to identify best solution

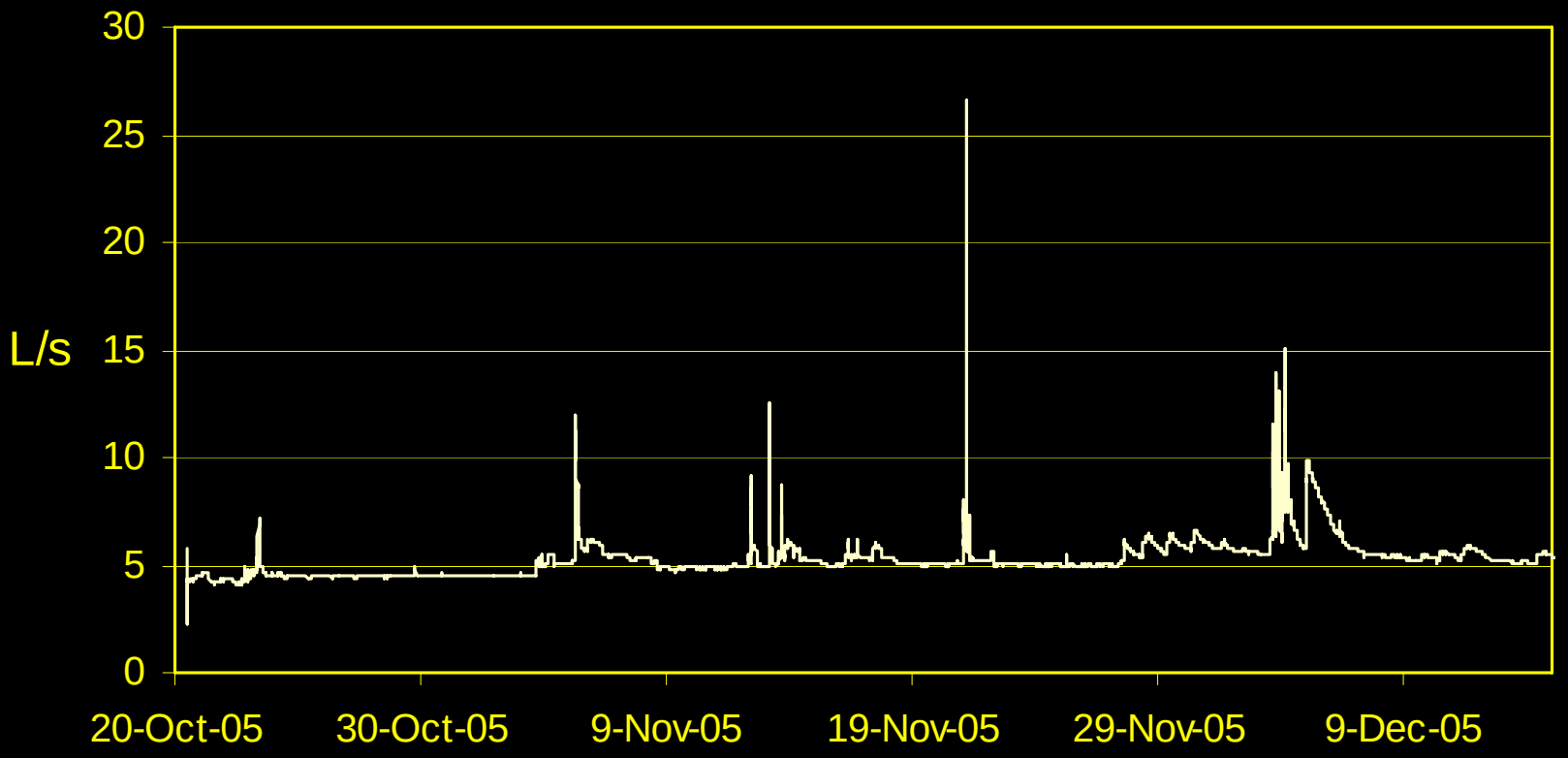

Ngakawau
Granity
Stockton
Millerton
Mangatini Stm
751 Mt Stockton
41
42
Mt Augustus
1011
Birchfield
James Creek
St Patrick
Hut
Dam
824
imangaroa River
Stony Stm
Mt Frederick
1105
Waimangaroa
865
Tiger Stm
67
Denniston
Rapid Stm
Mackley Ri


Mt Frederick
E
1105m
.1053
Herbert Stream
Whirlwind Stream
Cypress Stream
.867
Webb Stm
Ernest Stream
AE No 2
865m
.855
Stream
.750
1000
900
800
700


Herbert Stream

Water level every 15 min
Converted to flow rate

Herbert Stream Flow Rate



Average Flow 5.3 L/s

>6 L/s	10.2%
>7 L/s	3.8%
>8 L/s	2.2%
>9 L/s	1.1%
>10 L/s	0.4%

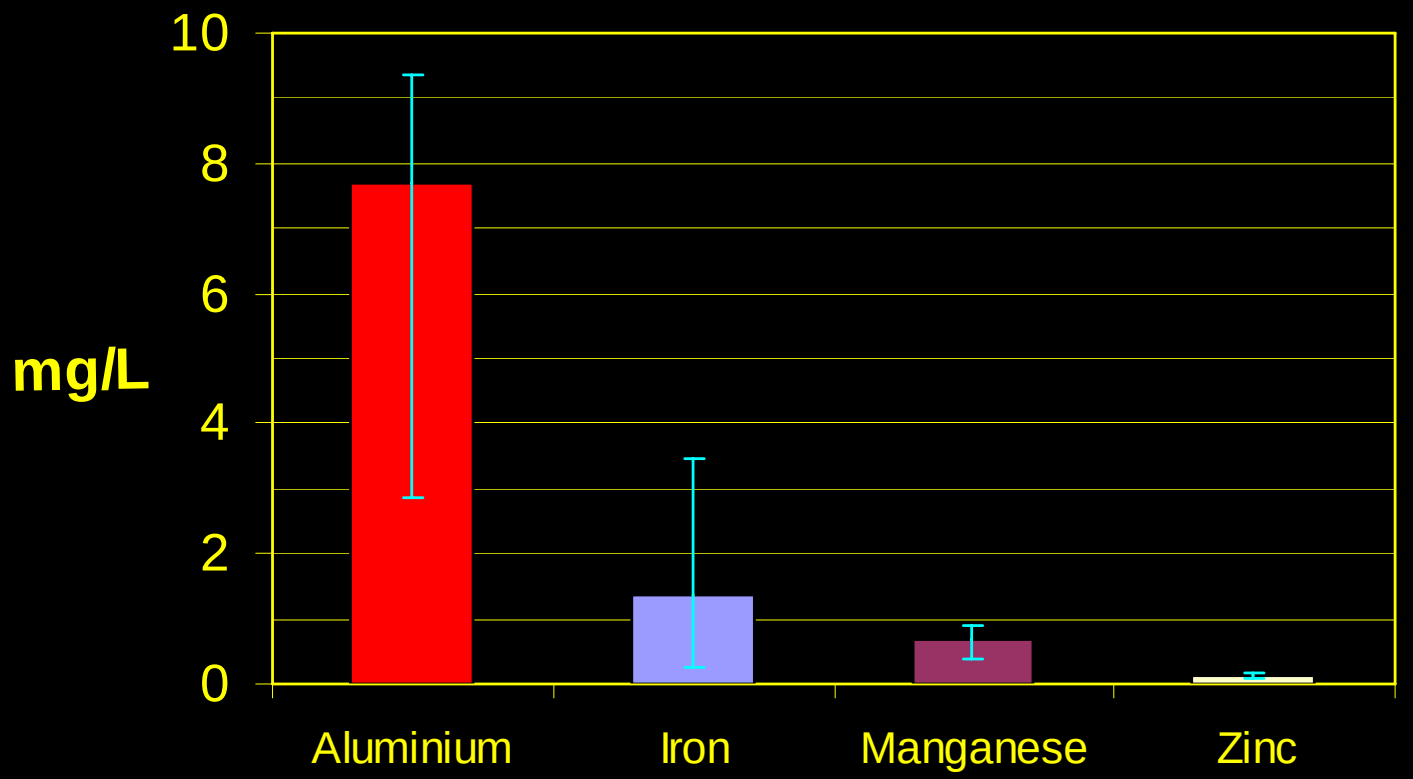
Herbert Stream Chemistry

pH 2.8 to 3.2

Aluminium is the dominant contaminant, followed by iron

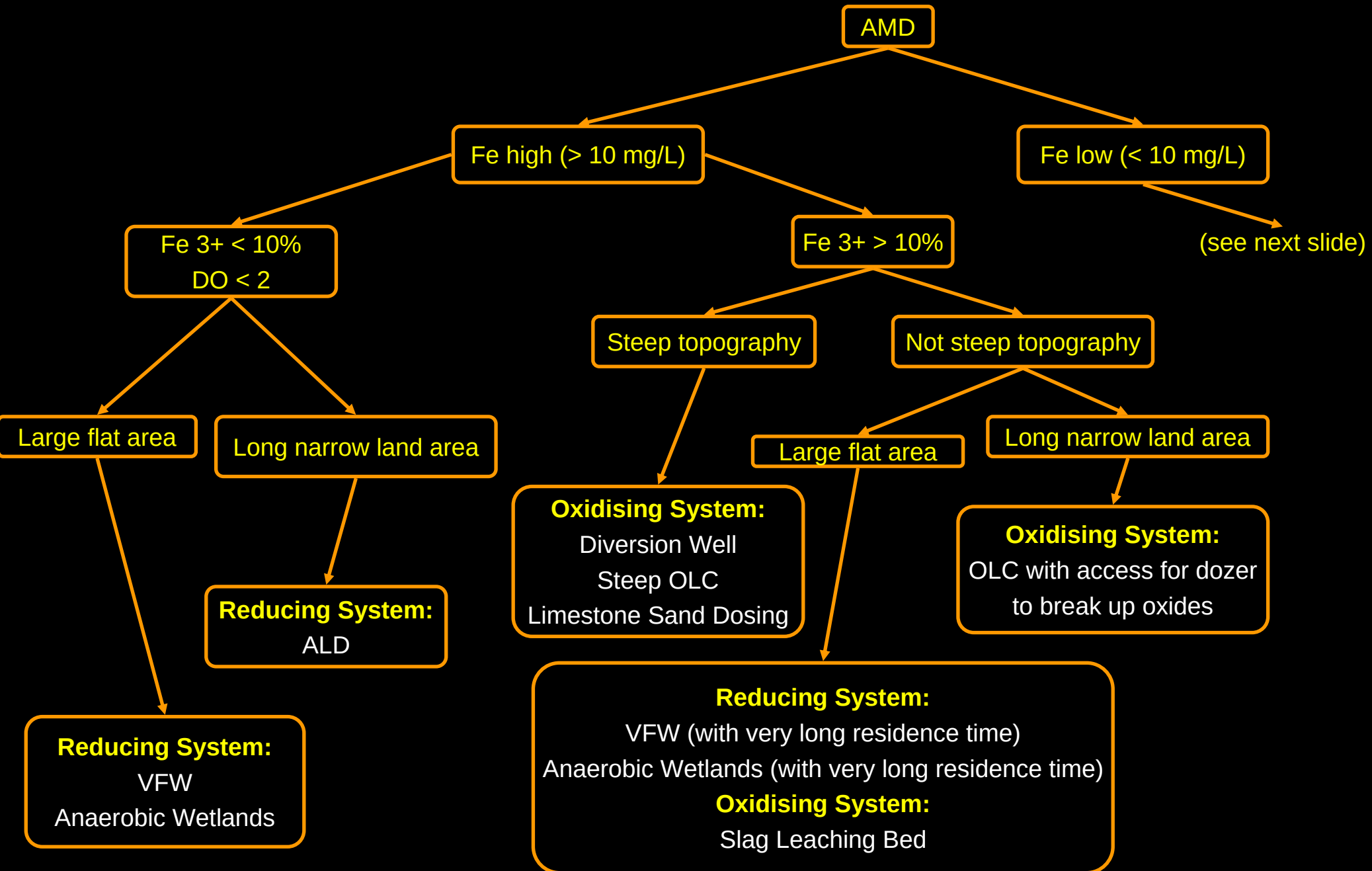
Dissolved oxygen concentration ~9 mg/L

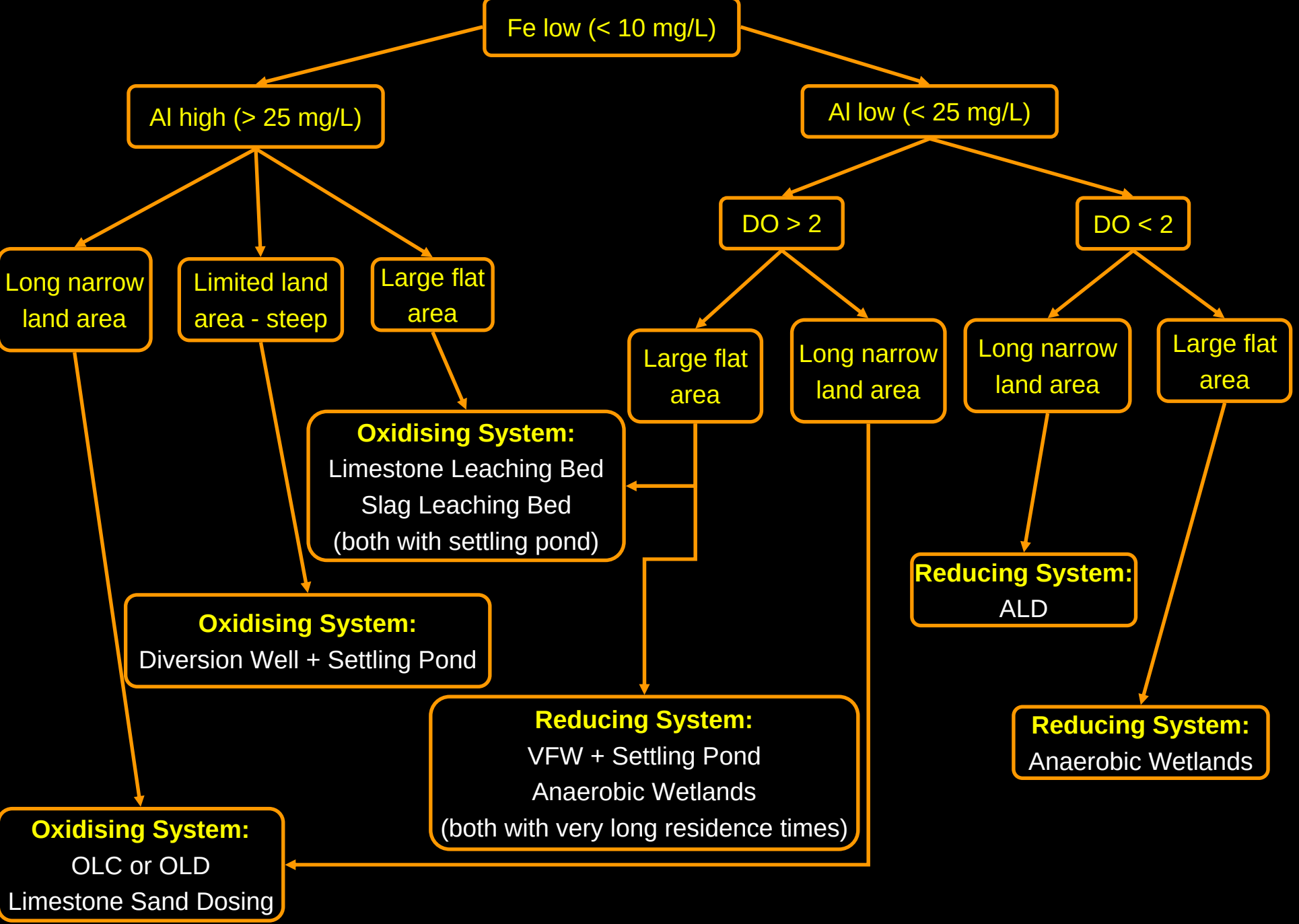
64% of total iron in oxidised state (Fe^{3+})



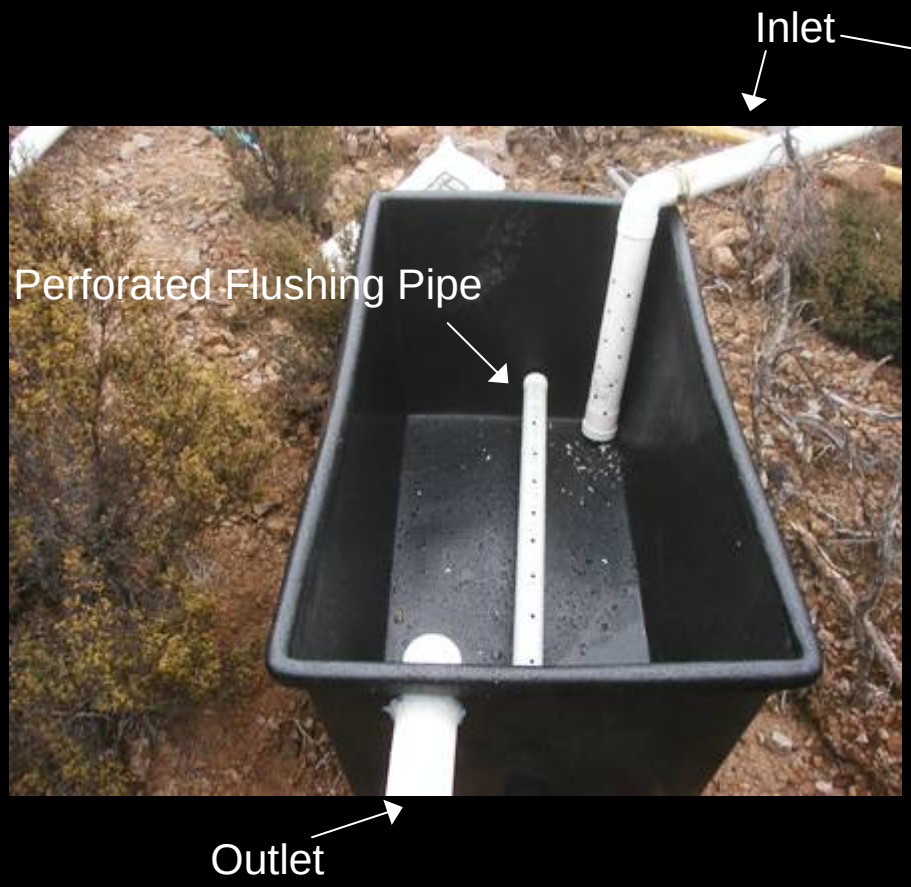
Incised streambed with riparian strip of native trees and shrubs

Passive Treatment Options Flow Chart




Fe low (< 10 mg/L)
Al high (> 25 mg/L)
Al low (< 25 mg/L)
Long narrow land area
Limited land area - steep
Large flat area
DO > 2
DO < 2
Large flat area
Long narrow land area
Long narrow land area
Large flat area
Oxidising System:
Limestone Leaching Bed
Slag Leaching Bed
(both with settling pond)
Reducing System:
ALD
Oxidising System:
Diversion Well + Settling Pond
Reducing System:
VFW + Settling Pond
Anaerobic Wetlands
(both with very long residence times)
Reducing System:
Anaerobic Wetlands
Oxidising System:
OLC or OLD
Limestone Sand Dosing

Limestone Leaching Bed (LLB)



Horizontal flow with vertical flushing capability to remove accumulated precipitates

Limestone treatment media, 76% between 15 and 25mm diam

Reducing and Alkalinity Producing System (RAPS)
Vertical Flow Wetland (VFW)

Perforated Pipe
(normal flow and flushing)

Inlet

Outlet normal flow

flushing line Outlet

Vertical flow system

Limestone treatment media at base (12cm thick)

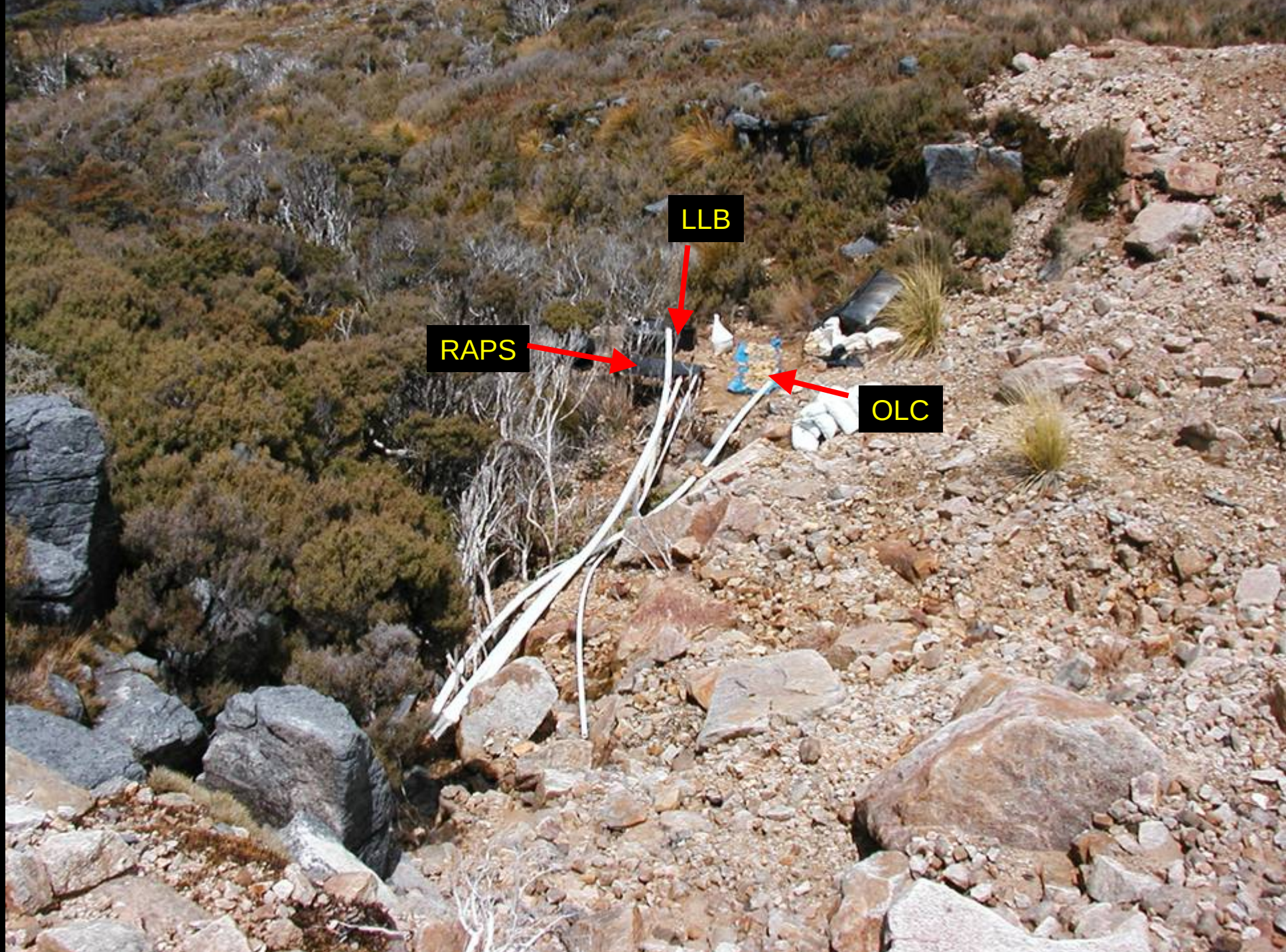
Mushroom compost over limestone (30cm thick)

Water depth over compost (8cm)

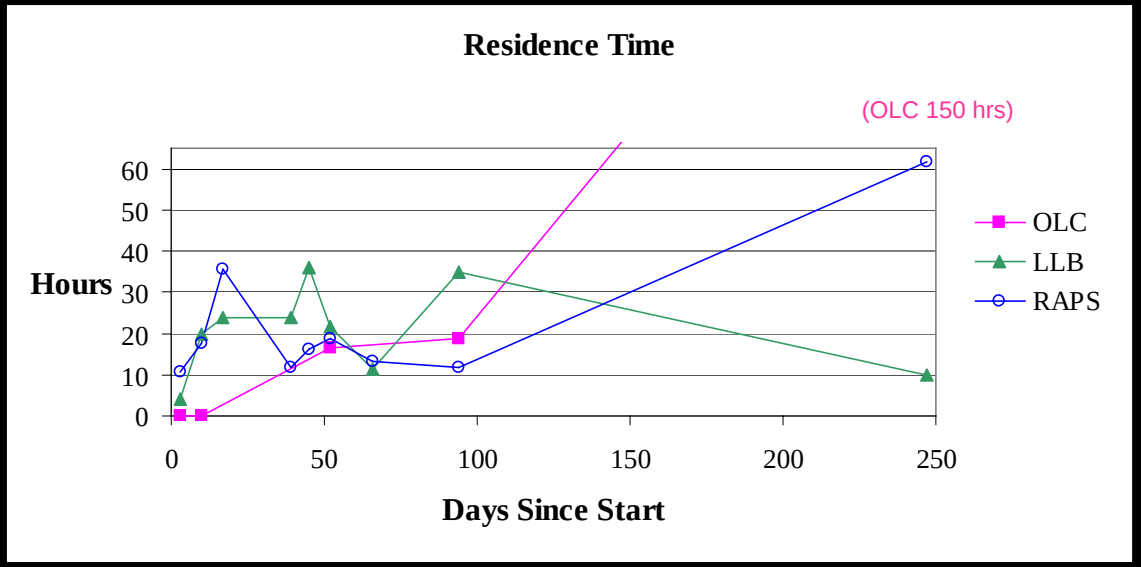
Open Limestone Channel (OLC)

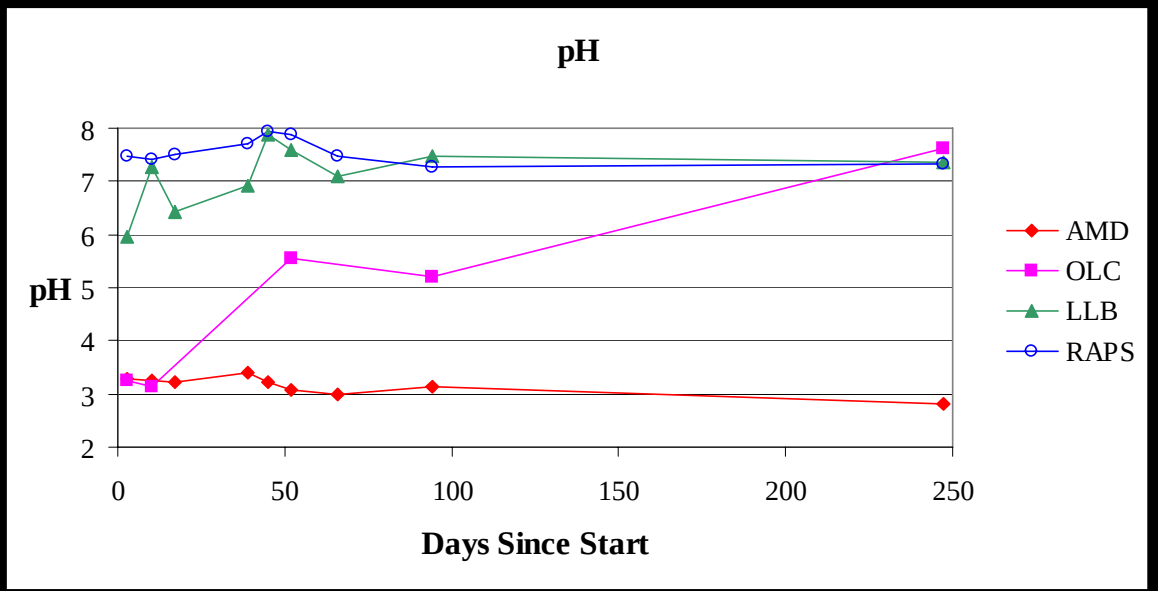
Inlet

Water flow
during operation

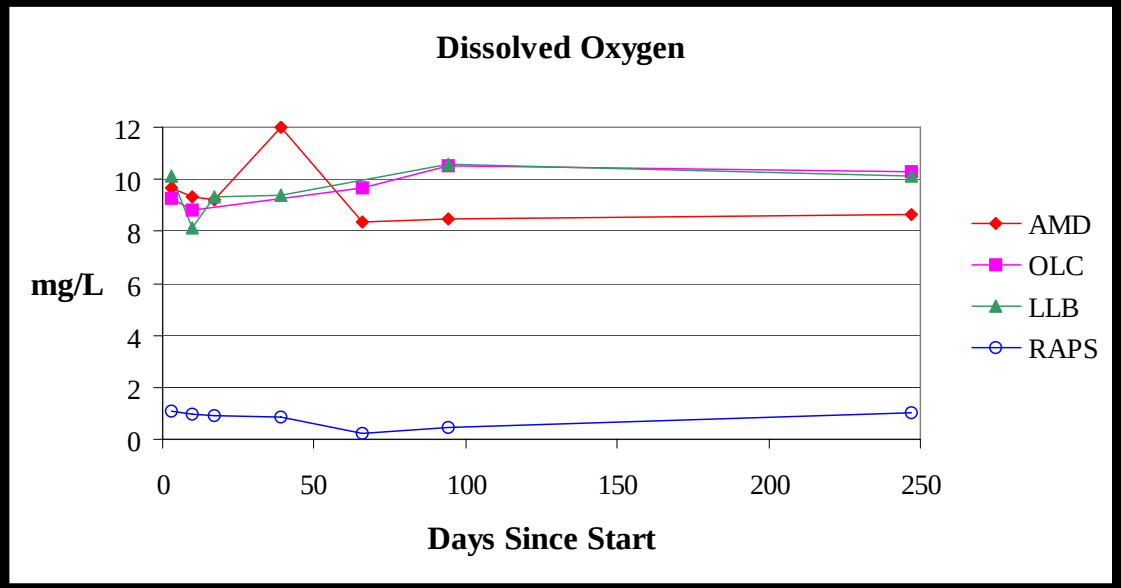

LLB
RAPS
OLC

Results



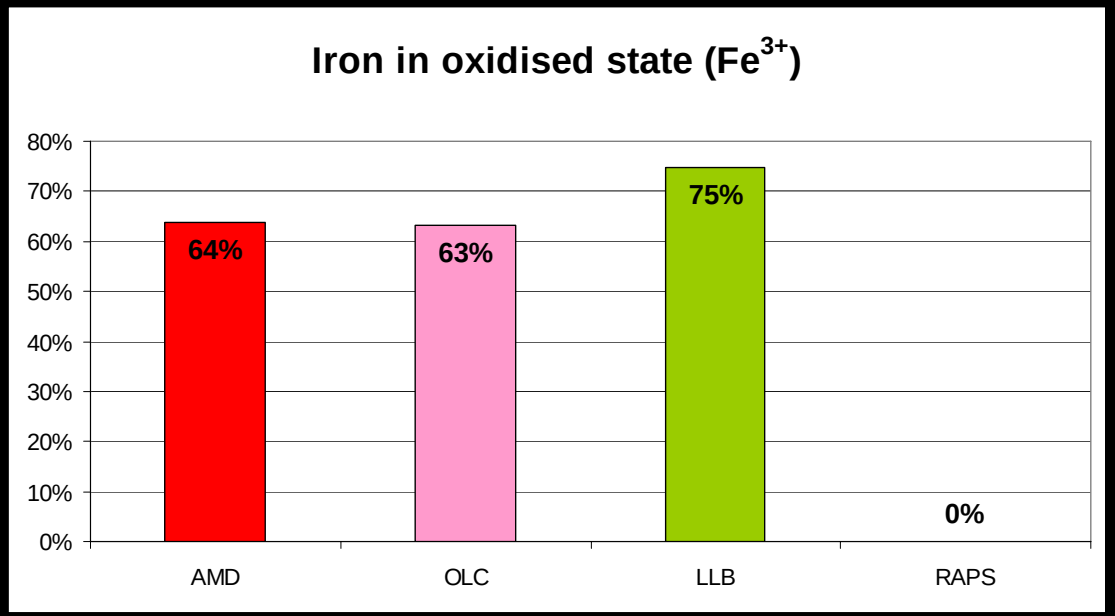


- Residence times in each system mostly between 10 and 35 hours
  - Average flow rates
    - OLC 5 L/hr
    - LLB 12 L/hr
    - RAPS 13 L/hr
- LLB, RAPS raised pH to neutral
- OLC raised pH to neutral at long residence times

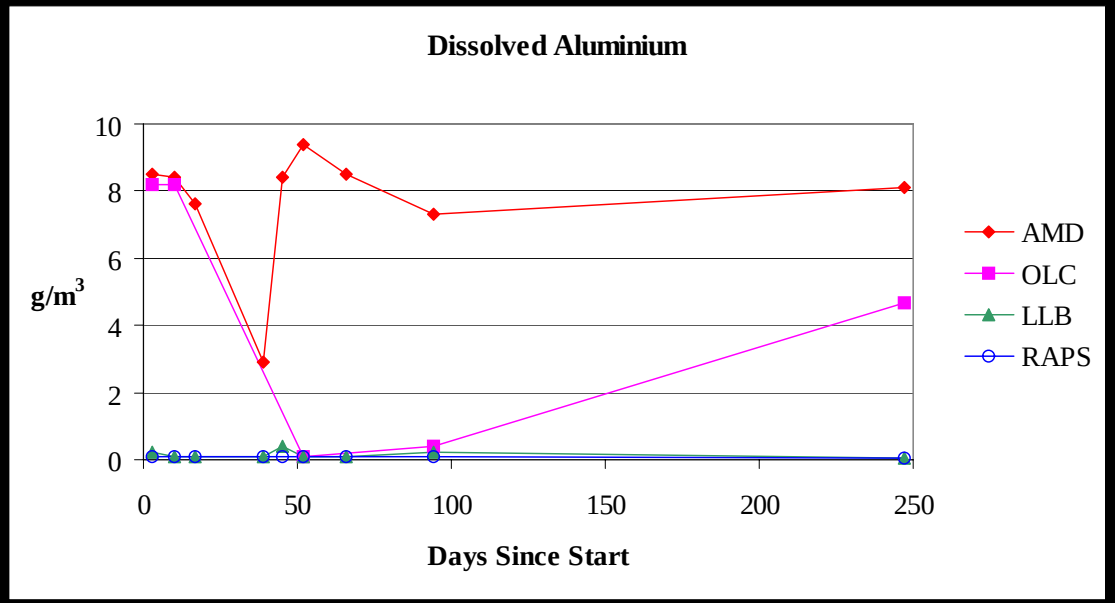


Reducing conditions achieved by RAPS unit

- DO lowered
- Percentage of iron in oxidised ferric form lowered

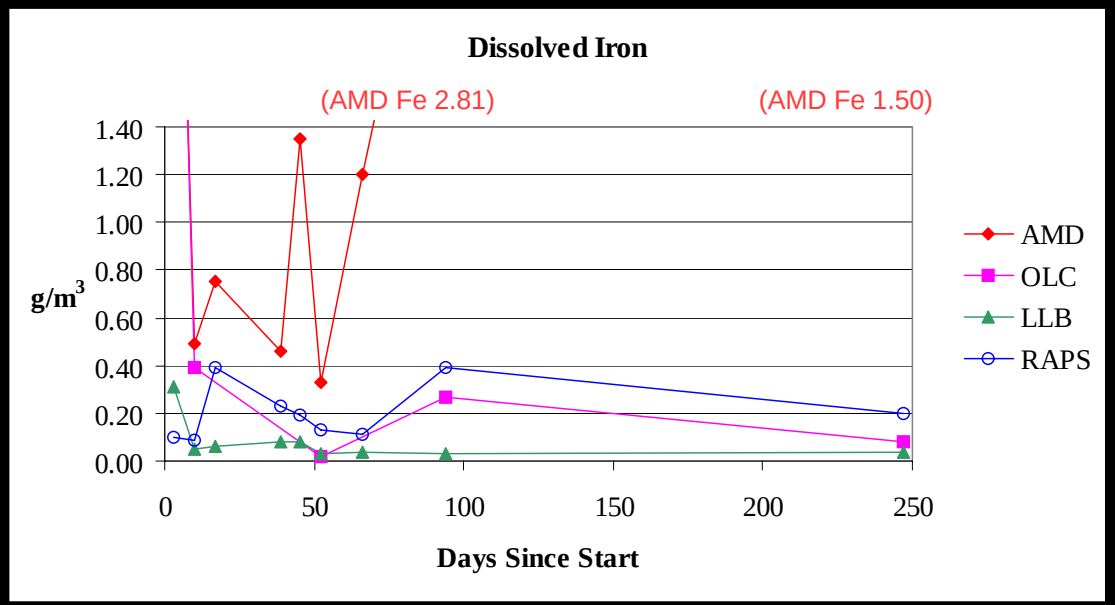


Oxidising conditions in LLB, OLC



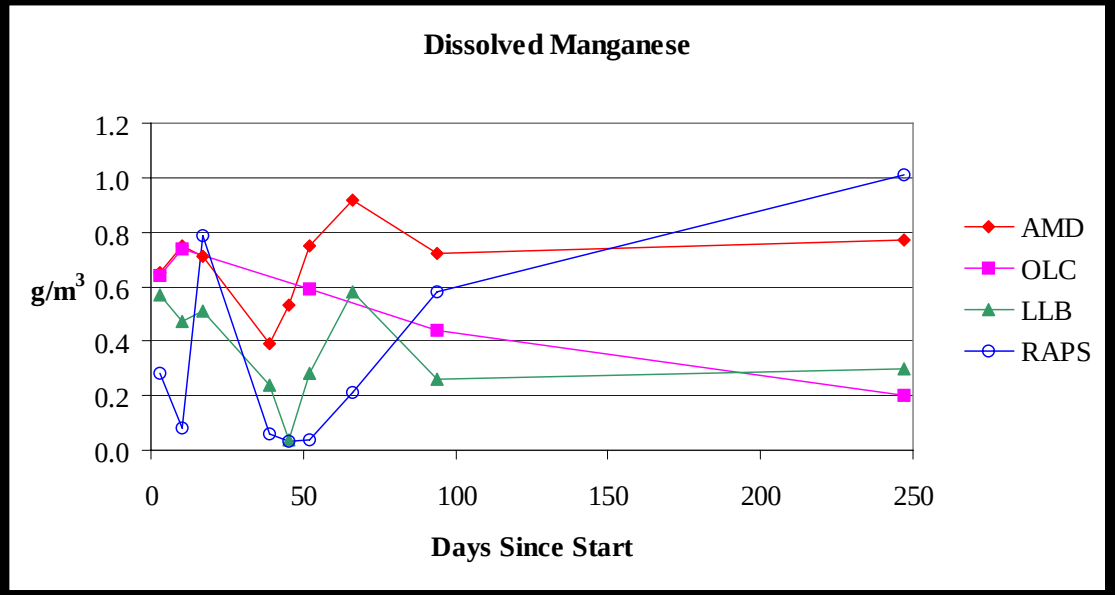
Aluminium consistently lowered by LLB and RAPS

OLC initially lowered aluminium (res time 20 hrs) but later was less effective (res time 150 hrs!)



Iron lowered by all systems

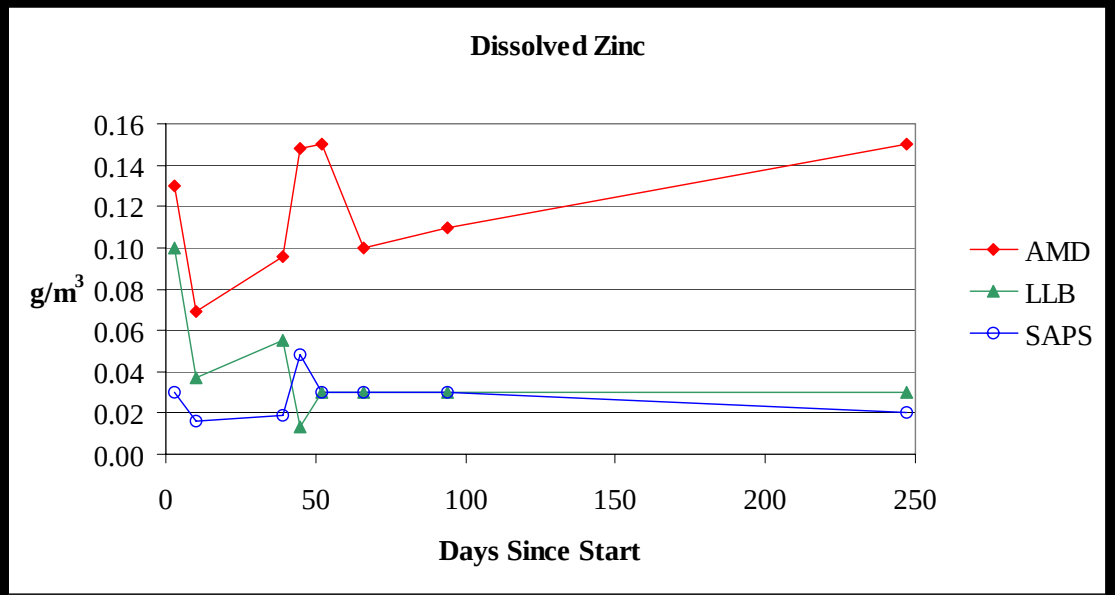
LLB most effective



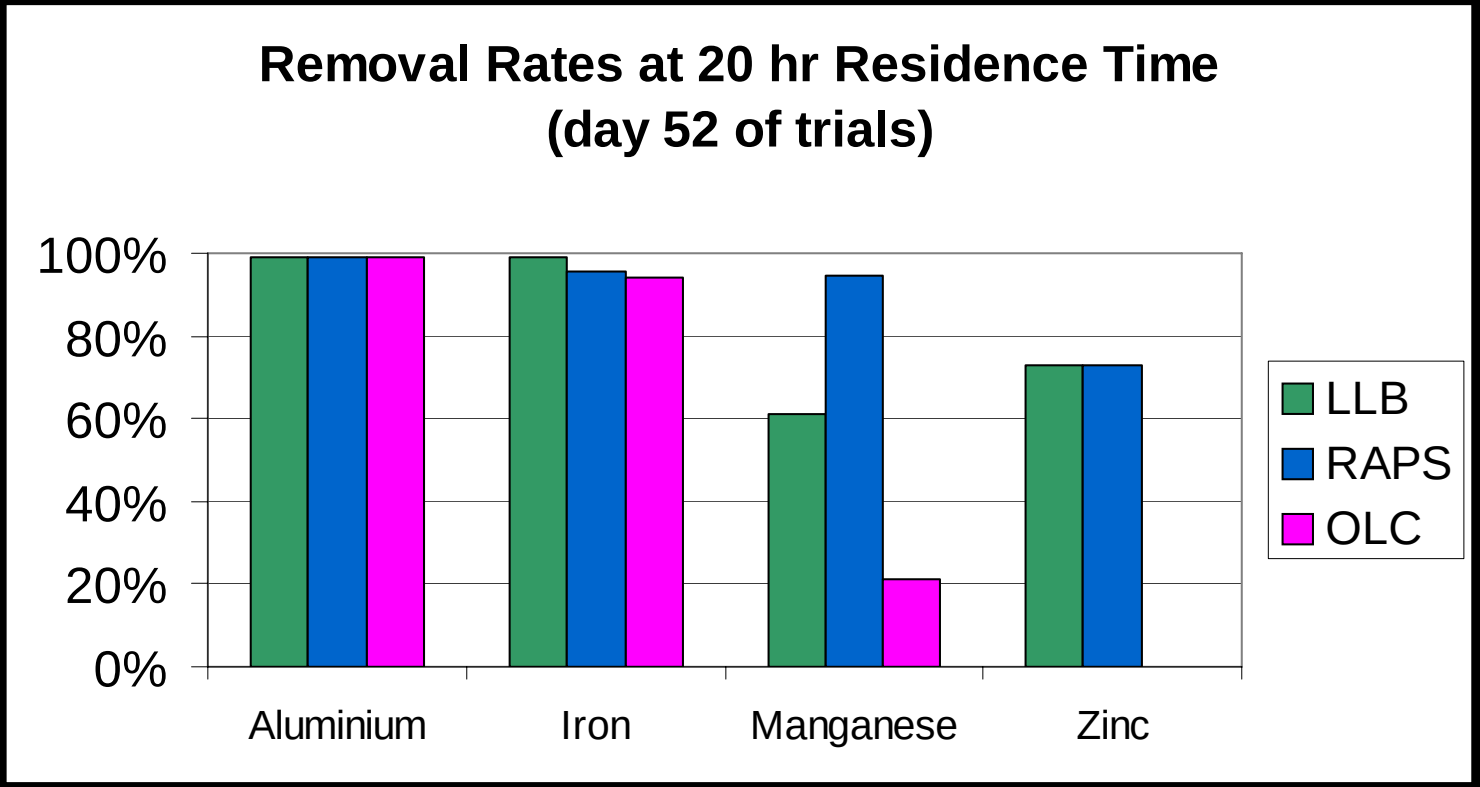
OLC, LLB effective at manganese removal

RAPS initially effective at manganese removal

net export at end of trial



LLB, RAPS effective at zinc removal (no data from OLC)



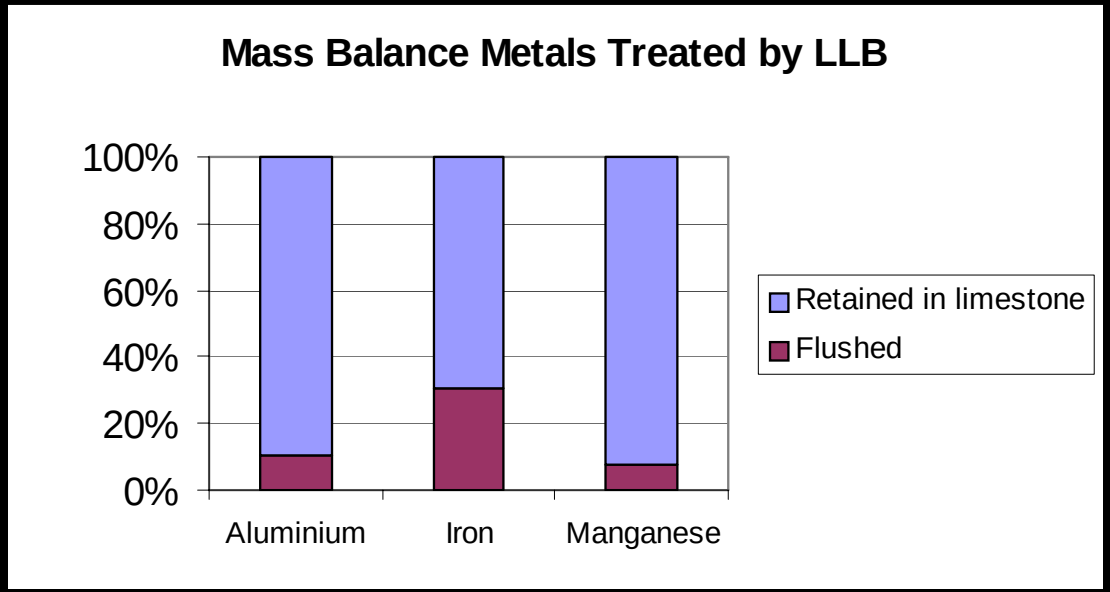
All three systems equally effective at aluminium, iron removal

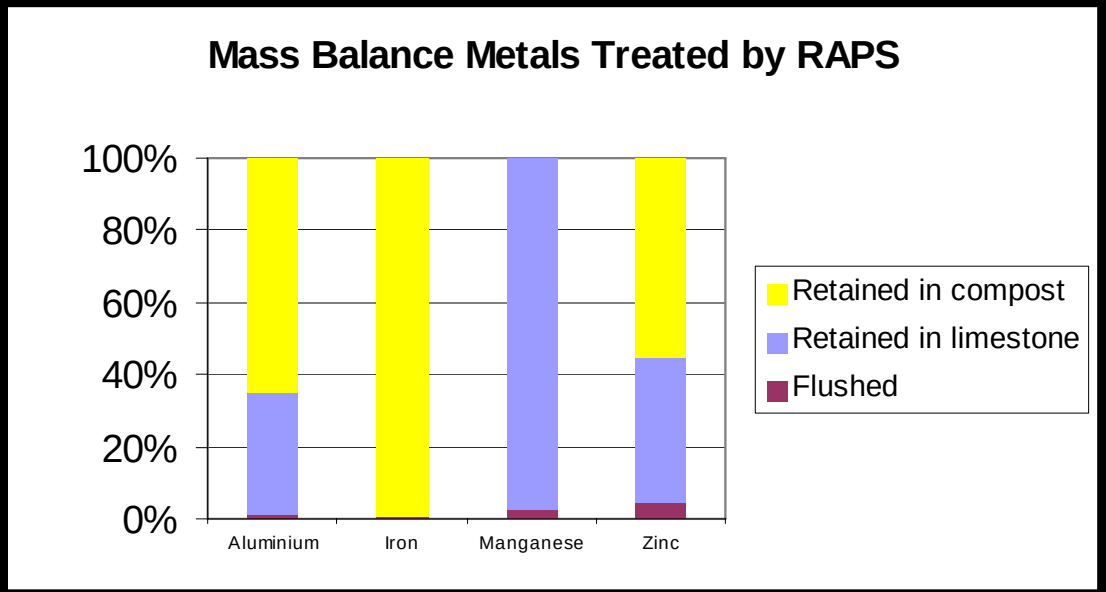
LLB best at manganese removal

LLB, RAPS equally effective at zinc removal (no data for OLC)

Therefore, for aluminium and iron removal any of these systems may be sufficient for treatment

Effectiveness of Flushing Systems





LLB

Flushing effective at removing:

11% of the aluminium

31% of the iron

8% of the manganese

RAPS

Flushing removed:

<10% of all metals

Majority of aluminium, iron, zinc retained in compost

Manganese retained in limestone

System Autopsies

LLB

No significant armouring of limestone with oxides and oxyhydroxides

RAPS

No significant armouring of limestone with oxides and oxyhydroxides

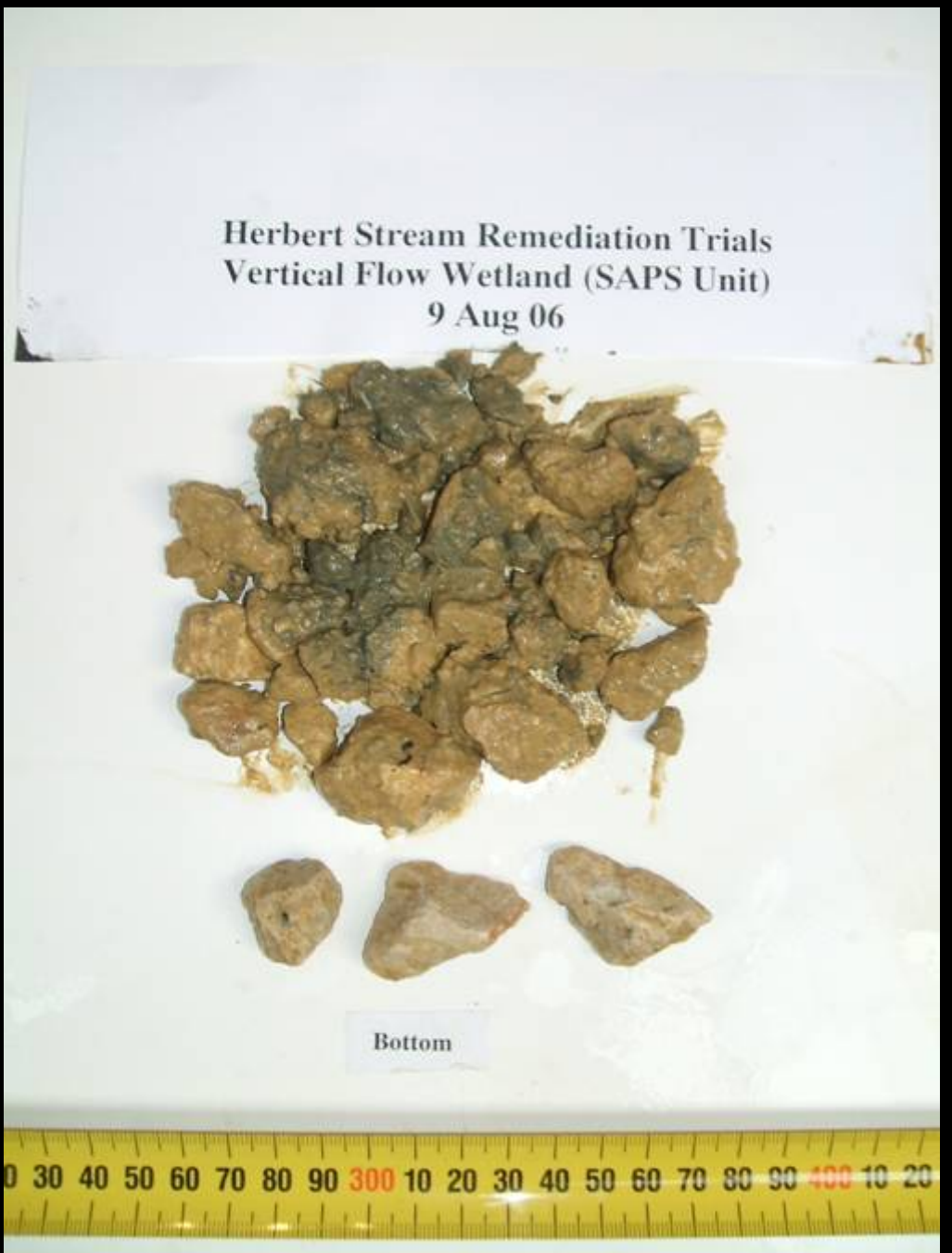
Black precipitate in upper layer likely from monosulphides


Herbert Stream Remediation Trials
Limestone Leaching Bed
9 Aug 06
Top
Middle
Bottom

LLB

RAPS


Herbert Stream Remediation Trials
Vertical Flow Wetland (SAPS Unit)
9 Aug 06
Top


Herbert Stream Remediation Trials
Vertical Flow Wetland (SAPS Unit)
9 Aug 06
Bottom

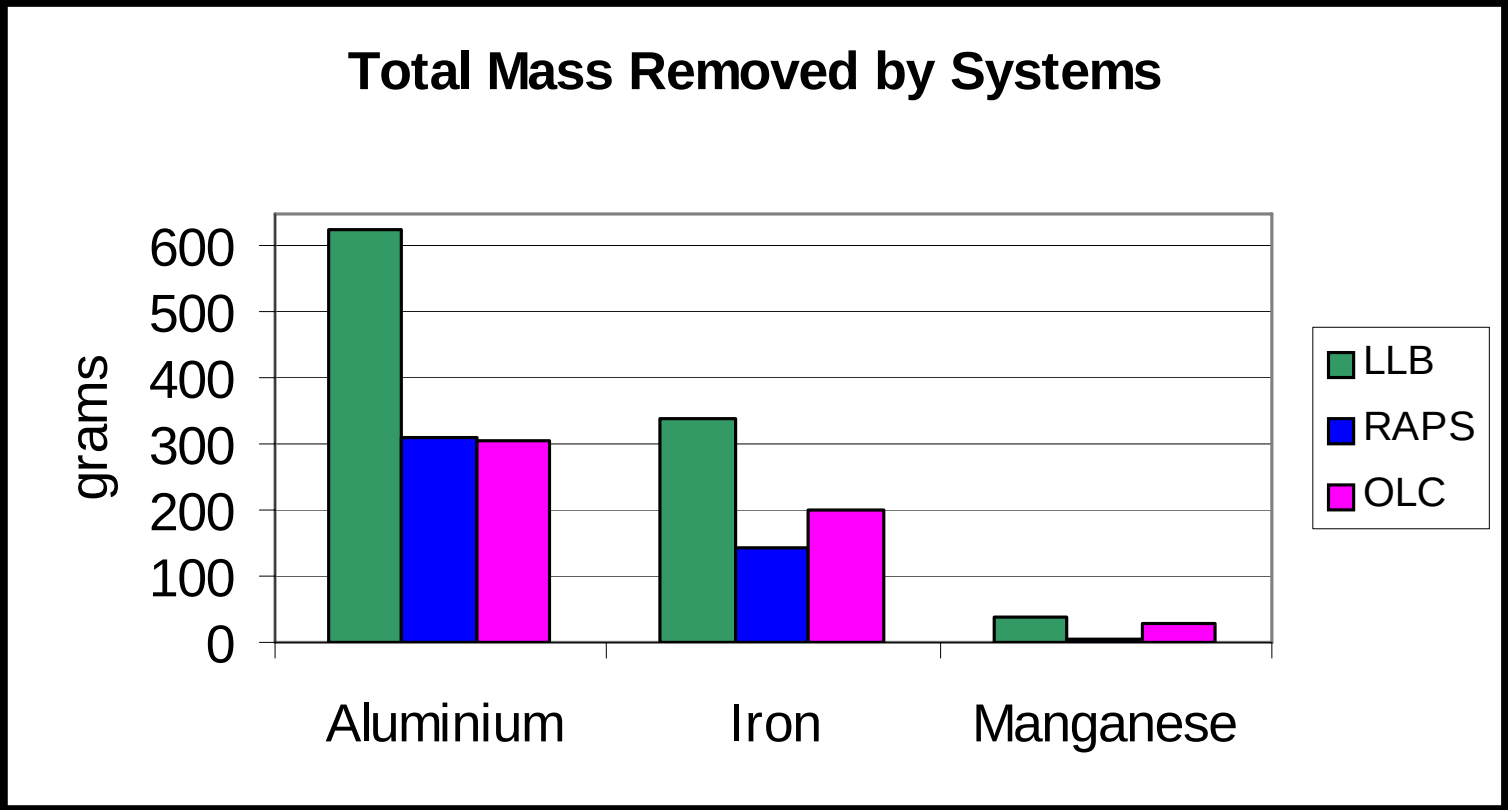
OLC

Armouring with ferric hydroxide

OLC


Herbert Stream Remediation Trials
Open Limestone Channel
9 Aug 06
Start
Middle
End

Total mass treated used to compare armouring of limestone



Although no significant armouring of limestone in LLB, this system removed the greatest mass of contaminants

Monosulphides in RAPS


0 hour
10
20
30
40
50
60

Pathway to Pyrite

$2CH_2O + SO_4^{2-} \longrightarrow H_2S + 2HCO_3^-$

Organic Carbon — Sulphate — Hydrogen Sulphide — Bicarbonate

$Fe^{2+} + H_2S + 2HCO_3^- \longrightarrow FeS + 2H_2O + 2CO_2$

Ferrous Iron — Hydrogen Sulphide — Bicarbonate — Mackinawite — Water — Carbon Dioxide

$3FeS + S^{2-} \longrightarrow Fe_3S_4$

Mackinawite — Sulphide — Greigite

$Fe_3S_4 + S^{2-} \longrightarrow 3FeS_2$

Greigite — Sulphide — Pyrite

Summary of Trials

- LLB, RAPS, OLC each capable of treating AMD to acceptable levels

  Effectiveness of OLC may be compromised if limestone becomes armoured with oxides and hydroxides

  OLC not feasible to construct at site (would require ~5km of open limestone channel)

- LLB simpler than RAPS, therefore full-scale LLB proposed for the site

  Although aluminium > iron, aluminium does not armour limestone and precipitates can be flushed from a leaching bed

Full Scale LLB Conceptual Design

Design

- 50 metres long, 25 metres wide, 2 metres deep
- 1000 m^3 limestone (~40-70mm dia)
- Horizontal flow with vertical flushing capability
  - perforated vertical pipes to induce horizontal flow
  - network of perforated pipes at base for vertical flush
- Two settling ponds in series
- Holding pond capable of holding full volume flushed water

Operating Parameters

- 20 hour residence in system
- 20 hour residence in each settling pond
- 25 year life expectancy
- 100 m^3 sludge accumulation per year (assumes 5% solids)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