Quantifying the Benefits of Waste Minimisation

A LTNZ Research project

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Waste minimisation

- **To develop a rational method to quantify the benefits of using waste minimisation techniques**

A 2003 Working Group

Concluded that reasons for not using waste minimisation included:

- a lack of clear direction in the TNZ specifications
- a lack of experience and confidence in the use and performance of the technologies in a New Zealand context,
- no methodology to quantify the benefits

Progress

- All TNZ specifications have been reviewed
- Demonstration projects using RAP, rubber crumb
- Allowance of glass and crushed concrete

Limitation of this research

- **The benefits have been estimated for the construction and not for the ‘whole of life”.**
- **The benefits can be used as an input into a whole of life NPV comparison where different pavement configurations have different performance**

Cost components

- Emissions =Energy + manufacture emissions
- Vehicle operating costs
- Traffic delay
- Resource Depletion

Flow chart


1. Raw Materials
2. Transport Raw Materials
3. Process Raw Materials
4. Transport
5. Manufacture
6. Transport
7. Construction
8. Transport Waste
9. Waste Disposal

Energy comparison

	unit	RRU 55	NCRP 85	ASCE 2005	Wrap	Vic University	Athena
Bitumen manufacture	kj/t	7.0E+05	6.8E+05	6.0E+06		4.4E+07	4.6E+06
Cement Manufacture	kj/t	6.9E+06	8.4E+06	6.3E+07	4.7E+06	7.8E+06	5.5E+06
Crushed Aggregate	kj/t	8.0E+04	6.8E+04	5.3E+04	1.7E+04	4.0E+04	5.0E+04
Hot mix manufacture	kj/t	4.8E+05	2.3E+04	3.5E+05	2.5E+05	3.4E+06	4.8E+05

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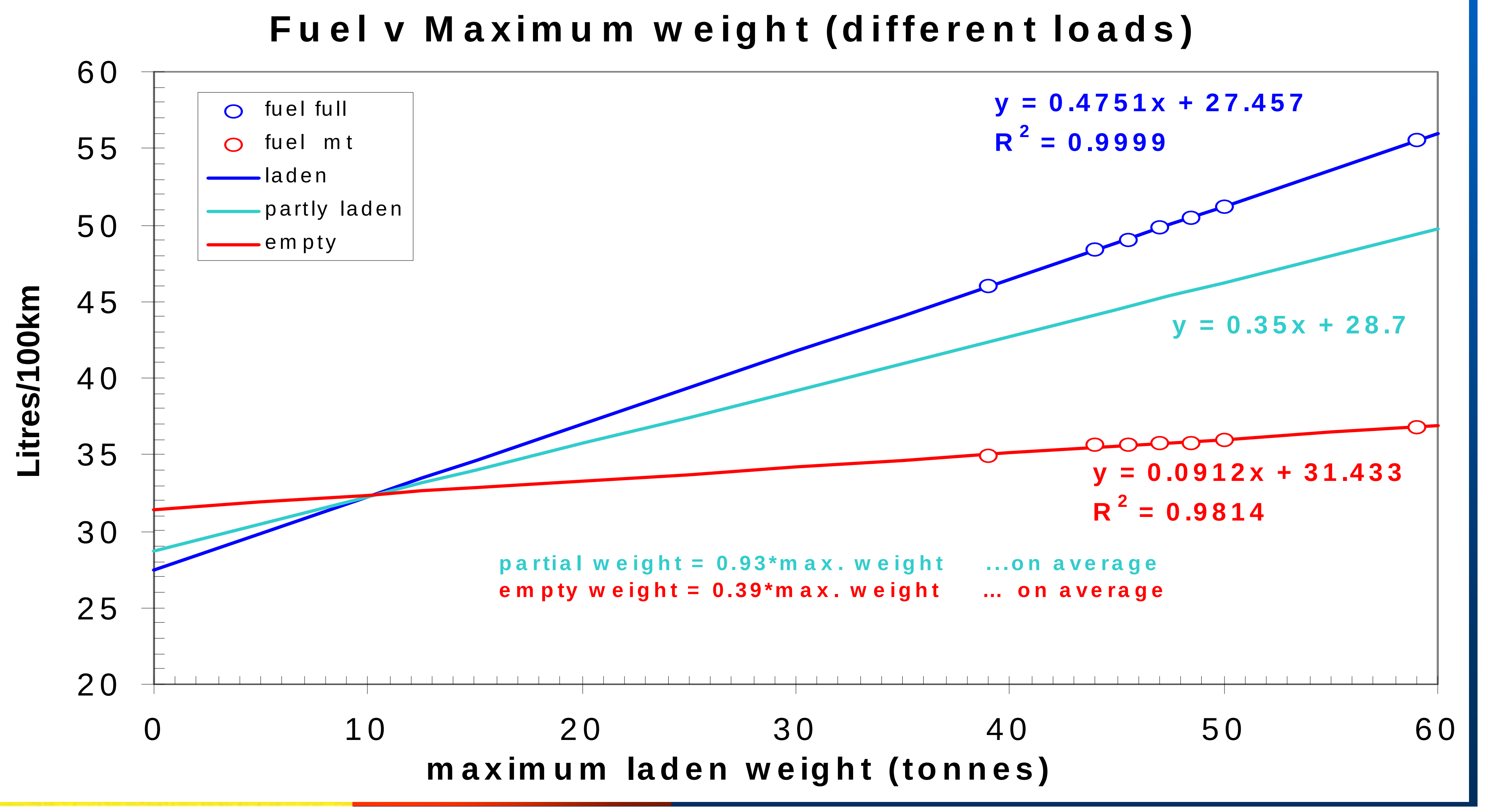
Transport Energy



Transport Energy

- a 32 tonne load max load-empty return

  930kj/t/km

14 tonne load max load-empty return

1825 kj/t/km.

CO2 Conversion

- Energy kj to equivalent litres of diesel

  ($3.87 * 10^4$ kj/l)

- 2.7 kg CO_2 /litre of diesel
- $7 * 10^{-5}$ kg CO_2 /kj

Aggregate v Concrete Crushing

- Aggregate in a quarry say 80% energy from electricity= 2.1 kg CO2/tonne
- Crushing concrete with a diesel powered generator = 3.5 kg CO2 /tonne
- Difference equivalent to approx 20km haul distance

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Value of emissions

- CO2 =$40/tonne
- Heavy Vehicle particulate 20c/km

Traffic Delay

	Morning peak	Daytime inter-peak	Afternoon peak
Traffic volume (ADT) =	2000	7000	2000
Speed during construction (km/hr)	5	20	5
Speed before construction (km/Hr)	60	70	60
Stopping time (min)	1	0	1

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Composite Values of Travel Time-Combining Occupant Time, Vehicle Time and Freight Time in $/h (July 2002)

	Urban		Rural	
	Arterial	Other	Strategic	Other
Morning Peak	15.13	16.23	23.25	22.72
Inter-Peak	17.95	16.23	23.25	22.72
Afternoon Peak	14.96	16.23	23.25	22.72

Vehicle operating costs -EEM

VOC=

base running costs by speed and gradient +
Road roughness costs +
Road surface texture costs +
pavement elastic deflection costs +
Congestion costs +
Bottleneck costs +
Speed change cycle costs

Vehicle operating costs -EEM

VOC=base running costs by speed

+

Congestion costs

+

Speed change cycle costs

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Aggregate Resource Depletion

Britain use £ 1.60 / tonne

(approx NZ $4.00/tonne)

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Not included

- Landfill costs
- Extra traffic wear
- Job creation

Insitu stabilisation

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Length	500m
Width	10m
AADT	15,000
Morning peak veh Inter peak veh Evening peak veh	3,000 9,000 3,000
Electricity % in processing aggregate	80%
Aggregate crushed or screened	All crushed
Transport distance plant to site km	20
Distance to dump km	30

	Convention	Stabilis
Construction time Days	15	10
Basecourse thickness	150mm	150mm
Subase mm	300	
Stabilised insitu mm		250
Additive		1.5% cement
Excavated to waste	450mm	150mm
Surface	Chip	Chip

CO_2 emissions

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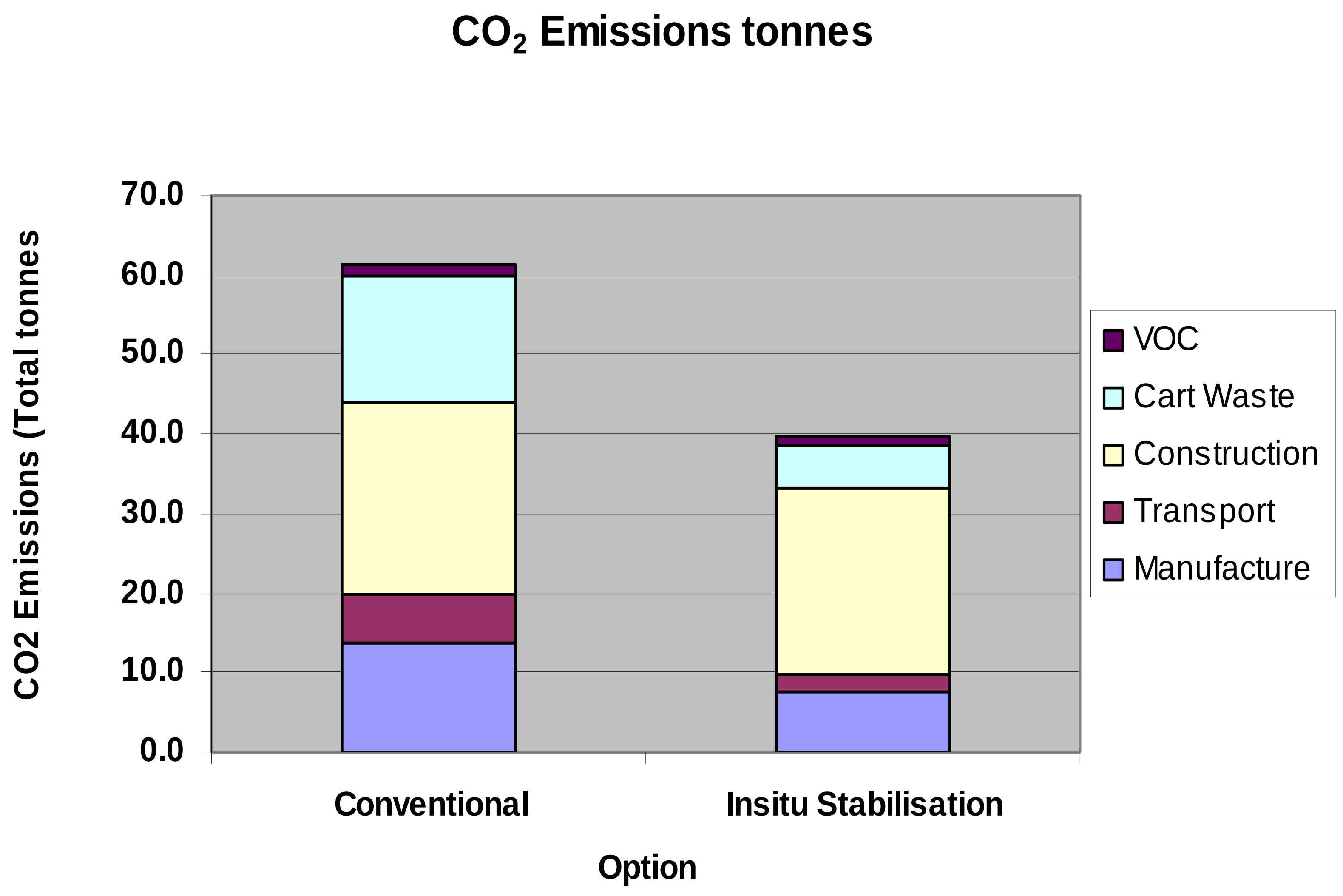
CO2 conversion for Electricity

- NZ approx 63% of electricity comes from hydro
- 6.5% from geothermal

- 1.6 $*10^{-5}$ kg CO_2/kj
- 4 times lower than from diesel


CO2 Emissions tonnes
CO2 Emissions (Total tonnes
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
Conventional
Insitu Stabilisation
Option
VOC
Cart Waste
Construction
Transport
Manufacture

Energy consumption

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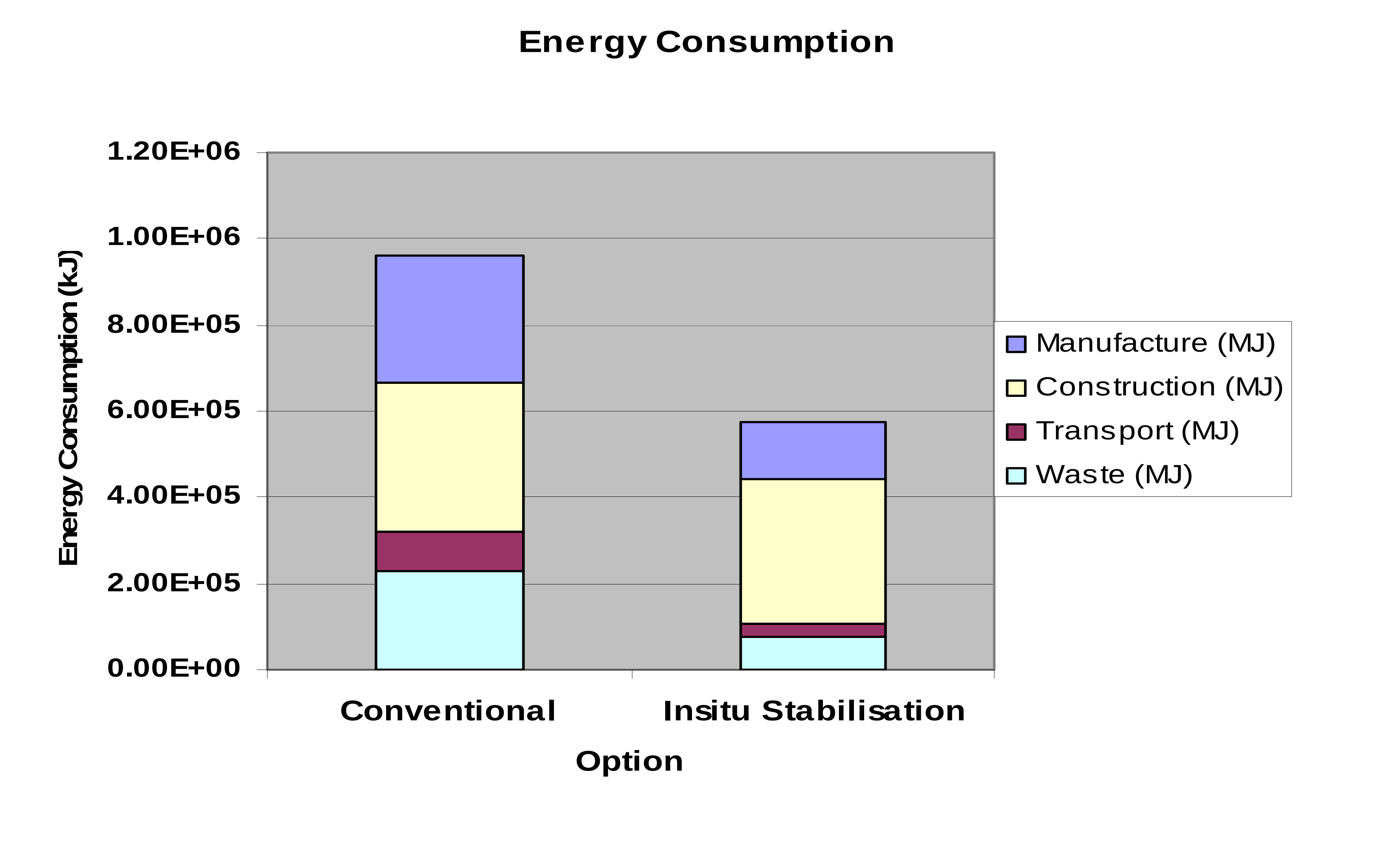

Energy Consumption
1.20E+06
1.00E+06
8.00E+05
6.00E+05
4.00E+05
2.00E+05
0.00E+00
Energy Consumption (kJ)
Conventional
Insitu Stabilisation
Option
Manufacture (MJ)
Construction (MJ)
Transport (MJ)
Waste (MJ)

Costs

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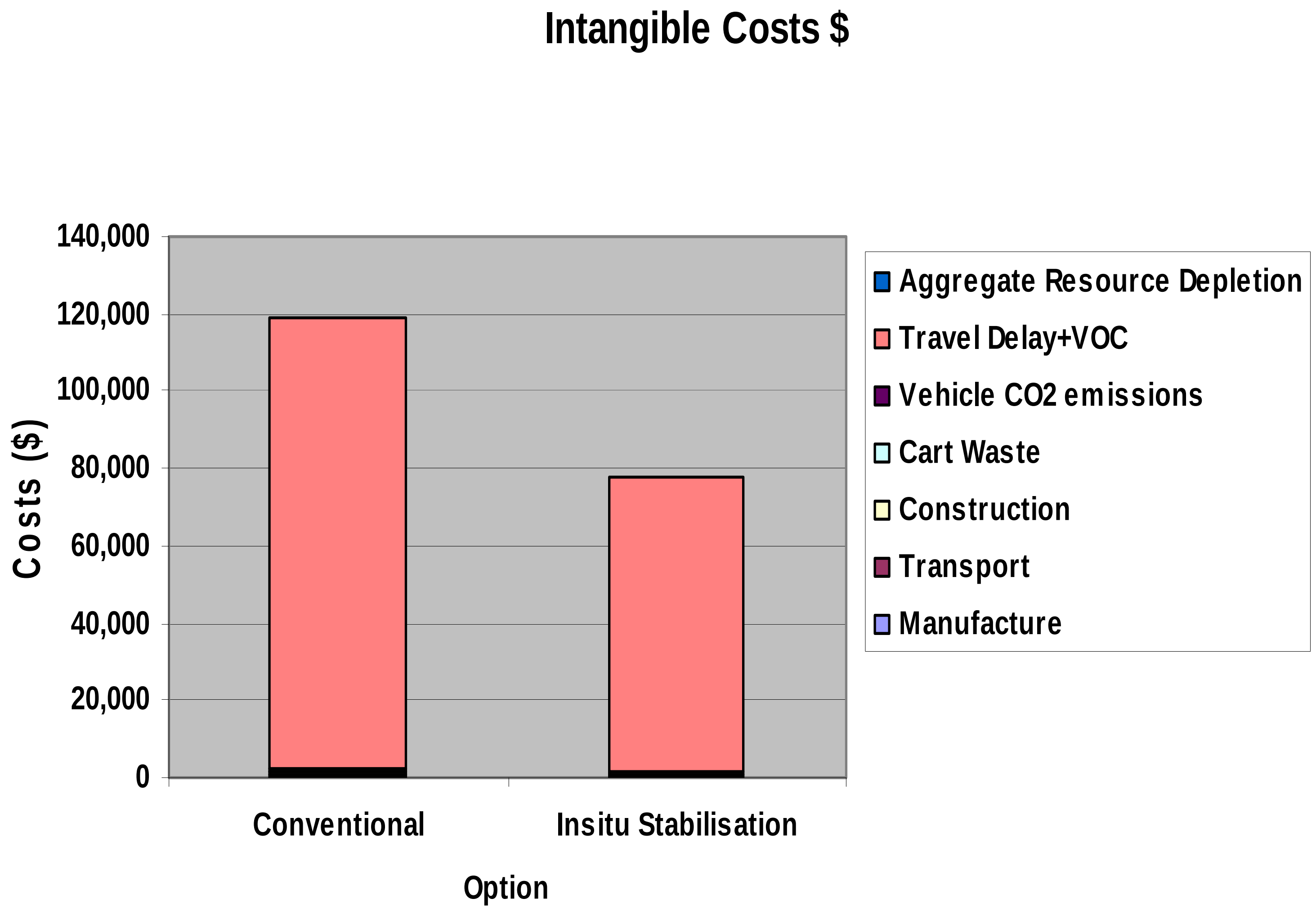
Intangible Costs $
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
Costs ($)
Conventional
Insitu Stabilisation
Option
Aggregate Resource Depletion
Travel Delay+VOC
Vehicle CO2 emissions
Cart Waste
Construction
Transport
Manufacture

Materials

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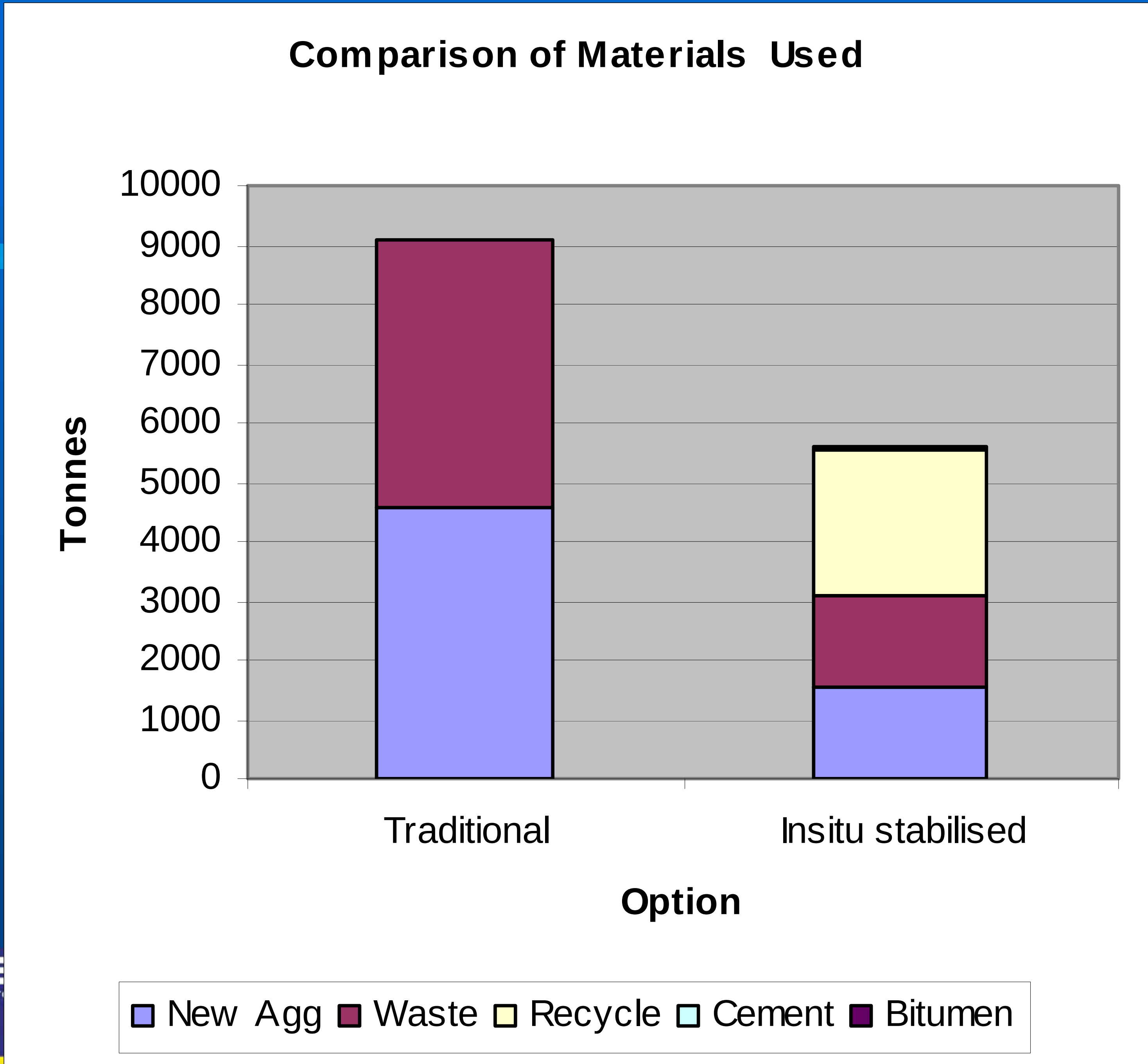
Comparison of Materials Used
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Tonnes
Traditional
Insitu stabilised
Option
New Agg
Waste
Recycle
Cement
Bitumen

CO2 Footprint of Recycled Concrete for use in the Christchurch Southern Motorway

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OPUS

Transit has requested Opus to:

Determine the Carbon Footprint of different methods of obtaining 60,000m³ of AP65 Subbase for use in construction of the Christchurch Southern Motorway.

The cases modelled:

- **Aggregate from the Waimakariri riverbed to placement**
- **Recycled concrete to stockpile and then placement**

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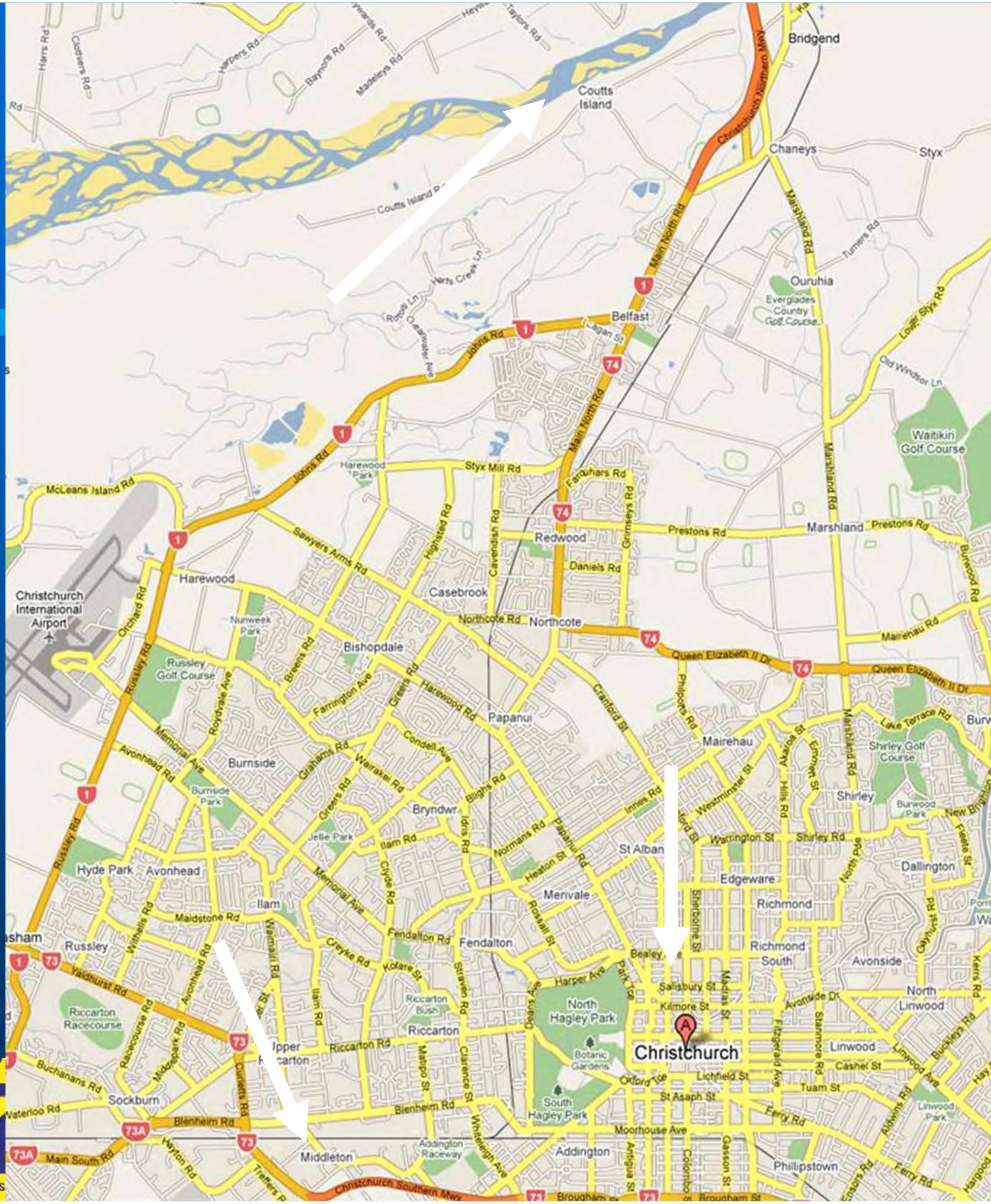
Cost

- Crushed concrete delivered to site is more expensive than the river sourced material
- $34.25/cum v $28/cum

- Why should NZTA (LTNZ) pay more?



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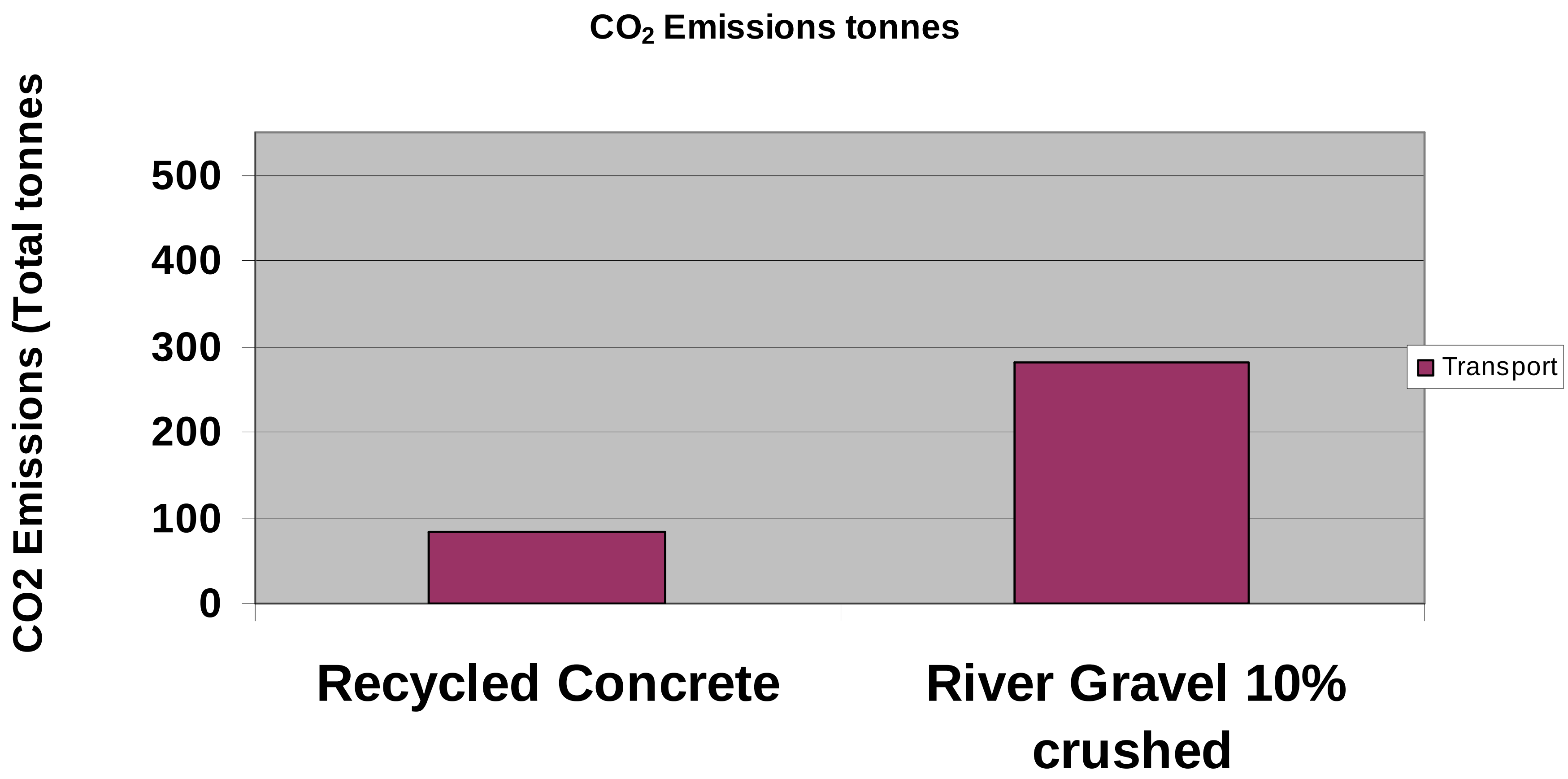
Transport

- Crushed Concrete 15km round trip
- River sourced 50km round trip



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Aggregate Processing

- Crushed Concrete – diesel powered
- River Sourced – electric powered screening and crushing 10% of material

Aggregate v Concrete Crushing

- Aggregate in a quarry say 80% energy from electricity= 2.1 kg CO_2/tonne
- Crushing concrete with a diesel powered generator = 3.5 kg CO_2 /tonne

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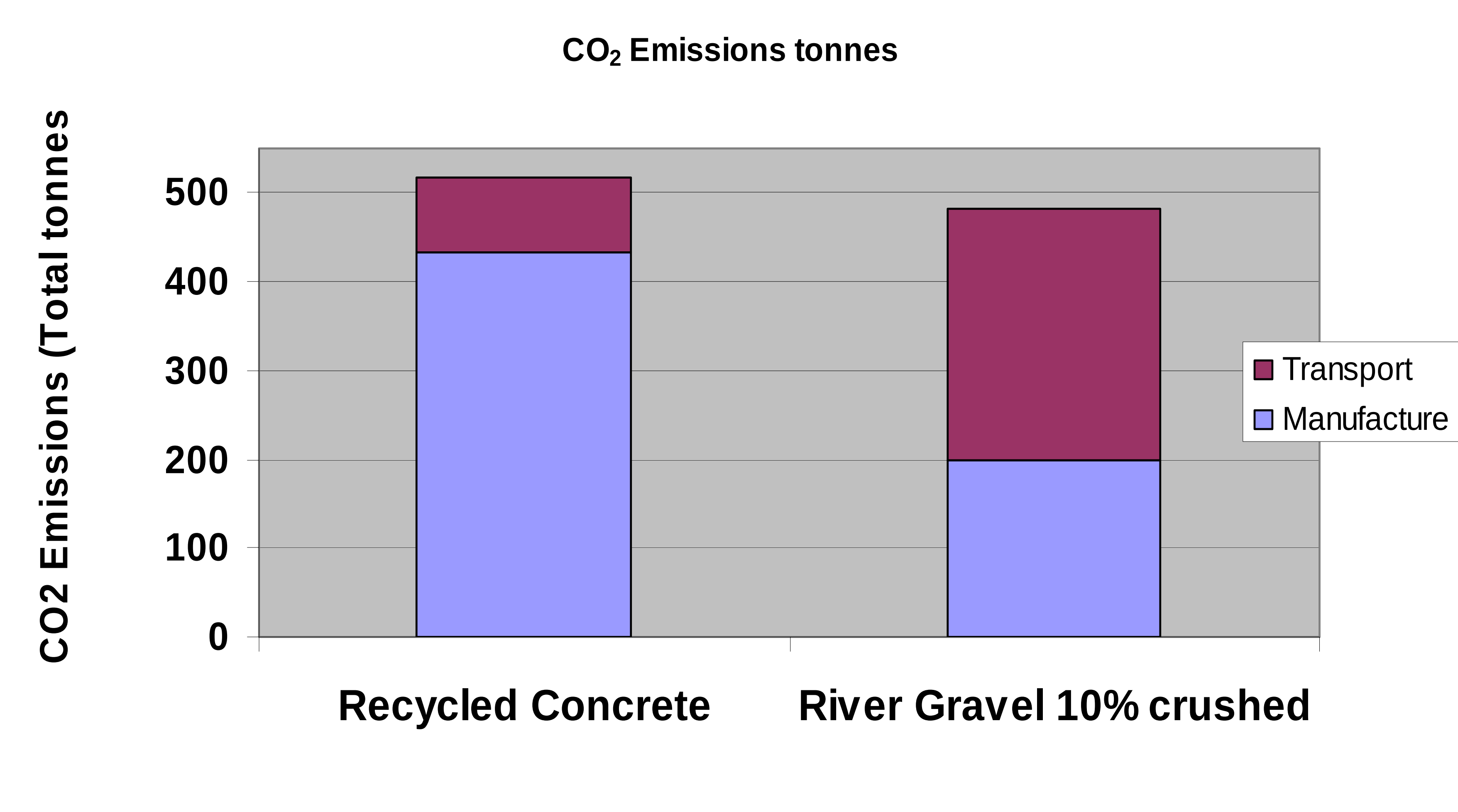

CO_2 Emissions tonnes
CO2 Emissions (Total tonnes)
500
400
300
200
100
0
Recycled Concrete
River Gravel 10% crushed
Transport
Manufacture

CO2 Uptake
A carbon sink!!!

- European research suggests that carbonation of crushed concrete can result in an uptake of CO_2 of 4% of the mass of the concrete.

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CO_2 Uptake

- 125,000 tonnes of concrete @ 4%

= 5,000 tonnes of CO_2

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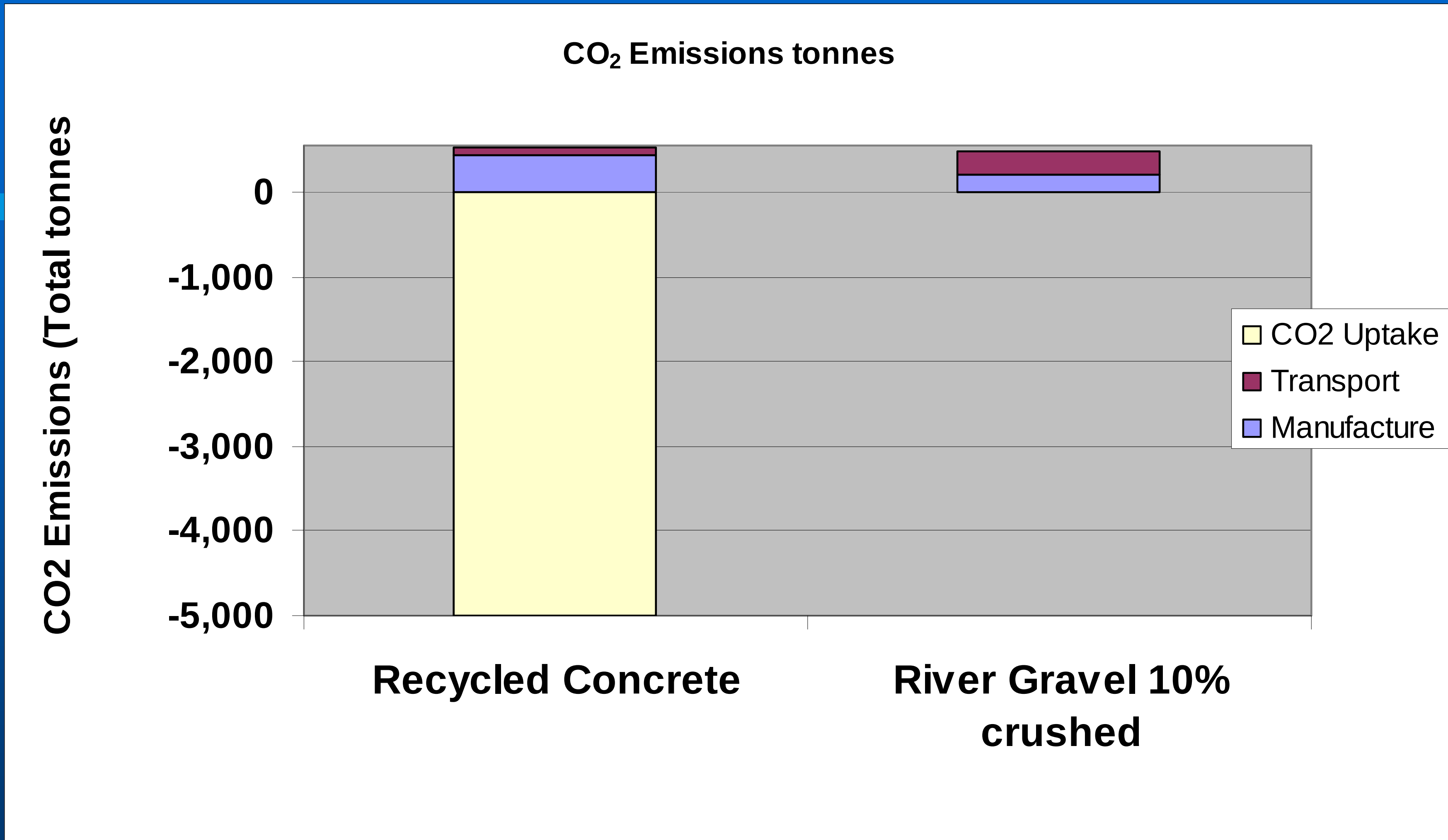
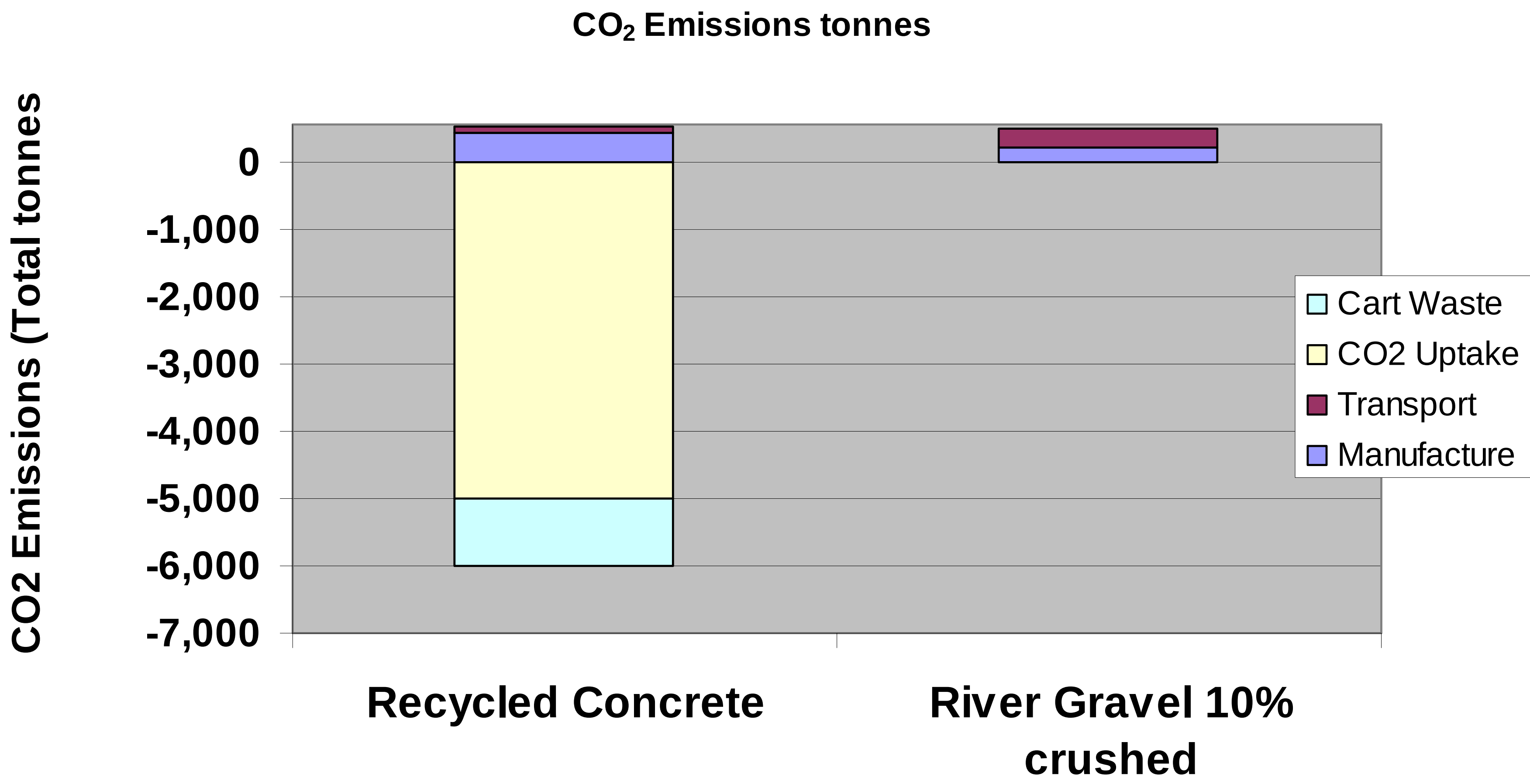

CO_2 Emissions tonnes
CO2 Emissions (Total tonnes
0
-1,000
-2,000
-3,000
-4,000
-5,000
Recycled Concrete
River Gravel 10% crushed
CO2 Uptake
Transport
Manufacture

Transport to Waste of the Concrete

- Round trip of 50 kilometres equivalent to 1000tonnes of CO_2



CO2 Emissions tonnes
CO2 Emissions (Total tonnes
0
-1,000
-2,000
-3,000
-4,000
-5,000
-6,000
-7,000
Recycled Concrete
River Gravel 10% crushed
Cart Waste
CO2 Uptake
Transport
Manufacture

Conclusion

- For the Christchurch Southern Motorway the CO_2 footprint comparison of the manufacture and transport of crushed concrete and river sourced show they are very similar.

Conclusions

- If the more intangible factors such as CO2 absorption and the transportation of the crushed concrete to waste are considered then there is a significant advantage to using crushed concrete

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BUT !!!!

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- Aggregate needs to be taken from the Waimakariri riverbed for flood protection!!

Outcome

- Crushed concrete is being used on the motorway

Thanks

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