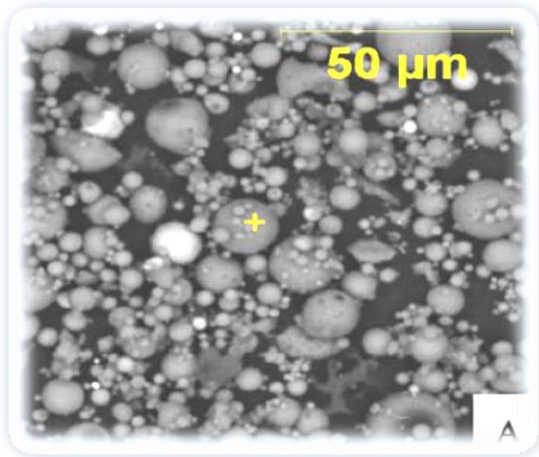




# Market Opportunities for Coal Ash within Australian Agriculture

Jane T Aiken<sup>A</sup>, Craig Heidrich<sup>A</sup>



<sup>A</sup> Ash Development Association Australia

- Background
- Market Opportunities
- Legal Certainty
- Marketing Knowledge
- Market Situation Analysis
- Summary



Ash Development  
Association of Australia  
formed 1990

Original membership  
based on use for  
cement/representation  
cement producers.

National Technical &  
Education Committee –  
accepting that other uses  
for CCPs can be  
adopted.

Policy for coal ash in agriculture

Agriculture accepted as a  
sustainable option within  
national and international  
research literature  
>1970.

Board support for  
research

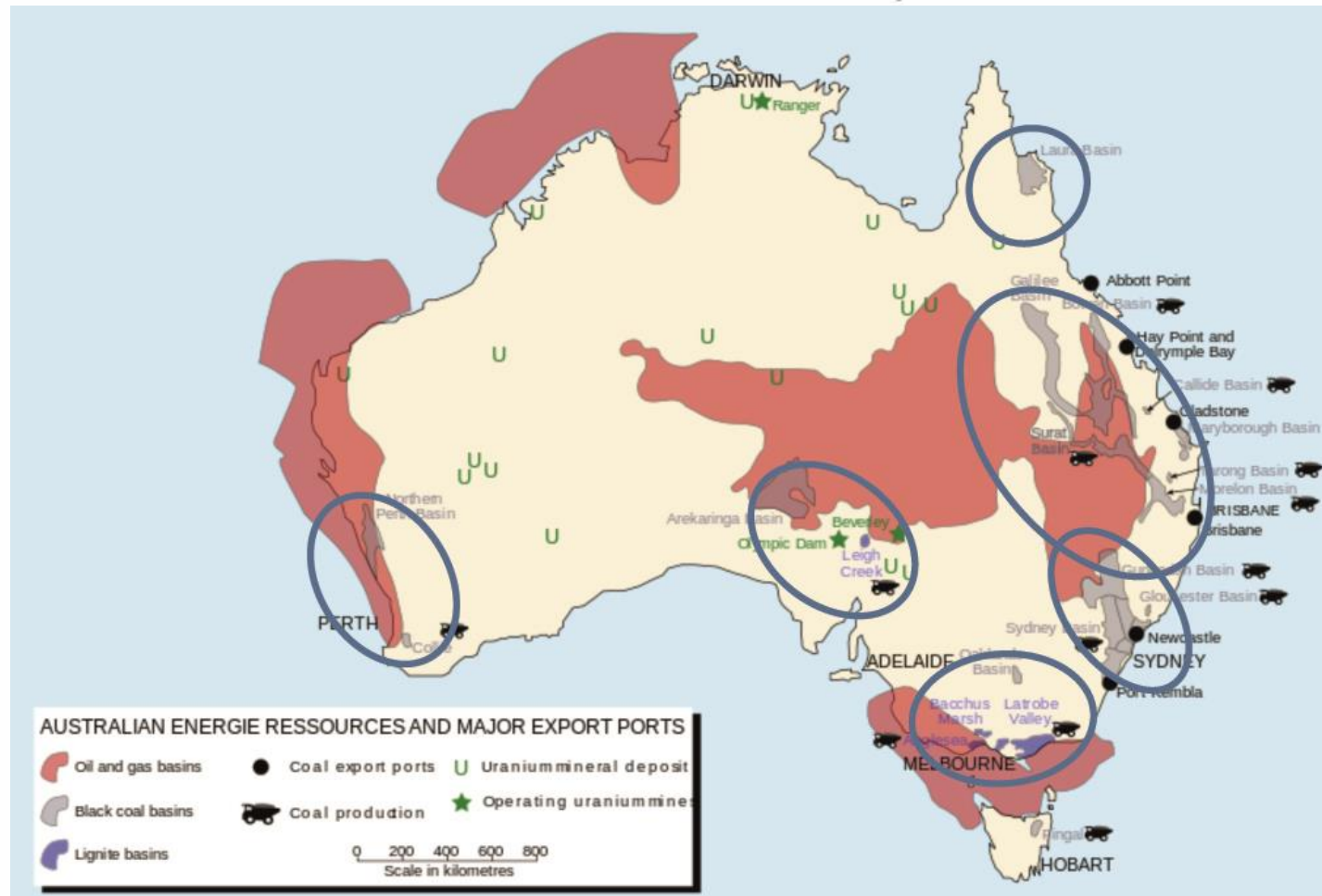
National Technical &  
Education Committee

Individual inputs by  
member companies.

Operational and Industry  
Leadership  
Applied research, review,  
advocacy, extension,  
technical support.



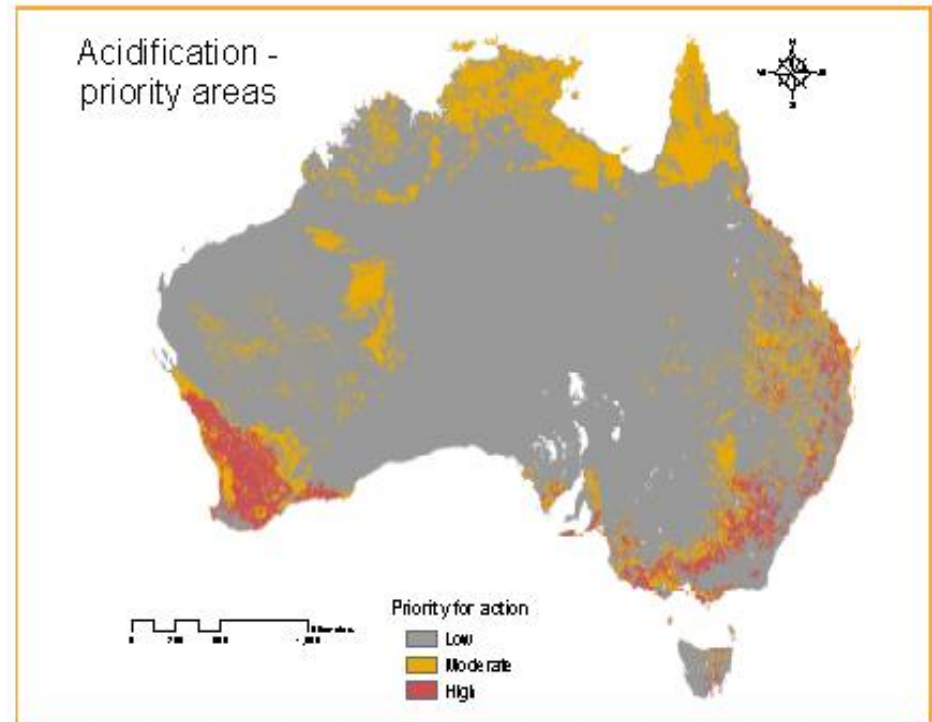
**Adelaide Brighton Cement (SA)**  
**Boral Cement (NSW)**  
**CS Energy (QLD)**  
**Holcim (NSW)**  
**Delta Electricity (NSW)**  
**Eraring Energy (NSW)**  
**ESAA (National)**  
**Alinta Power (SA)**  
**Flyash Australia (NSW, WA)**  
**Golden Bay Cement (New Zealand)**  
**Hyrock (NSW)**  
**International Power (VIC)**  
**Independent Fly ash Brokers (QLD)**  
**Loy Yang Power (VIC)**  
**Intergen (QLD)**  
**NuCrush (QLD)**  
**Pozzolanic Enterprises (QLD, VIC)**  
**Rocla (NSW)**  
**RTA (NSW)**  
**Tarong Energy (QLD)**  
**Tarong North (QLD)**  
**TRUenergy (VIC)**  
**Verve Energy (WA)**





# Market Segment Acidic & Sodic Soils

- Market potential easily identifiable, 50 million ha of highly < pH 4.8 and moderately pH 4.8-5.5 soils found mostly along coastal areas.
- Promote the CCP materials as products suited to improving profitability. Push the market
- Provide the market with highly specific information. Pull the market





# Market Supply

**Current market is construction and quarrying - cement, cementitious, civil**

<b>Production as Tonnes (2012) Member survey</b>	<b>Fly Ash (Mt)</b>	<b>Furnace Bottom Ash (Mt)</b>	<b>Total CCP<sup>1</sup> for 2012 (Mt)</b>
<b>Total Produced (Jan-Dec)</b>	<b>11.3</b>	<b>1.4</b>	<b>12.7</b>
<b>Total Production Used (23%<sub>FA</sub>, 25%<sub>FBA</sub>)</b>	<b>2.7</b>	<b>.34</b>	<b>3.04</b>
<b>Total Not Used Stored (77%<sub>FA</sub>, 75%<sub>FBA</sub>)</b>	<b>8.7</b>	<b>1.0</b>	<b>9.7</b>
<b>Total Amounts removed or diverted from storage</b>	<b>2.2</b>	<b>0.9</b>	<b>2.3</b>
<b>Total of all used</b>	<b>4.9</b>	<b>.47</b>	<b>5.3</b>
<b>5 % of total produced</b>	<b>0.57</b>	<b>0.07</b>	<b>.64</b>

*Therefore options for coal ash agricultural market sector*

*CCP - A valuable Resource*





# Strategy for Agriculture

Strategy	Aspect	Action
Market Identification	1. Applied Research 2. Review	Amelioration of soil constraints – baseline aspects of (i) mitigation of soil acidity (ii) amelioration of sodicity (iii) nutrient supply and minimisation of nutrient loss (iv) amelioration of soil structural and hydrological properties (v) Carbon sequestration – enhancement, capture & protection
Market Development	3. Materials knowledge	Investment into broader testing suites relevant to agricultural /soils Build on data for with characterisation of heavy metals and radioactivity. Fly ash, Furnace bottom ash
	4. Regulations	General exemptions and legal certainty, environmental resource recovery policies
Advocacy and Education	5. Knowledge extension	ADAA technical literature Research 2 x projects CCP Handbook Technical reference data National testing programs
	6. Technical support and monitoring	Annual monitoring



Market opportunities lie in the ability to ameliorates soil constraints – worth 3 B\$ in improved profits to agricultural sector.

- (i) Mitigation of soil acidity
- (ii) Amelioration of sodicity
- (iii) Nutrient supply and minimisation of nutrient loss
- (iv) Amelioration of soil structural and hydrological properties

and

- (i) Carbon sequestration – enhancement, capture & protection

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ABOUT US

Environmental  
issuesWaste and resource  
recovery

- + Waste Less, Recycle More
- + Waste legislation
- + Waste avoidance and resource recovery in NSW
- Regulating waste in NSW

Waste licensing

Classifying waste

- Resource recovery exemptions

Current general  
exemptions

How to apply for an exemption

- + Waste and environment levy
- + Tracking and transporting waste
- + Exemptions for residue waste
- + Exemptions from tracking waste
- + Waste immobilisation
- + Online waste tracking
- + Online waste reporting
- + Environmental guidelines
- + Types of waste
- + Litter
- + Illegal dumping
- + Information for local

You are here: [Home](#) > [Waste and resource recovery](#) > [Regulating waste in NSW](#) > [Resource recovery exemptions](#) > Current general exemptions

## General resource recovery exemptions

The EPA issues general exemptions for commonly recovered, high volume and well characterised waste materials.

A general exemption may be used by anyone, without seeking approval from the EPA, provided the generators, processors and consumers fully comply with the conditions of the exemption. However, these exemptions do not release those using them from complying with relevant planning consent requirements and it is their responsibility to seek any necessary development consents from the appropriate regulatory authority.

The general exemptions currently in force are listed below. Any additional exemptions will be published in the NSW Government Gazette and added to the list below.

## List of general exemptions

Name of exemption	Link to exemption (PDF)	Last updated
Acetylene gas lime slurry	<a href="#">ex08acetylenegaslimeslurry.pdf</a> (55KB)	20 June 2008
AWT outputs (mixed waste organic outputs)	<a href="#">ex11mixedwasteorganicoutputs.pdf</a> (94KB)	4 March 2011
Basalt fines	<a href="#">ex08basaltfines.pdf</a> (56KB)	20 June 2008
Biosolids	<a href="#">ex08biosolids.pdf</a> (35KB)	20 June 2008
Coal ash	<a href="#">ex13coalash.pdf</a> (67KB)	22 April 2013
Coal washery rejects	<a href="#">ex09CWR.pdf</a> (47KB)	1 November 2009
Coal washery rejects (coal mine void)	<a href="#">ex09CWRminevoid.pdf</a> (30KB)	1 November 2009
Composted paunch	<a href="#">ex11paunchcompost.pdf</a> (38KB)	31 January 2011





- Exemption regulations identify what not to apply to soil
- A quick reference to selection of materials based on regulatory testing
- Interests in metals concentrations and thresholds for pH, soluble salts, boron,
- Differences in metals and levels between states
- Materials characterisations (testing) typically driven from regulatory perspective



# CCP SELECTION – RISK - REGULATIONS

Legal certainty – commodity sales –  
responsibilities are well defined

Australian approach is to use regulatory  
thresholds to guide CCP selection for agronomic  
purposes, .....then requires specific matching  
to soil / growth conditions



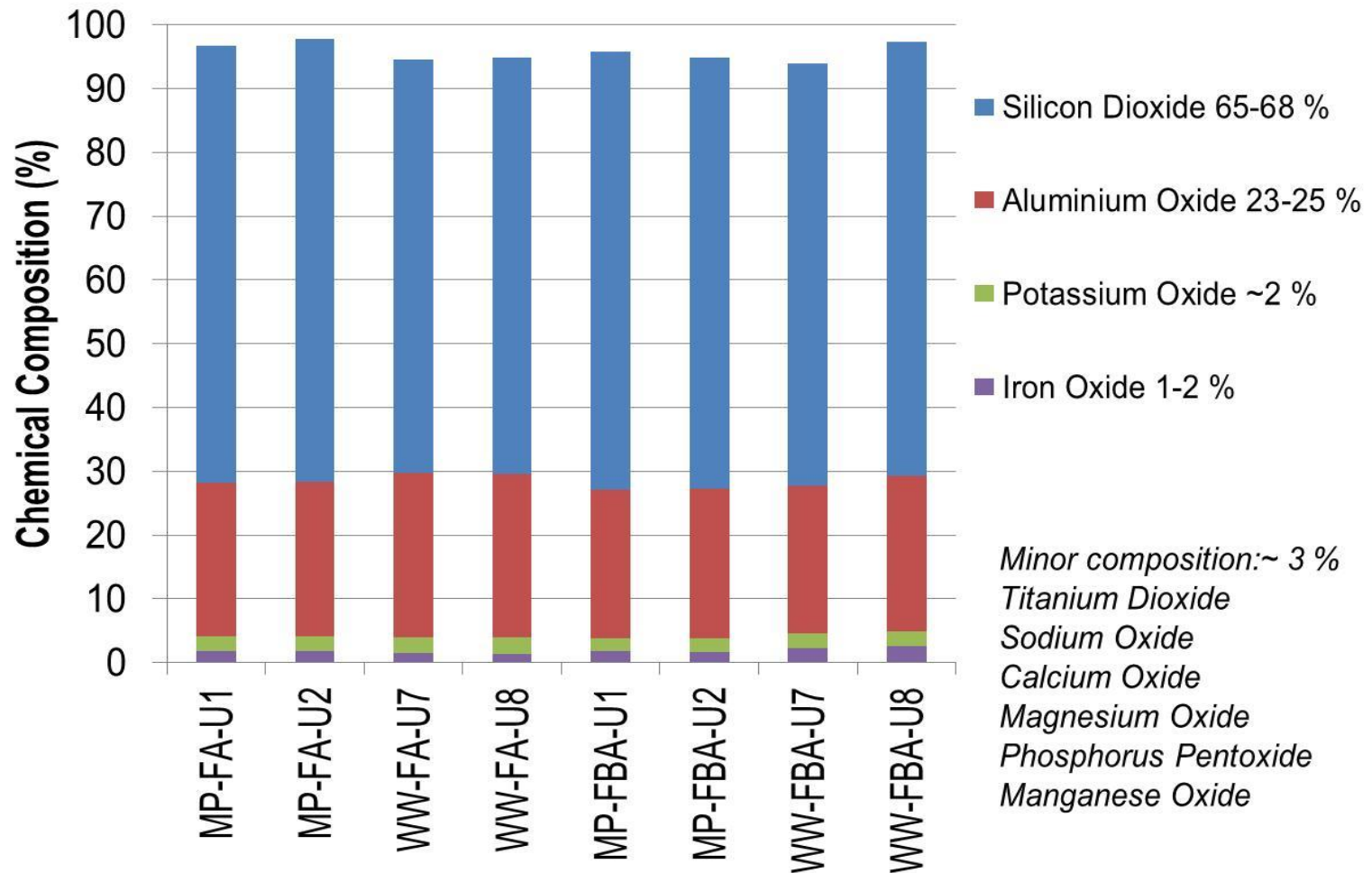
Australian fly ashes measured on soluble boron and soil electrical conductivity, then metals, 100 mg/kg for Pb, 10 mg/kg for Cd, 5 mg/kg for Hg.

- Brown coal and black coal similar
- Brown coal FA high salinity associated with chloride and sulphates

Australian furnace bottom ashes low salinity, low total boron, low soluble boron, sulphates and chlorides variables between source ashes

# Chemical Composition

Figure 1 Chemical Composition FA and FBA Western Coal







- Class F, 60-80 % silicon dioxide Figure 1.
- Low calcium < 3 %
- Low magnesium < 1 % to 11 %
- Negligible P, N, K
- THEREFORE NOT REPLACEMENT MATERIALS FOR FERTILISER, GYPSUM OR LIME
- Micronutrient benefits
- Aim – to optimise soil conditions for plant growth and yield



# Product Attributes– Class F - FA

1. Raise the pH of amended acidic soils over an extended period
2. Positive responses in plant growth a combination of factors (liming, nutrient supply physical properties)
3. Phytotoxicity risk low
4. Al dissolution risk low due to long term aluminosilicate dissolution → pH toward neutral
5. Risks reduced due to agronomically sustainable rates ie, lime or gypsum
6. Most benefits obtained 5-10 Mg/ha
7. Second season benefits after initial application
8. Most black coal ashes meet regulatory thresholds

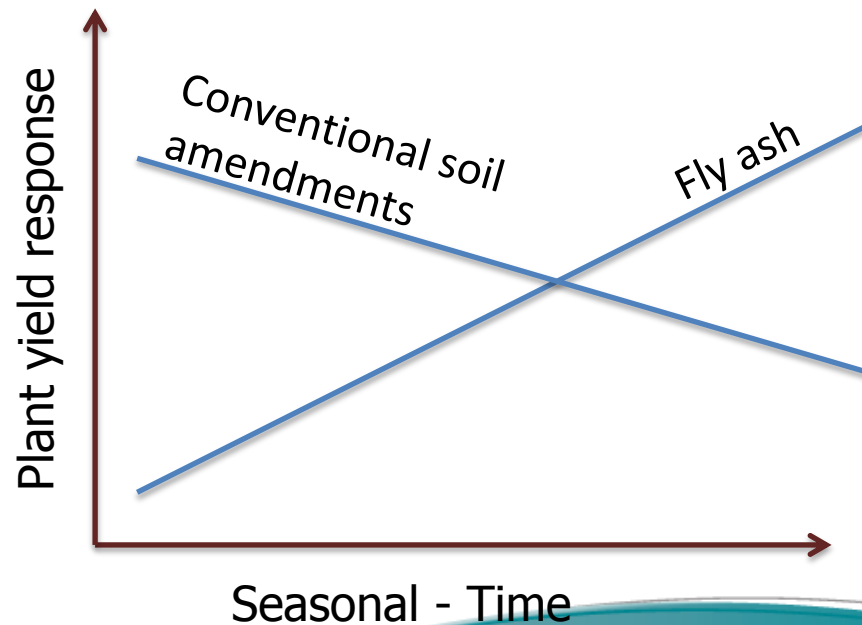


# Benefits



# AGRONOMIC POTENTIAL

- Australian recommendations of 5 -10 Mg/ha (Yunusa *et al.* 2012) to achieve plant yield response (can achieve response with 3.5 Mg/ha)
- Hypothesis







- Example calculation silica, for a clay loam soil nutrient level need 0.157 Mg/ha
- WHY SILICA?
- Identify plant available elements Al, Si, Fe, Ca, Mg.

% Ratio of total elemental digest (by concentration)	
FA H <sub>2</sub> O	Ca > K > Mg > Si ≡ Al > Fe
FBA H <sub>2</sub> O	Si > K ≡ Ca > Mg ≡ Al > Fe
FA Mehlich	Si > Ca > K > Mg ≡ Al > Fe
FBA Mehlich	Si > Ca > K > Mg ≡ Al > Fe
Original total (mg/kg)	<i>360 360 1150 7500 7500 3000</i>

FA, FBA Samples from one power station

(Al implication of toxicity but ECEC) very low (< 6 cmol<sup>+</sup>/kg)



# Calculation Si

Example Values: Si (Mehlich)

FA 220 mg/kg  $\equiv$  220 kg /1000 kg

FBA Si, 260 mg/kg  $\equiv$  260 kg /1000 kg

Silicon sufficiency	mg Si/kg	kg Si/ha (x 1.3)
Clay	50	65
Clay loam	45	58.5
Loam	40	52
Loamy sand	35	45.5

Environmental & Analysis Laboratory, Southern Cross University

## Example

Got Clay loam soil 18 mg Si/kg, 18 kg/tonne x 1.3<sub>BD</sub> = 23.4 kg Si /ha

Want Clay loam soil 45 mg Si/kg, 45 kg/tonne x 1.3<sub>BD</sub> = 58 kg Si /ha

Need from FA = 34.6 kg Si /ha

FA contain = 220 kg Si / tonne

Apply = **0.157 t / ha**



**Ash Development  
Association of Australia**

[www.adaa.asn.au](http://www.adaa.asn.au)

# Market Situation Analysis



## •PRICE

- Commercial risk
  - No commercial \$ value defined
  - Only other soil amendment products

## PRODUCT

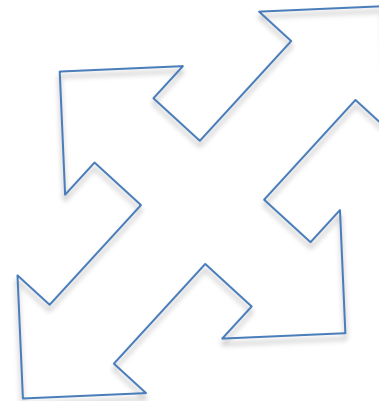
**Inherent value** ( $Ca + Cr + Ct < Vu$ )

where

Ca is avoided cost,  
Cr is product recovery and processing,  
Ct is transport cost,  
Vu is value in the hands of the end user

*(Heeley 2007).*

# Strategy



## •PROMOTION

- Existing ADAA Strategy, Research, Review, Materials, Legislation, Advocacy & Education, Technical Support





## STRENGTHS, WEAKNESSES, OPPORTUNITIES, THREATS (SWOT)

**S** - CCP a choice for the landholder not a substitute

- well defined materials testing program
- materials fit with regulatory thresholds
- Legal certainty defined
- CCPs source of plant micronutrients

**W** – lack of strong economic drivers

- lack of perceived value
- Only 600 tonne use to date, no current market
- issues with modes for field delivery
- waste & resource recovery status;
- lack of field trials
- lack of promotional push to intended market
- CCPs cannot substitute gypsum or lime
- Logistics, transport & application

**O** – Market as an ethical product

- supply model is independent of the current market segments

**T** – Market a material that is a waste and ongoing need to continually prove benefits

- extended time frames



# 1. Soil Blend - 2. Raw Mix

- Opportunities for research and development
  - PROBLEM - How to manage raw-feed production ashes. All research with run-of-station products.
  - Conventional soil incorporation techniques not suited to FA
  - Need for topsoil incorporation to achieve productive results in soils
  - Without appropriate soil delivery techniques risk to atmosphere and water
- *Figure Conventional field techniques will not be appropriate*

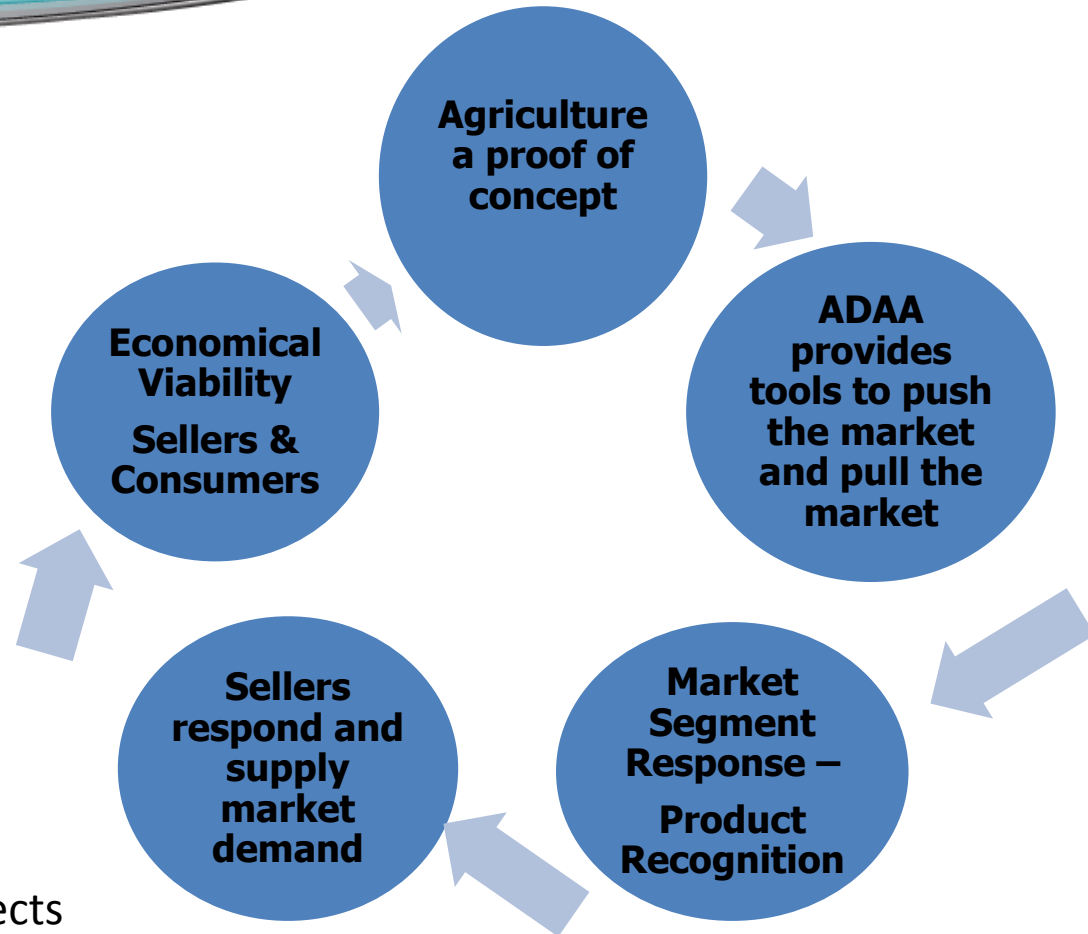




<b>Sites</b>	<b>Regional</b>	<b>State</b>	<b>National</b>	<b>Establishment (yrs)</b>
<b>Variations of coal source, production plants and therefore ash properties and characteristics</b>				<b>1-2</b>
<b>Variations in target soil and soil conditions, therefore variations in predicted soil responses</b>				<b>1-5</b>
<b>Regulatory frameworks that may differ from state to state</b>				<b>2-5</b>
<b>Distribution for a national commodity subject to product competition</b>				<b>5-10</b>
<b>Field trials and favourable commercial agronomic outcomes</b>				<b>2-10</b>
<b>Commercial production opportunities from RAW-FEED or MANUFACTURED materials</b>				<b>5-10</b>



# PLAN...



1. Endorse research projects
2. Establish field sites
3. Promote products (raw / blended)
4. Establish agricultural stakeholder ADAA representation



# Summary



## **Australian coal ash industry has**

1. Market opportunities – to improve soil constraint to agriculture production
2. Agricultural market is independent of current industry stakeholders
3. 8 Mt of annual production to draw from
4. A method for product selection for all land-based applications, agricultural, horticultural, civil
5. CCP with low risk of phyto toxicity or environmental ground water
6. Predictions for sustainable soil responses and an establish baseline application rate
7. Potential to address soil acidity, soil sodicity, nutrient retention, soil structural and hydrological properties, carbon sequestration
8. Opportunities to build an ethical brand
9. Conceptually resource recovery but this industry is not about disposal
10. CCPs are an alternate option for soil management





THANK YOU FOR THIS OPPORTUNITY TO SHARE THE  
AUSTRALIAN EXPERIENCES



Metal (mg/kg)	Test LOR	Australian Black Coal Fly Ash <sup>3</sup>	Australian Brown Coal Fly Ash <sup>3</sup>	NSW Max Absolute <sup>1</sup>	QLD Total <sup>1</sup>	Yunusa <i>et al</i> 2007 <sup>4</sup>
Antimony	1	<b>2.2</b>	<b>&lt;1</b>			
Arsenic	1	<b>14</b>	<b>6.1</b>	20	100	
Barium	5	<b>1400</b>	<b>370</b>		NS	
Beryllium	1	<b>6.3</b>	<b>3</b>		20	
Boron	5	<b>450</b>	<b>320</b>	150	NS	
Cadmium	0.1	<b>0.4</b>	<b>0.1</b>	1	20	10
Chromium (III)	2	<b>26</b>	<b>10</b>	50	12%	
Cobalt	1	<b>23</b>	<b>31</b>		100	
Copper	2	<b>37</b>	<b>38</b>	40	1000	
Lead	2	<b>30</b>	<b>15</b>	50	300	100
Manganese	5	<b>690</b>	<b>3200</b>		1500	
Mercury	0.05	<b>0.14</b>	<b>0.6</b>	1	15	5
Molybdenum	1	<b>18</b>	<b>6</b>	20	NS	
Nickel	1	<b>58</b>	<b>160</b>	50	600	
Selenium	2	<b>3.8</b>	<b>18</b>	20		
Silver	0.1	<b>0.2</b>	<b>0.1</b>			
Vanadium	5	<b>150</b>	<b>110</b>			
Zinc	5	<b>69</b>	<b>67</b>	70	7000	
<sup>1</sup> Criteria for land application - civil uses						
<sup>2</sup> Black coal 13 samples; 3 brown coal samples						
<sup>3</sup> Maximum of all sample values						
<sup>4</sup> Coal Combustion Products Handbook Yunusa <i>et al.</i> 2007, Chapter 12						



13 sites black coal; 3 sites brown coal

			NSW	NSW	NSW	Qld	Qld	Qld	Qld	Qld	Qld	Qld	Qld	WA	WA	SA	Vic	Vic
	Coal Colour		Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Brown	Brown	Brown
	Coal Basin		Sydney Newcastle	Sydney West	Sydney West	Tarong Basin	Tarong Basin	Surat Basin	Callide Basin	Bowen Basin	Bowen Basin	Surat Basin	Surate Basin	Collie Basin	Collie Basin	Telfor Basin	Gippsland Basin	Gippsland Basin
	LOR	Units	Run-of-Station Fly Ash (Coal Combustion Product)															
pH (1:5)	0.1	units	12	3.4	3.9	4.1	6.8	4.4	6.4	12	11	12	12	4	4	10	9.3	12
Conductivity (1:5)	0.01	dS/cm	2.3	0.96	0.35	0.15	0.033	0.12	0.095	10	1.2	2.6	6.7	0.75	0.89	0.49	13	46
Conductivity (se)		dS/cm	5.175	2.16	0.788	0.338	0.074	0.27	0.214	22.5	2.7	5.85	15.08	1.688	2.003	1.103	29.25	103.5
Boron total	5	mg/kg	68	30	20	6.8	<5	< 5	< 5	20	450	99	70	15	12	120	240	320
Boron soluble	10	mg/kg	< 10	16	< 10	< 10	< 10	< 10	< 10	< 10	55	12	< 10	< 10	< 10	< 10	< 10	< 10
Chloride	10	mg/kg	< 10	10	< 10	< 10	51	< 10	10	29	< 10	< 10	17	< 10	< 10	27	550	8100
Sulphate (S)	10	mg/kg	170	1300	430	150	< 10	79	49	480	730	95	130	1000	1200	270	21000	6900

	LOR		Run-of-Station Furnace Bottom Ash															
pH (1:5 Aqueous extract)	0.1	units	9.4	8.7	7.3	7.3	6.7	8	9.6	11	8.8	9.6	11	5.2	7.5	9.1	8.3	5.8
Conductivity (1:5))		dS/cm	0.041	0.045	0.14	0.012	0.005	0.34	0.038	0.41	1.9	0.055	0.68	0.29	0.1	6.3	0.11	0.72
Conductivity (se)		dS/cm	0.092	0.101	0.315	0.027	0.011	0.765	0.086	0.923	4.275	0.124	1.53	0.653	0.225	14.18	0.2475	1.62
Boron total	5	mg/kg	5	5.5	<5	< 5	< 5	< 5	< 5	< 5	25	11	15	< 5	< 5	59	17	7.3
Boron (Hot Water / CaCl2 extractable)*	10	mg/kg	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Sulphate (S)	10	mg/kg	<10	15	96	< 10	< 10	230	< 10	72	110	< 10	180	150	54	850	34	1200
Chloride	10	mg/kg	<10	< 10	30	< 10	< 10	380	< 10	44	2700	< 10	380	440	29	21000	< 10	63



<div> <div>NPKS</div> <div>ESP</div> <div>Ca Mg</div> </div>			NSW	NSW	NSW	Qld	Qld	Qld	Qld	Qld	Qld	Qld	Qld	WA	WA	SA	Vic	Vic
	Coal Colour	Coal Basin	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Black	Brown	Brown	Brown
	LOR	Units	Run-of-Station Fly Ash (Coal Combustion Product)															
Total Calcium	1	mg/kg	8900	420	160	19	1	170	350	33000	19000	10000	19000	4200	5000	21000	70000	140000
Total Magnesium	1	mg/kg	600	140	140	52	25	98	360	5800	4100	320	1800	1800	1800	6500	110000	95000
Total Potassium	1	mg/kg	320	1100	480	62	14	23	43	570	760	170	200	670	390	1000	1400	2000
Total Sodium	1	mg/kg	170	250	72	19	43	26	28	240	900	120	380	440	360	3000	15000	22000
Total Sulfur	100	mg/kg	420	1200	360	210	<100	120	< 100	1300	900	300	950	920	980	440	34000	29000
Total Phosphorus	10	mg/kg	400	230	78	32	< 10	< 10	12	2300	3800	130	< 10	1200	1100	1800	210	33
Total Nitrogen	10	mg/kg	51	77	16	50	<10	34	< 10	96	< 10	< 10	< 10	< 10	82	< 10	36	140
Nitrate & Nitrite (N)	0.1	mg/kg	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	< 0.1	0.2	< 0.1	0.5	< 0.1	< 0.1	< 0.1	0.1	0.8
Total alkali metals		mg/kg	9990	1910	852	152	83	317	781	39610	24760	10610	21380	7110	7550	31500	196400	259000
ESP		%	2	13	8	13	52	8	4	1	4	1	2	6	5	10	8	8
Ca % (of total cations)		%	89	22	19	13	1	54	45	83	77	94	89	59	66	67	36	54
Mg % (of total cations)		%	6	7	16	34	30	31	46	15	17	3	8	25	24	21	56	37
Ca:Mg		ratio	15	3	1.1	0.37	0.04	2	1.0	6	5	31	11	2.3	2.8	3.2	0.6	1.5

- **Potential applications to sodic soils**