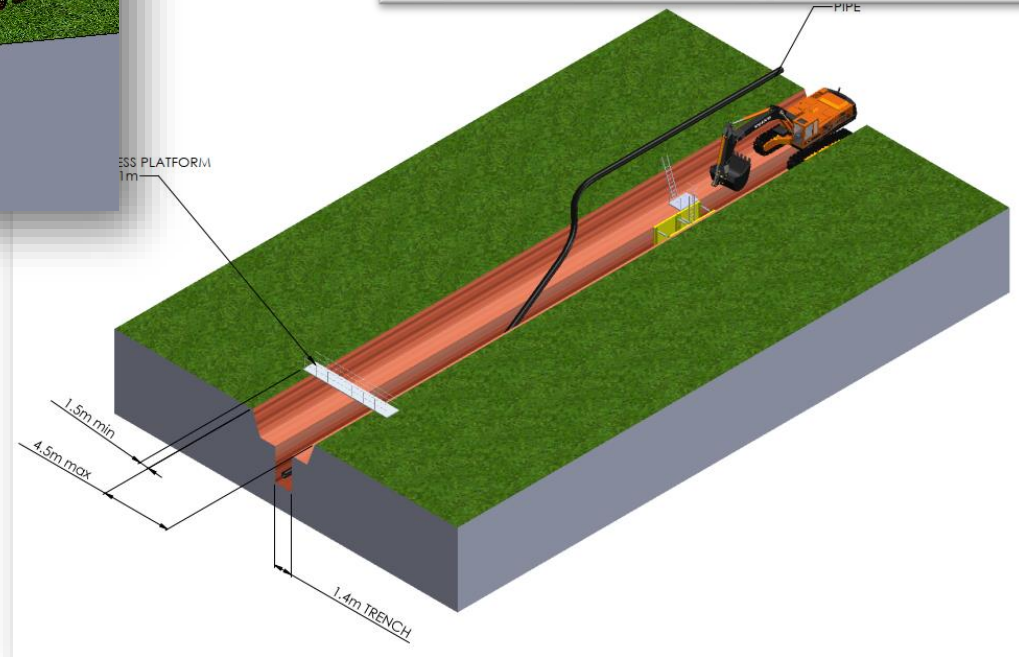
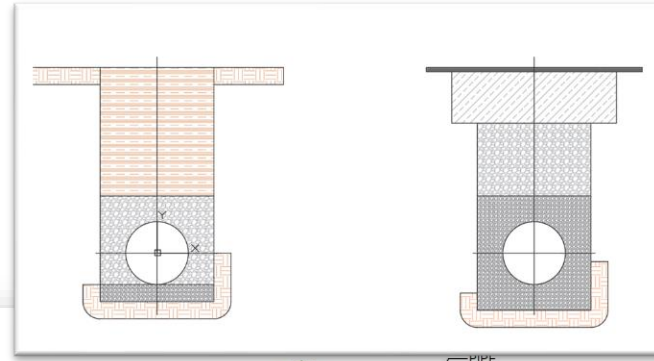
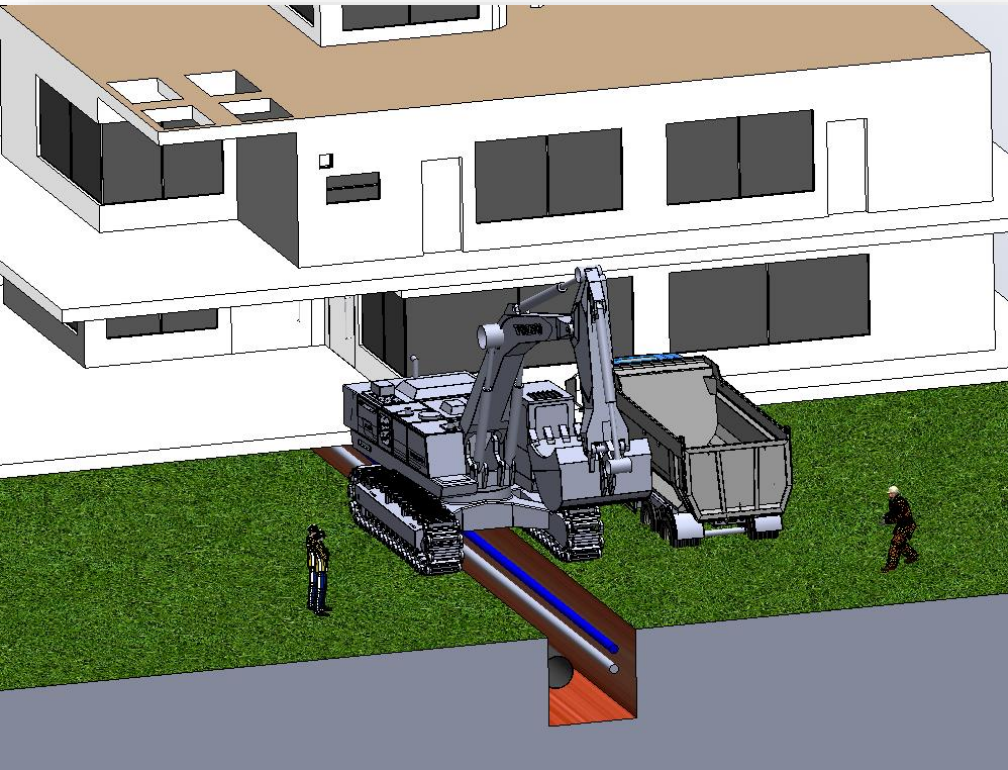




# Carbon Footprint of Open-cut Pipelines (NZ Context)

Presented by: Kevin Manalo



# Acknowledgements



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**Building Research Levy**



**MASSEY**  
**UNIVERSITY**  
TE KUNENGA KI PŪREHUROA

UNIVERSITY OF NEW ZEALAND

- **Narrel Brogan** Research Investment Analyst
- **Dr. Niluka Domingo** Senior Lecturer in Quantity Surveying
- **Dr. Naseem Ali** Associate Professor and Director for Internationalisation

# ALTA

**Introduction/Background**

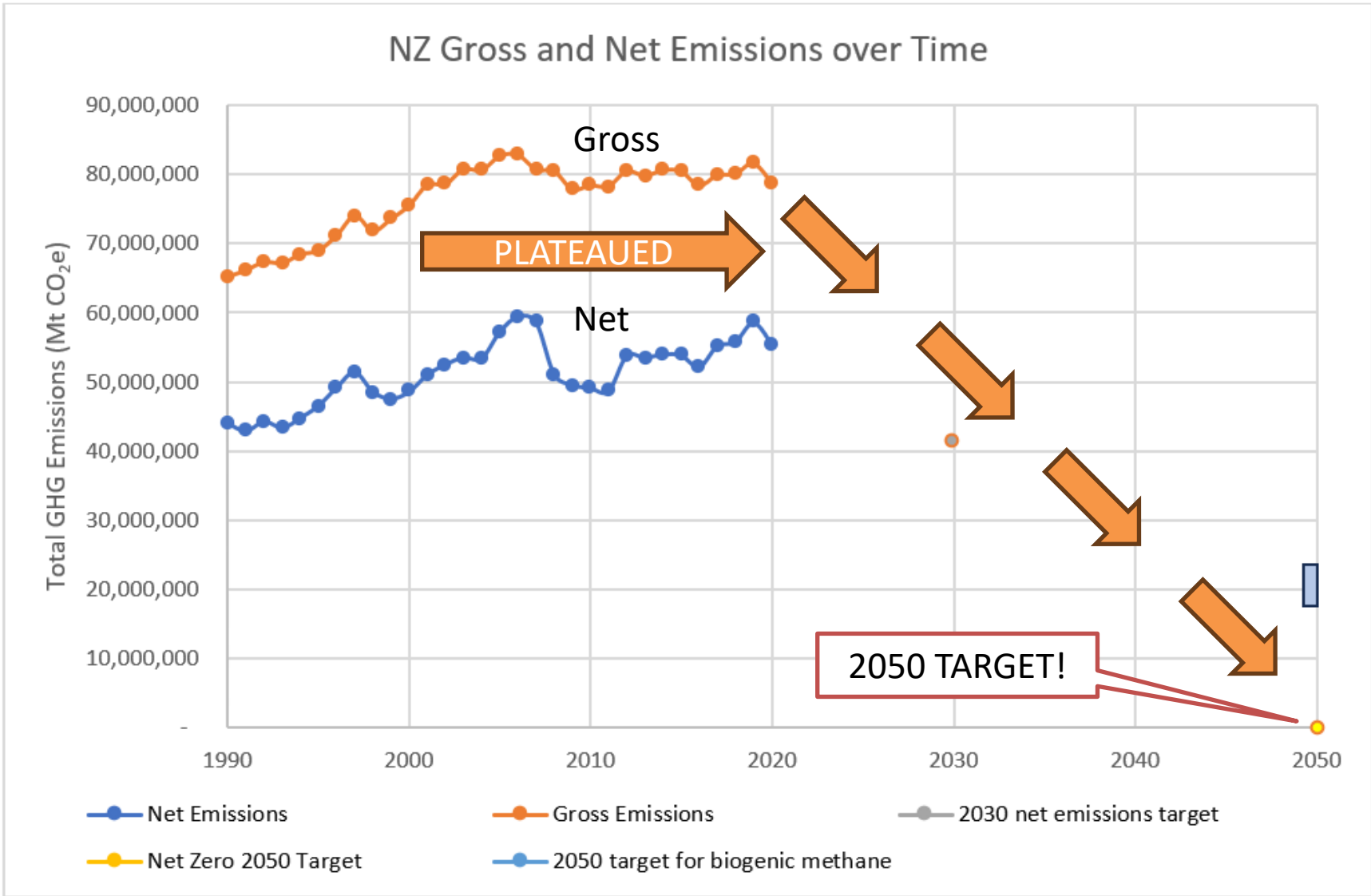
**Aim of the Research**

**Methodology**

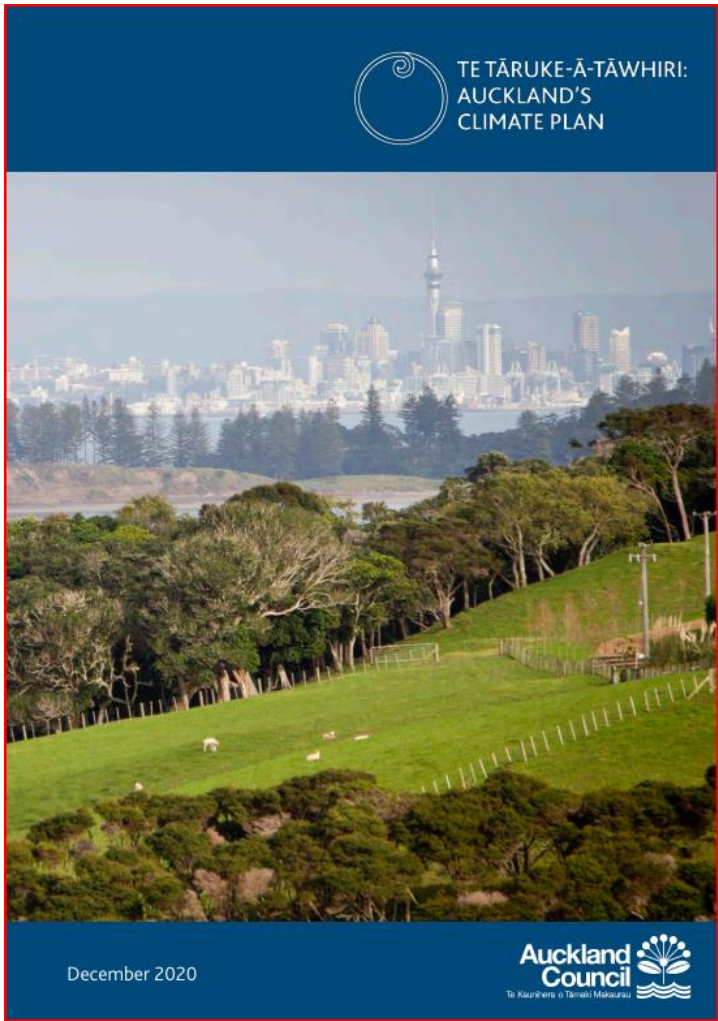
**Results**

**Findings and Conclusions**

# Introduction/Background



# Problem



## Reduce Construction Emissions by 40% by 2025

# Carbon Emissions/ Carbon Accounting

Technically challenging *(Crampton 2022)*

Complex *(Elhag 2015)*

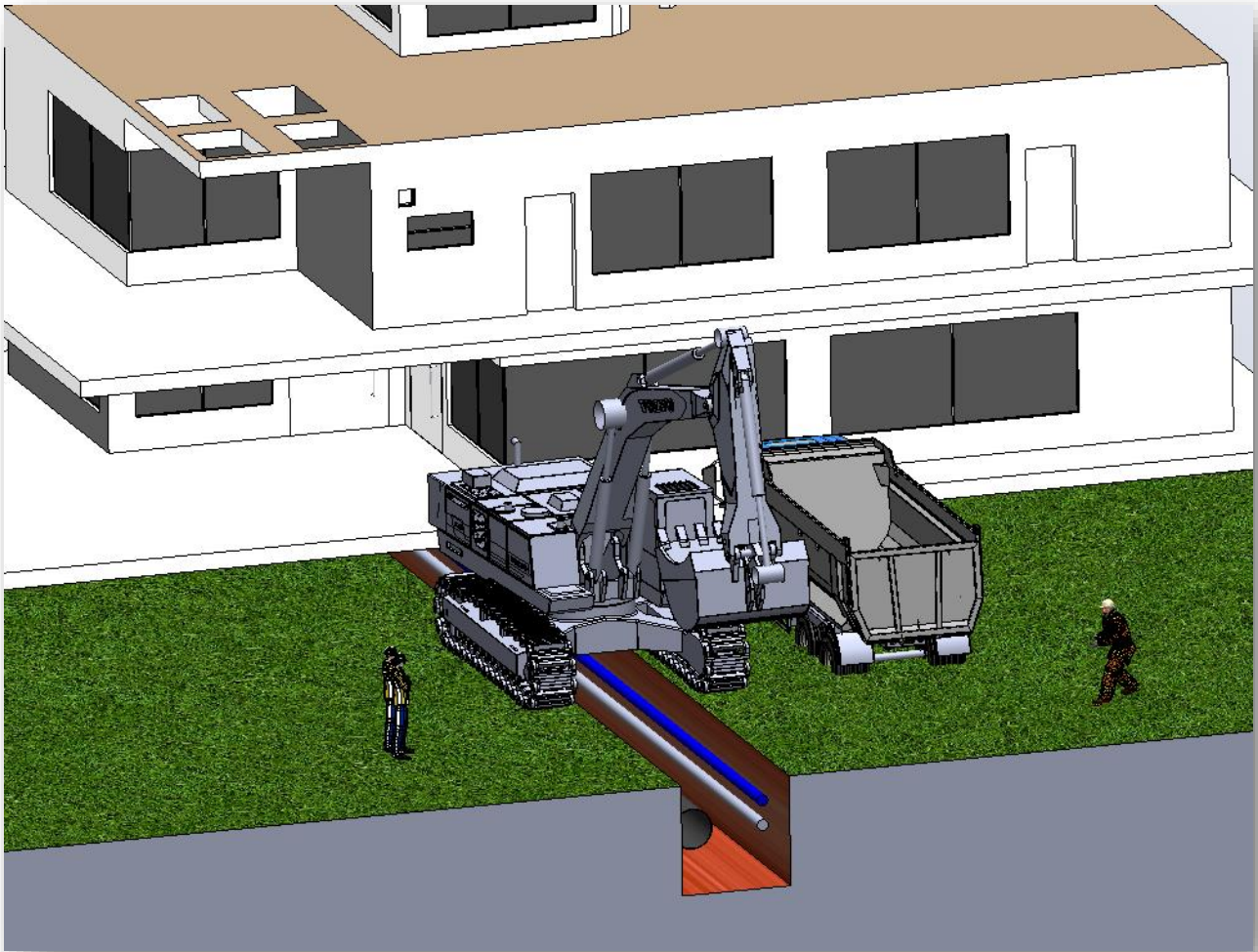
Focus on direct costs *(Alsadi & Matthews 2020)*

No clear understanding *(BDO 2023)*

No need to quantify *(BDO 2023)*

Different standards and systems *(Pandey et al. 2011)*

Aim:

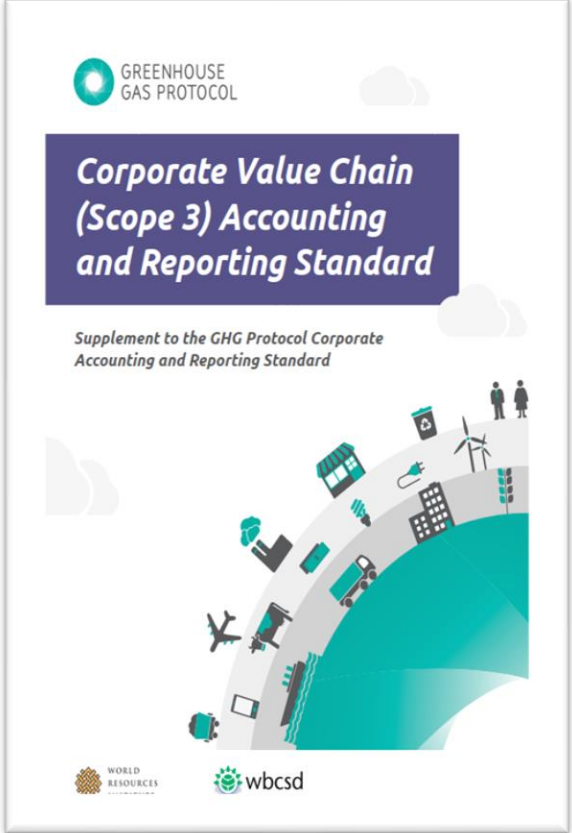
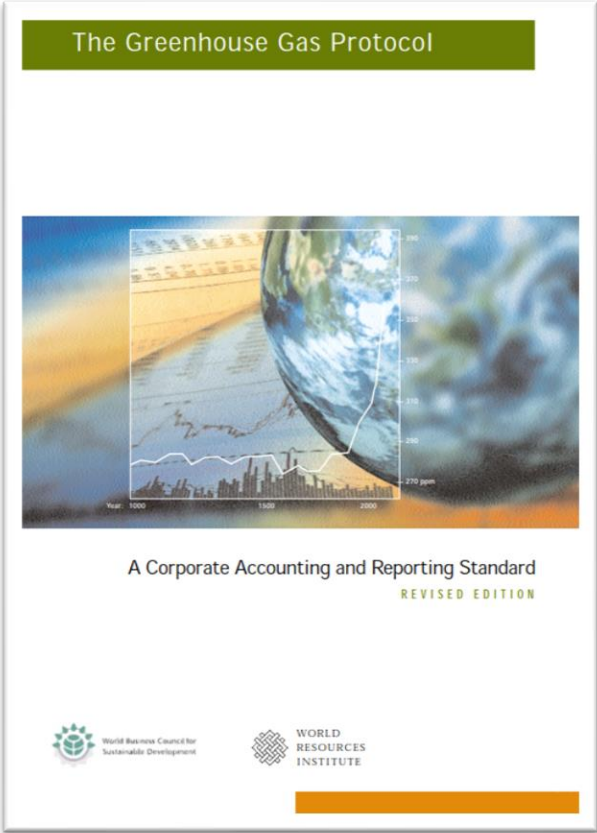


Simplify  
the  
method





## Recommendations - Ministry of the Environment



# Carbon Methodology

## GHG Protocol – Basic



S1	Direct Emissions	Emission Controlled by the company	Fuel used
S2	Indirect Emissions	Emissions from the generation of purchase electricity	Electricity
S3	Indirect Emissions - Other	Other indirect emissions	

# Carbon Methodology

## ISO 14064 - Standard

<b>Scope 1</b>	<b>C1</b>	<b>Direct GHG Emissions –</b> <i>Think fuel used/burn – petrol/diesel!</i>
<b>Scope 2</b>	<b>C2</b>	<b>Indirect GHG emissions –</b> <i>Think electricity!</i>
<b>Scope 3</b>	<b>C3</b>	Indirect GHG emissions from -- Transportation - Business Travel - Freight Transport - Employee Commute
	<b>C4</b>	Indirect GHG emissions from products an organisation uses - Materials and waste
	<b>C5</b>	Indirect GHG emissions (use of products from the organisation)
	<b>C6</b>	Indirect GHG emissions (other sources)

# Carbon Methodology

## GHG Protocol – Scope 3

Scope 1		Direct GHG Emissions and Removals - Fuel
Scope 2		Indirect GHG emissions from imported energy
Scope 3	C1	Purchased Goods and Services
	C2	Capital Goods
	C3	Fuel and Energy Related Activities (Not included in Scope 1 or 2)
	C4	Upstream Transportation and Distribution
	C5	Waste Generated in Operations
	C6	Business Travel
	C7	Employee Commuting
	C8	Upstream Leased Assets
	C9	Downstream Transportation and Distribution
	C10	Processing of Sold Products
	C11	Use of Sold Products
	C12	End-of-Life Treatment of Sold Products
	C13	Downstream Leased Assets
	C14	Franchises
	C15	Investments

# Carbon Methodology

## GHG Protocol

Scope 1	Direct GHG Emissions and Removals - Fuel
Scope 2	Indirect GHG emissions from imported energy
Scope 3	Indirect GHG emissions (Optional)

## ISO 14064

Scope 1	C1	Direct GHG Emissions and Removals - Fuel
Scope 2	C2	Indirect GHG emissions from imported energy
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute
	C4	Indirect GHG emissions from products an organisation uses - Materials and waste
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## GHG Protocol – Scope 3

Scope 1	Direct GHG Emissions and Removals - Fuel	
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	C14	Franchises
	C15	Investments

# Carbon Methodology

Define Goals, Scope,  
and Assumptions

Set Study Boundary

Work Breakdown  
Structure

Identify Sources

Select calculation  
approach

Collect data and  
choose emission  
factors

Calculate GHG  
Emissions

Roll Up data /  
Reporting

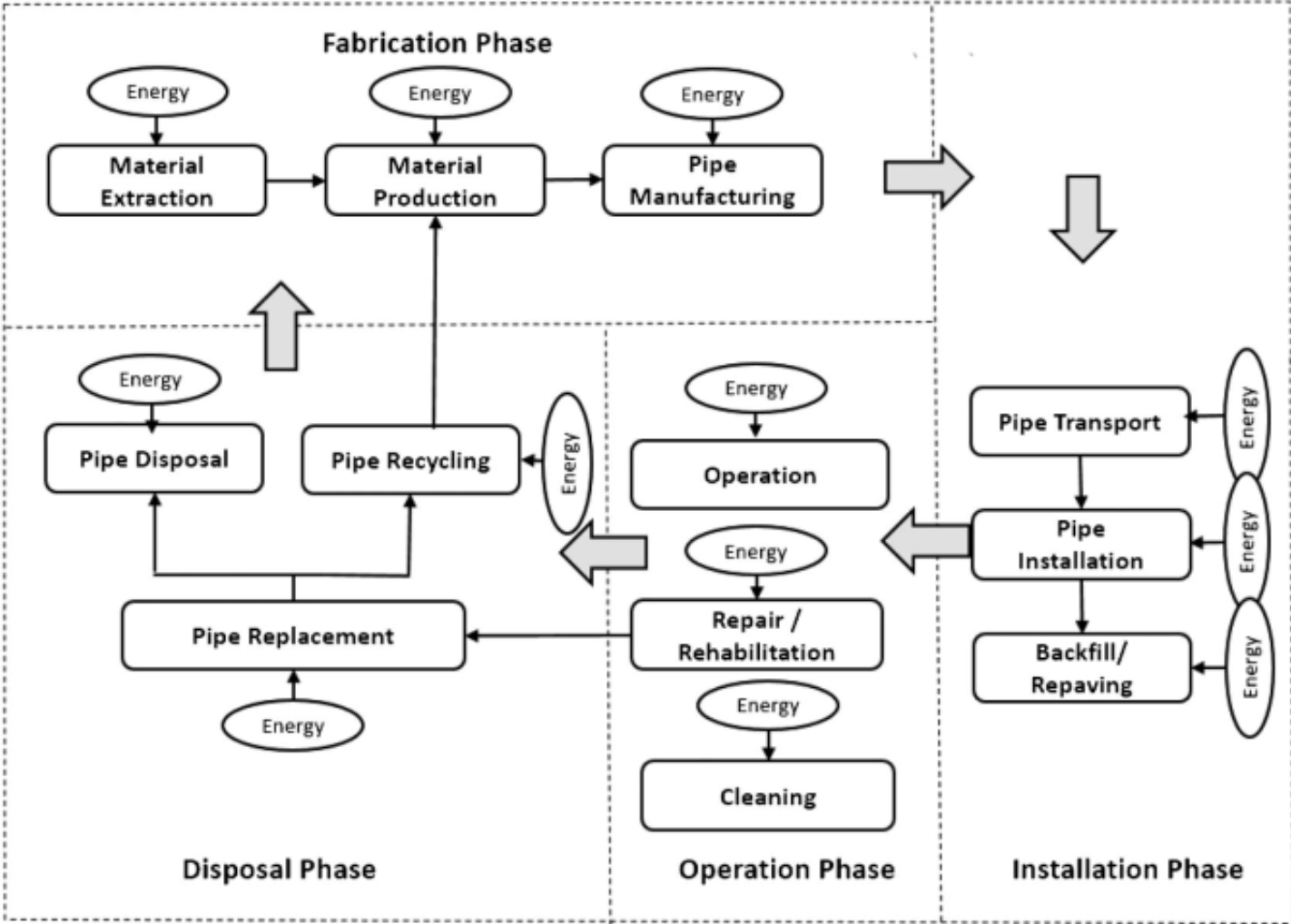
# Carbon Methodology – Set Study Boundary

Define Goals, Scope, and Assumptions

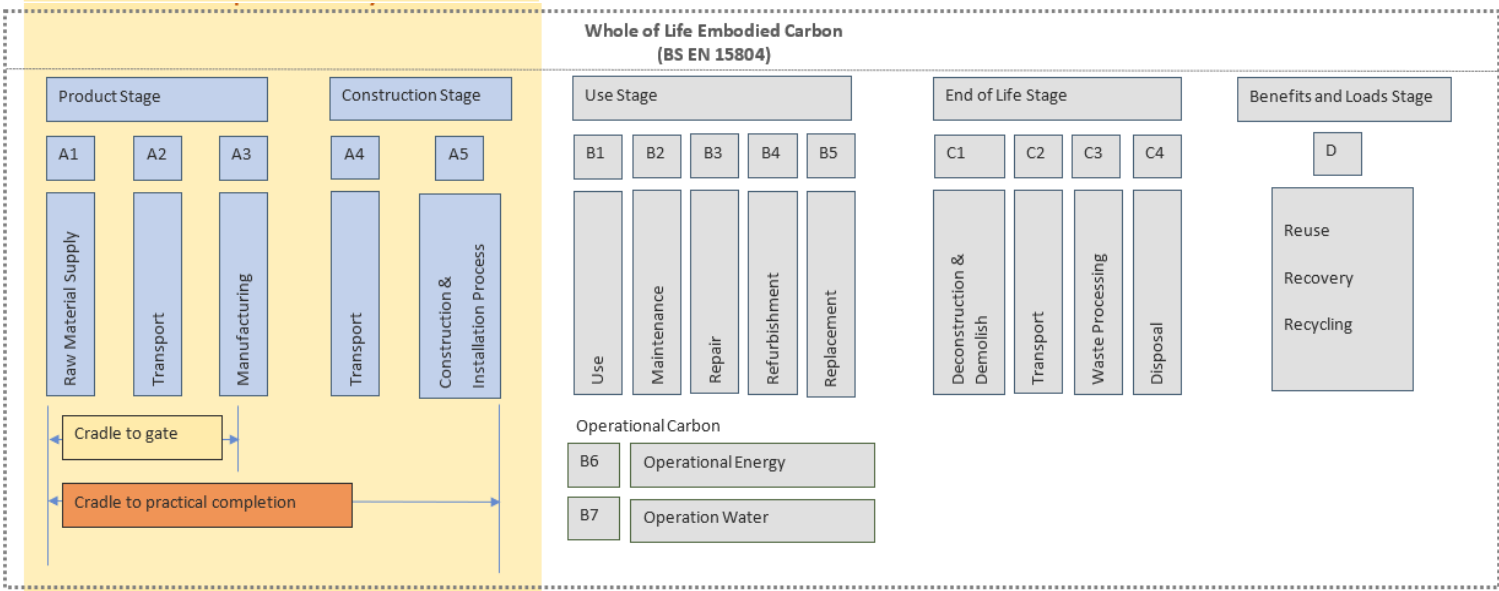
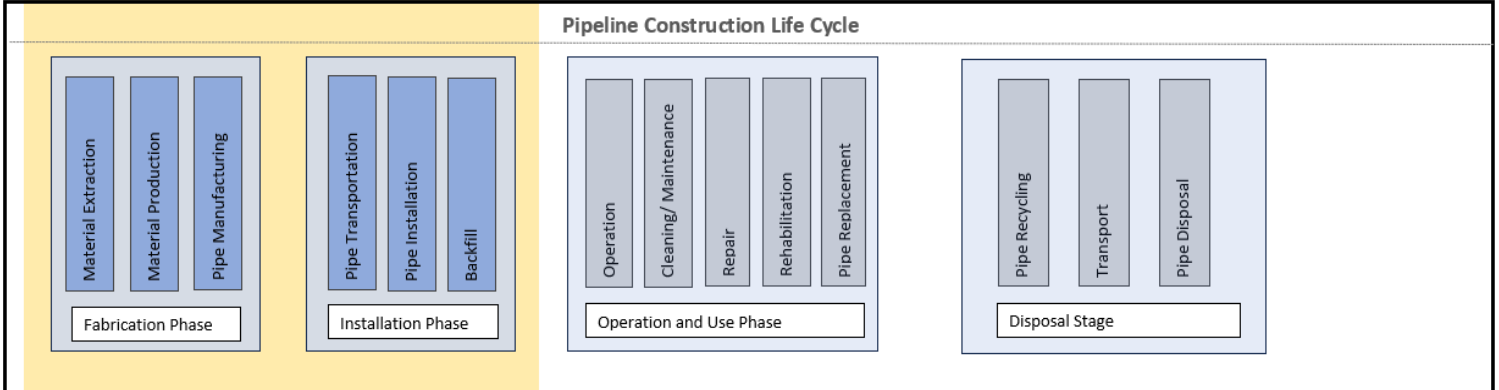
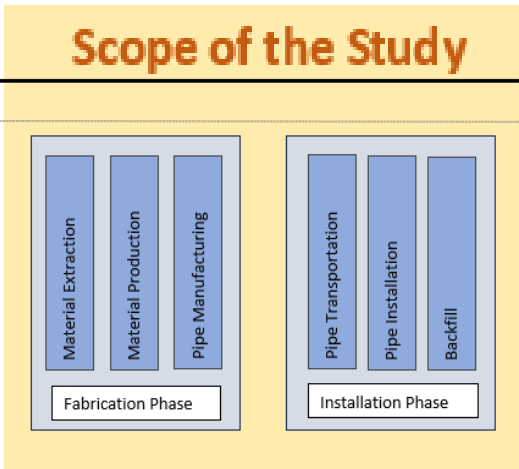
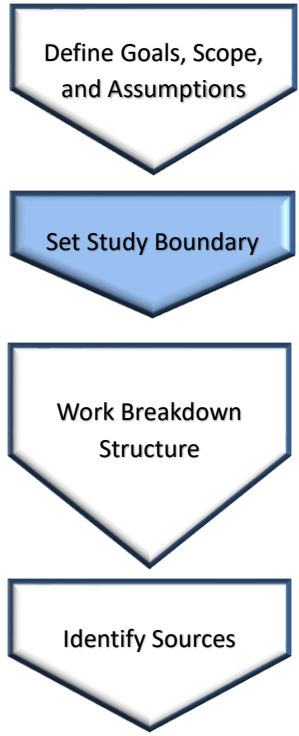
Set Study Boundary

Work Breakdown Structure

Identify Sources

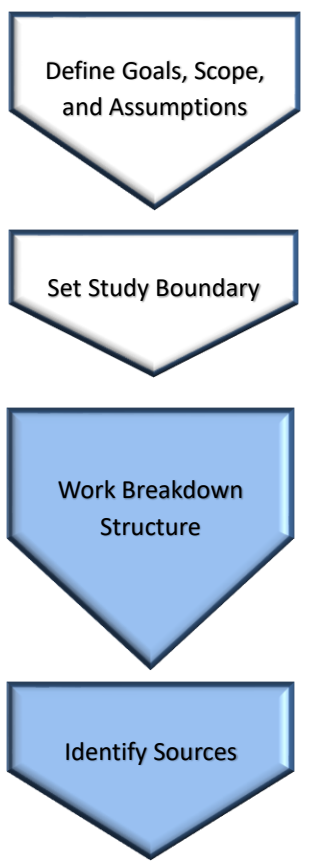


# Carbon Methodology – Set Study Boundary





# Carbon Methodology – Work Breakdown Structure



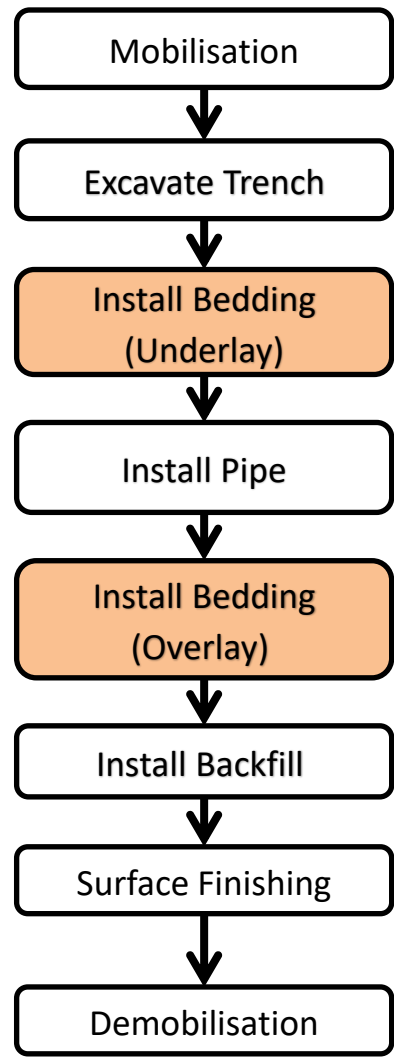
Scope 1

Transport Excavator

Truck Transport Import - Aggregates

Truck Transport Minor Plant Vibro plate/Wacker

Truck Transport Pipes, Manholes



Scope 3

Truck Transport Export - Tipping

Truck Transport Export Excavator

Scope 3

Pipe Aggregates

# Calculation Methodology

$$\text{Emission (kg CO}_2\text{e)} = \text{Activity Data} \times \text{Emission Factor}$$

Select calculation approach

Collect data and choose emission factors

Calculate GHG Emissions

Roll Up data / Reporting

$$E = Q \times F \text{ (Equation 1)}$$

Where:

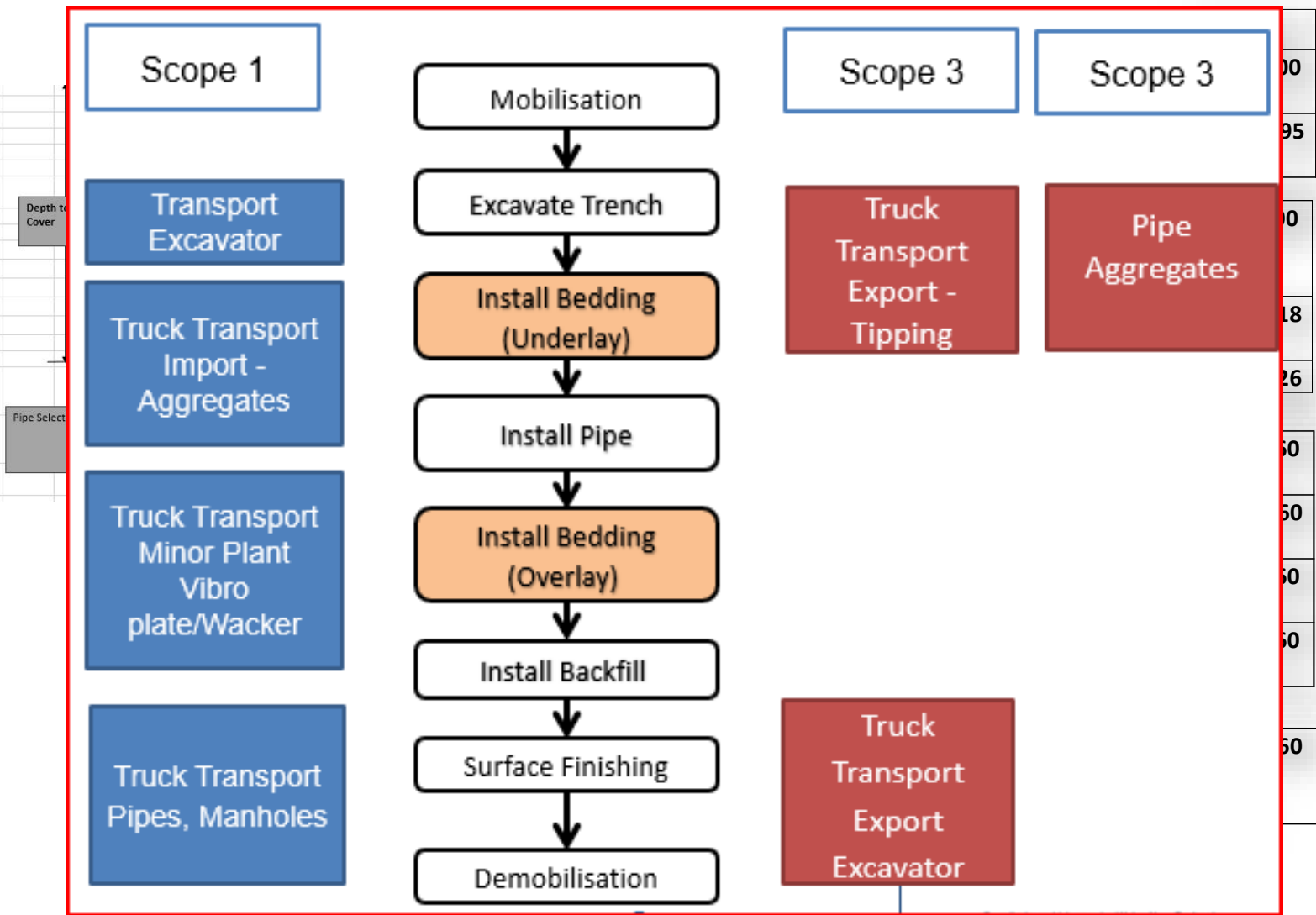
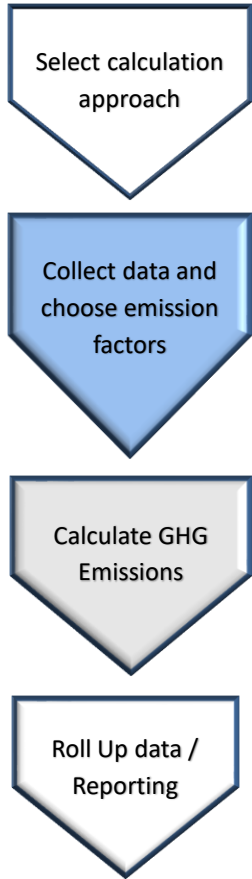
- $E$  = emissions from the emission source in kg CO<sub>2</sub>e
- $Q$  = activity data (e.g. quantity of fuel)
- $F$  = emission factor for emissions source

Variable Q is the independent variable, while E is the dependent variable.

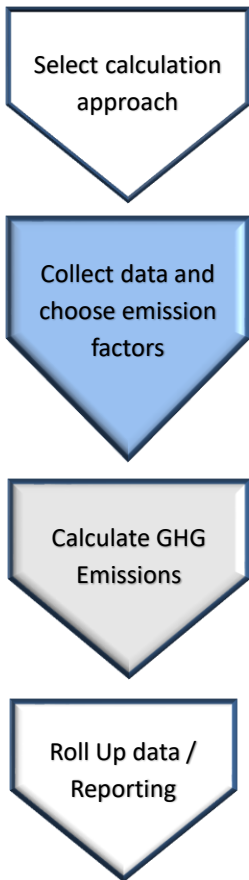
Independent variable (Q)	Function (F)	Dependent variable (E)
(Input) Activity Data	x Emission Factor (Regular Petrol)	= (Output) Emissions
5 litres	x 2.46 kg CO <sub>2</sub> e/litre	= 12.3 kg CO <sub>2</sub> e

# Calculating Activity Values

Scenario – Open Cut, 150ø pipe, 1m depth



# Emission Factors



**Measuring emissions: A guide for organisations**  
 2022 summary of emissions factors  
 Using data from the 2020 calendar year

**Table 4: Transport fuels**

Transport fuel type	Unit	kg CO <sub>2</sub> -e/unit
Regular petrol	litre	2.46
Premium petrol	litre	2.48
Diesel	litre	2.69
LPG	litre	1.64
Heavy fuel oil	litre	3.04
Light fuel oil	litre	2.94
Aviation fuel (Kerosene) / Jet A1	GJ	70.6
	litre	2.63
Aviation gasoline	GJ	68.3
	litre	2.31

**Table 25: Road freight: Default light commercial vehicles**

Emission source	Unit	kg CO <sub>2</sub> -e/unit
Petrol	km	0.317
Diesel	km	0.296
Petrol hybrid	km	0.250
Diesel hybrid	km	0.265

**Table 26: Road freight: Heavy goods vehicles**

Emission source	Unit	Pre-2010 fleet kg CO <sub>2</sub> -e	2010–2015 fleet kg CO <sub>2</sub> -e	Post-2015 fleet kg CO <sub>2</sub> -e	
HGV diesel	<5,000 kg	km	0.446	0.423	0.421
	5,000– <7,500 kg	km	0.510	0.484	0.477
	7,500– <10,000 kg	km	0.624	0.592	0.583
	10,000– <12,000 kg	km	0.740	0.702	0.692
	12,000– <15,000 kg	km	0.841	0.798	0.786
	15,000– <20,000 kg	km	0.982	0.957	0.955
	20,000– <25,000 kg	km	1.308	1.274	1.271
	25,000– <30,000 kg	km	1.460	1.423	1.420
≥30,000 kg	km	1.538	1.499	1.496	


# Emission Factors


**Winstone AGGREGATES**

## Environmental Product Declaration

For Aggregate and Sand Products

In accordance with ISO 14025 and EN 15804+A1 for WINSTONE AGGREGATES


 Programme: EPD Australasia, <https://epd-australasia.com/>  
 Programme operator: EPD Australasia  
 EPD registration number: S-P-04664  
 Publication date: 2022-02-23  
 Valid until: 2027-02-23  
 Geographical scope of EPD: New Zealand



EPD of construction products may not be comparable if they do not comply with EN 15804.

Full product name	Product abbreviated name	Product group
Road Metal 65mm	RM65	Aggregate - Primary Crushing & Screening
Scalplings	SCALP	Aggregate - Primary Crushing & Screening
TG Metal 65mm	TGM65	Aggregate - Primary Crushing & Screening
TGTopcourse 20mm Standard	TGS20	Aggregate - Primary Crushing & Screening
TGS40mm	TGS40	Aggregate - Primary Crushing & Screening
Topcourse Domestic 20mm	TOP20D	Aggregate - Primary Crushing & Screening
Topcourse 20mm Standard	TOP20S	Aggregate - Primary Crushing & Screening
Scalped 40mm	SCALP40	Aggregate - Primary Screening Only
Scalped 65mm	SCALP65	Aggregate - Primary Screening Only
TGFILL 65mm+	TCFILL65+	Aggregate - Primary Screening Only
Basecourse 40mm R	BC40R	Aggregate - Secondary Crushing & Screening
Bedding Mix	BEDM	Aggregate - Secondary Crushing & Screening
Cribwall Backfill 40-20	CRIB40	Aggregate - Secondary Crushing & Screening
Cribwall Backfill 80-20	CRIB80	Aggregate - Secondary Crushing & Screening
Drainage 150/40	DRAIN15040	Aggregate - Secondary Crushing & Screening
Drainage 25	DRAIN25	Aggregate - Secondary Crushing & Screening
Drainage 40	DRAIN40	Aggregate - Secondary Crushing & Screening
Drainage 40-20	DRAIN4020	Aggregate - Secondary Crushing & Screening
Drainage 65-19	DRAIN65	Aggregate - Secondary Crushing & Screening
Drainage 65-40	DRAIN6540	Aggregate - Secondary Crushing & Screening
Filter B	FILB	Aggregate - Secondary Crushing & Screening
Gabion Stone	GABION	Aggregate - Secondary Crushing & Screening
Gabion 100-250	GABION100	Aggregate - Secondary Crushing & Screening
General All Passing 10	GAP10	Aggregate - Secondary Crushing & Screening
General All Passing 20	GAP20	Aggregate - Secondary Crushing & Screening
General All Passing 25	GAP25	Aggregate - Secondary Crushing & Screening
General All Passing 40	GAP40	Aggregate - Secondary Crushing & Screening
General All Passing 65	GAP65	Aggregate - Secondary Crushing & Screening
Hardfill 150-65	HF150-65	Aggregate - Secondary Crushing & Screening
Local Roads AP40	LR40	Aggregate - Secondary Crushing & Screening
Local Roads AP40 PP	LR40PP	Aggregate - Secondary Crushing & Screening
Local Roads AP65	LR65	Aggregate - Secondary Crushing & Screening
Local Roads AP65 PP	LR65PP	Aggregate - Secondary Crushing & Screening
Main Alignment AP65	PP65	Aggregate - Secondary Crushing & Screening
TGAP65	TGAP65	Aggregate - Secondary Crushing & Screening
WHAP65	WHAP65	Aggregate - Secondary Crushing & Screening
Asphaltic Sand	AS	Aggregate - Tertiary Crushing & Screening, Unwashed
Pap 7 ASP	ASP PAP7	Aggregate - Tertiary Crushing & Screening, Unwashed
Builders Mix 20	BM20	Aggregate - Tertiary Crushing & Screening, Unwashed
Crusher Fines	CRF	Aggregate - Tertiary Crushing & Screening, Unwashed
General All Passing 7	GAP7	Aggregate - Tertiary Crushing & Screening, Unwashed
Premium All Passing 7	PAP7	Aggregate - Tertiary Crushing & Screening, Unwashed
TGAP40	TGAP40	Aggregate - Tertiary Crushing & Screening, Unwashed

## Environmental Performance

Auckland/ Northland – non-stabilised products – Module A1-A3

Indicator	Unit	ANP	APS	APSC	ASSC	ATSC	ATSCW	NS	MS
<b>Environmental impacts</b>									
GWP	kg CO <sub>2</sub> eq.	3.31	3.24	3.61	4.12	3.65	3.59	3.00	3.57
ODP	kg CFC 11 eq.	2.34E-15	2.19E-15	2.94E-15	2.86E-15	3.87E-15	3.89E-15	1.44E-15	3.20E-15
AP	kg SO <sub>2</sub> eq.	0.0245	0.0240	0.0265	0.0303	0.0254	0.0250	0.0223	0.0262
EP	kg PO <sub>4</sub> <sup>3-</sup> eq.	0.00625	0.00611	0.00677	0.00770	0.00643	0.00636	0.00566	0.00670
POCP	kg C <sub>2</sub> H <sub>2</sub> eq.	0.00248	0.00245	0.00267	0.00310	0.00258	0.00253	0.00233	0.00260
ADPE	kg Sb eq.	8.26E-08	8.12E-08	9.86E-08	1.09E-07	1.36E-07	1.33E-07	6.72E-08	1.00E-07
ADPF	MJ	44.5	43.7	48.5	55.5	48.8	48.0	40.7	47.7

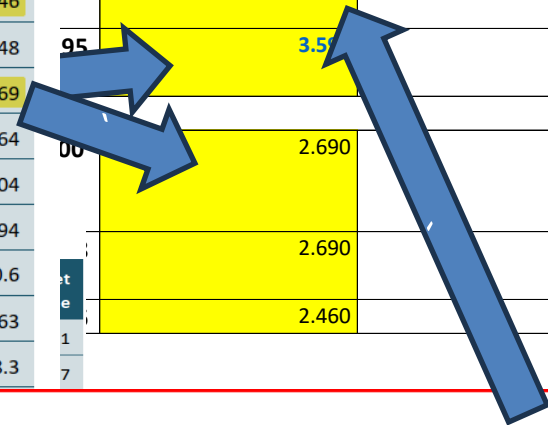
Resource Use

# Calculate GHG Emissions - Results

Table 4: Transport fuels

Transport fuel type	Unit	kg CO <sub>2</sub> -e/unit
Regular petrol	litre	2.46
Premium petrol	litre	2.48
Diesel	litre	2.69
LPG	litre	1.64
Heavy fuel oil	litre	3.04
Light fuel oil	litre	2.94
Aviation fuel (Kerosene) / Jet A1	GJ	70.6
	litre	2.63
Aviation gasoline	GJ	68.3

	Emission Factors (kg CO <sub>2</sub> e/unit)	Calculated Emissions (kg CO <sub>2</sub> e)
100	11.067	1,107
95	3.5	339
100	2.690	807
	2.690	49
	2.460	64



Type	Pipe	Manufacturer	Life Cycle	Mass kg/m	Length (m)	Mass (kg)	GWP Emission Unit (kg CO <sub>2</sub> e/kg)	GWP Emission Unit (kg CO <sub>2</sub> e/m)	Calculated GWP Flexible Pipe (kg CO <sub>2</sub> e)
PVC	Stormwater/Wastewater - Non Pressure - DN150 DWV Series 100, SN16100.6RJ	RXP	A1-A3	4.650	100	465	2.38	11.067	1106.70

<https://epd-australasia.com/epd/rxp-pvc-pipes/>



## EPD Results - PVC non-pressure

Results for modules A1-4, C - D

Table 8. Results for 1kg of Series 100 - DWV

Indicator	Unit	A1-A3
GWP-fossil	kg CO <sub>2</sub> eq.	2.38E+00

# Carbon Methodology

## GHG Protocol

Scope 1	Direct GHG Emissions and Removals - Fuel
Scope 2	Indirect GHG emissions from imported energy
Scope 3 (Optional)	Indirect GHG emissions

## ISO 14064

Scope 1	C1	Direct GHG Emissions and Removals - Fuel
Scope 2	C2	Indirect GHG emissions from imported energy
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute
	C4	Indirect GHG emissions from products an organisation uses - Materials and waste
	C5	Indirect GHG emissions (use of products from the organisation)
	C6	Indirect GHG emissions (other sources)

## GHG Protocol – Scope 3

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	C9	Downstream Transportation and Distribution
	C10	Processing of Sold Products
	C11	Use of Sold Products
	C12	End-of-Life Treatment of Sold Products
	C13	Downstream Leased Assets
	C14	Franchises
	C15	Investments

# Calculate GHG Emissions - Results

			Unit	Qty	Emission Factors (kg CO <sub>2</sub> e/unit)	Calculated Emissions (kg CO <sub>2</sub> e)
Pipe Material	Pipe Diameter (∅)	150	m	100	11.067	1,107
Aggregate Material	tonnes (t)	95	t	95	3.590	339

Excavator Fuel	Diesel	Stationary Combustion of Fuels: Industrial Use	L	300	2.690	807
Small Plant - Wacker	Petrol	Fuel	L	18	2.690	49
Small Plant - Vibro	Petrol	Fuel	L	26	2.460	64

Truck - Mobilisation	Diesel	Heavy Goods Vehicle 7,500<10,000kg	km	160	0.624	100
Transport - Aggregates	Diesel	Heavy Goods Vehicle 7,500<10,000kg	km	1,760	0.624	1,098
Transport - Pipes	Diesel	Heavy Goods Vehicle 7,500<10,000kg	km	160	0.624	100
Truck - Demobilisation	Diesel	Heavy Goods Vehicle 7,500<10,000kg	km	160	0.624	100

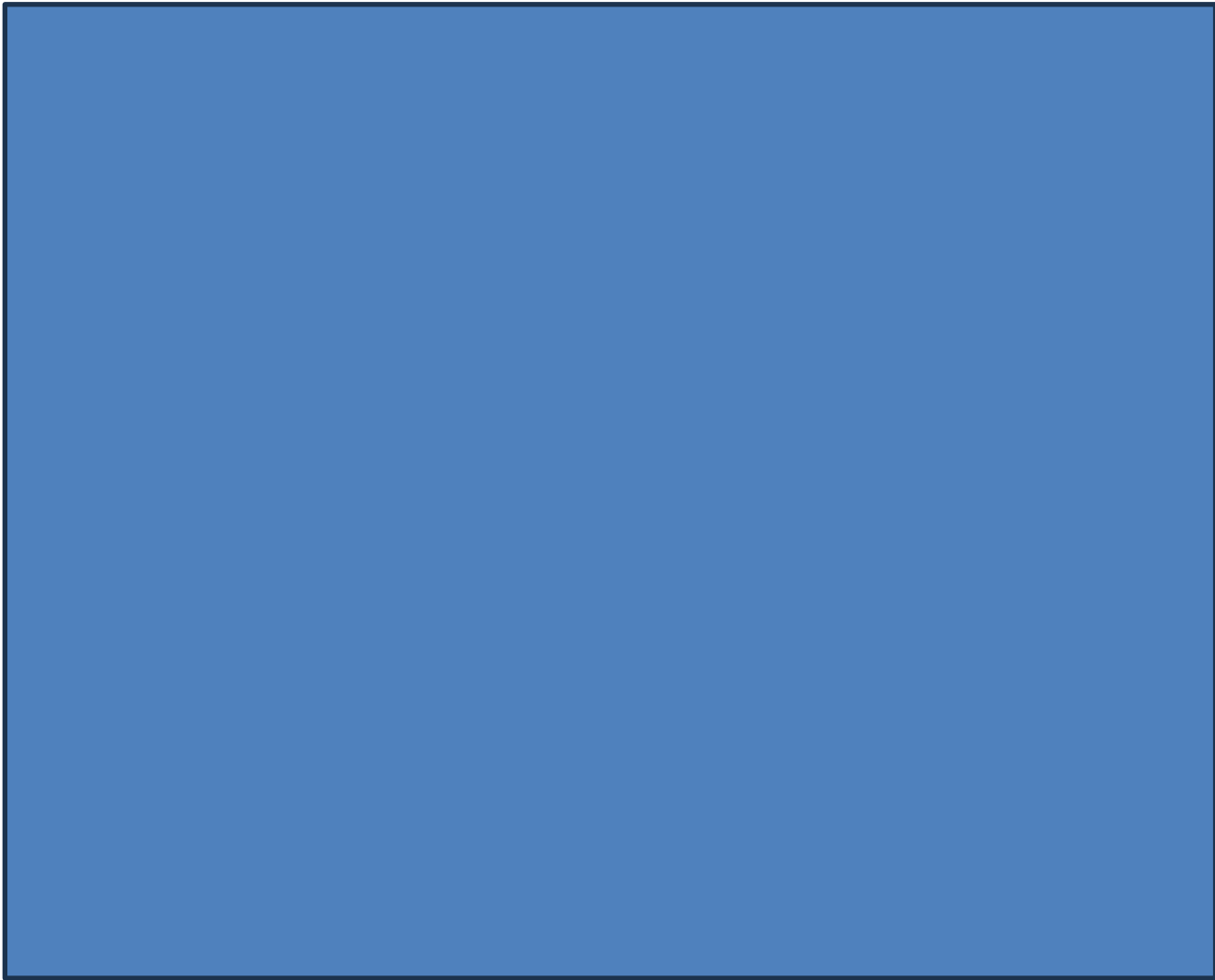
Employee Commuting	Petrol	Light Commercial Vehicles 2000<3000cc	km	960	0.317	304
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Calculated Emissions  
Emission per m

4,068  
**40.68**



# Calculate GHG Emissions - Results



	Calculated Emissions (kg CO <sub>2</sub> e)
Pipe Material	1,107
Aggregate Material	339
Excavator Fuel	807
Small Plant - Wacker	49
Small Plant - Vibro	64
Truck - Mobilisation	100
Transport - Aggregates	1,098
Transport - Pipes	100
Truck - Demobilisation	100
Employee Commuting	304

# Calculate GHG Emissions - Results

GHG Protocol	[Redacted Content]		Calculated Emissions (kg CO <sub>2</sub> e)
Description		Pipe Material	1,107
Scope 3		Aggregate Material	339
Scope 1		Excavator Fuel	807
		Small Plant - Wacker	49
		Small Plant - Vibro	64
Scope 3		Truck - Mobilisation	100
		Transport - Aggregates	1,098
		Transport - Pipes	100
		Truck - Demobilisation	100
Scope 3		Employee Commuting	304

# Calculate GHG Emissions - Results

GHG Protocol	ISO 14064			Calculated Emissions (kg CO <sub>2</sub> e)
Description	Category	Description		
Scope 3	C4	Indirect GHG emissions from products an organisation uses - Materials and waste		Pipe Material 1,107
Scope 1	C1	Direct GHG Emissions and Removals - Fuel		Aggregate Material 339
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute		Excavator Fuel 807
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute		Small Plant - Wacker 49
				Small Plant - Vibro 64
				Truck - Mobilisation 100
				Transport - Aggregates 1,098
				Transport - Pipes 100
				Truck - Demobilisation 100
				Employee Commuting 304

# Calculate GHG Emissions - Results

GHG Protocol	ISO 14064		GHG Protocol - Scope 3			Calculated Emissions (kg CO <sub>2</sub> e)
Description	Category	Description	Category	Description		
Scope 3	C4	Indirect GHG emissions from products an organisation uses - Materials and waste	C1	Purchased Goods and Services	Pipe Material	1,107
					Aggregate Material	339
Scope 1	C1	Direct GHG Emissions and Removals - Fuel	C3	Fuel and Energy Related Activities (Not included in Scope 1 or 2)	Excavator Fuel	807
					Small Plant - Wacker	49
					Small Plant - Vibro	64
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute	C4	Upstream Transportation and Distribution	Truck - Mobilisation	100
					Transport - Aggregates	1,098
					Transport - Pipes	100
					Truck - Demobilisation	100
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute	C7	Employee Communiting	Employee Commuting	304

# Calculate GHG Emissions - Results

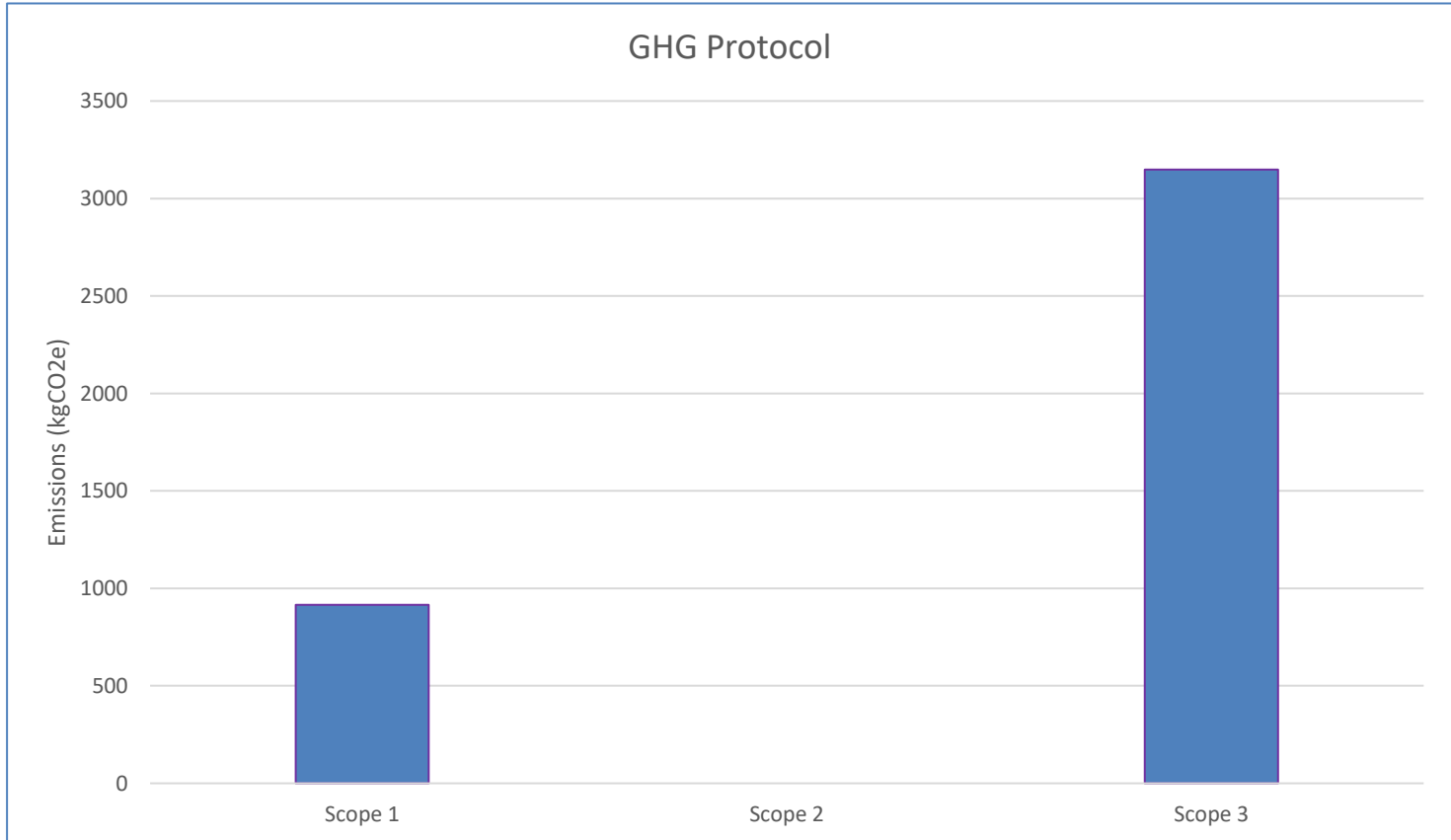
Select calculation approach

Collect data and choose emission factors

Calculate GHG Emissions

Roll Up data / Reporting

GHG Protocol		
Scope 1	Direct GHG Emissions and Removals - Fuel	915
Scope 2	Indirect GHG emissions from imported energy	0
Scope 3	Indirect GHG emissions (Optional)	3148
	kg(CO2e)	4064



# Calculate GHG Emissions - Results

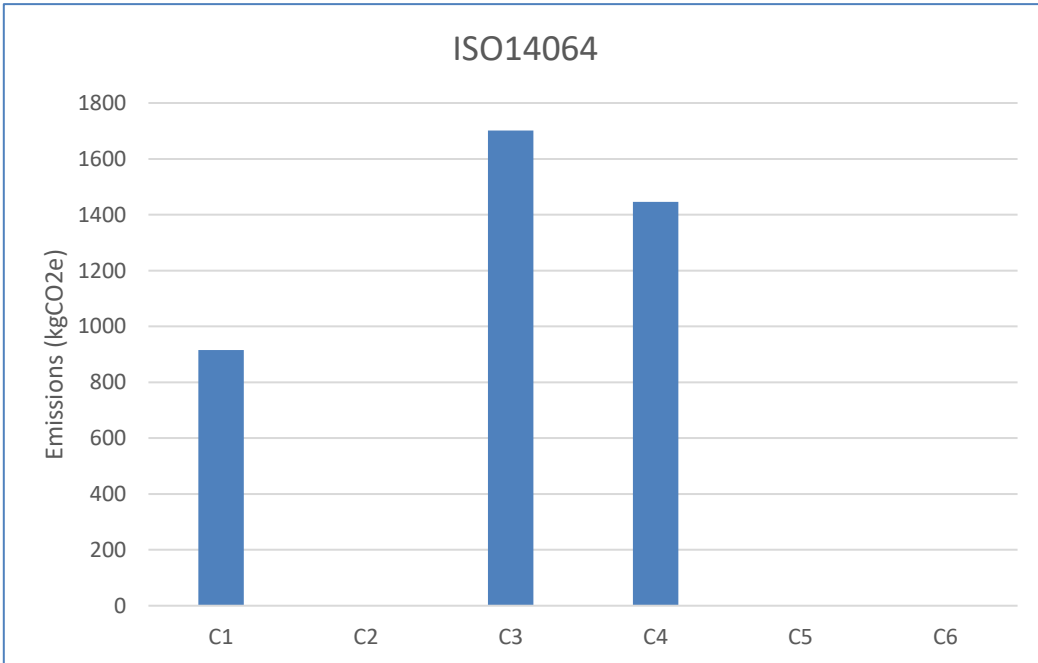
Select calculation approach

Collect data and choose emission factors

Calculate GHG Emissions

Roll Up data / Reporting

ISO14064			
Scope 1	C1	Direct GHG Emissions and Removals - Fuel	915
Scope 2	C2	Indirect GHG emissions from imported energy	0
Scope 3	C3	Indirect GHG emissions from Transportation - Freight Transport - Employee Commute	1702
	C4	Indirect GHG emissions from products an organisation uses - Materials and waste	1446
	C5	Indirect GHG emissions (use of products from the organisation)	0
	C6	Indirect GHG emissions (other sources)	0
kg(CO2e)			4064



# Calculate GHG Emissions - Results

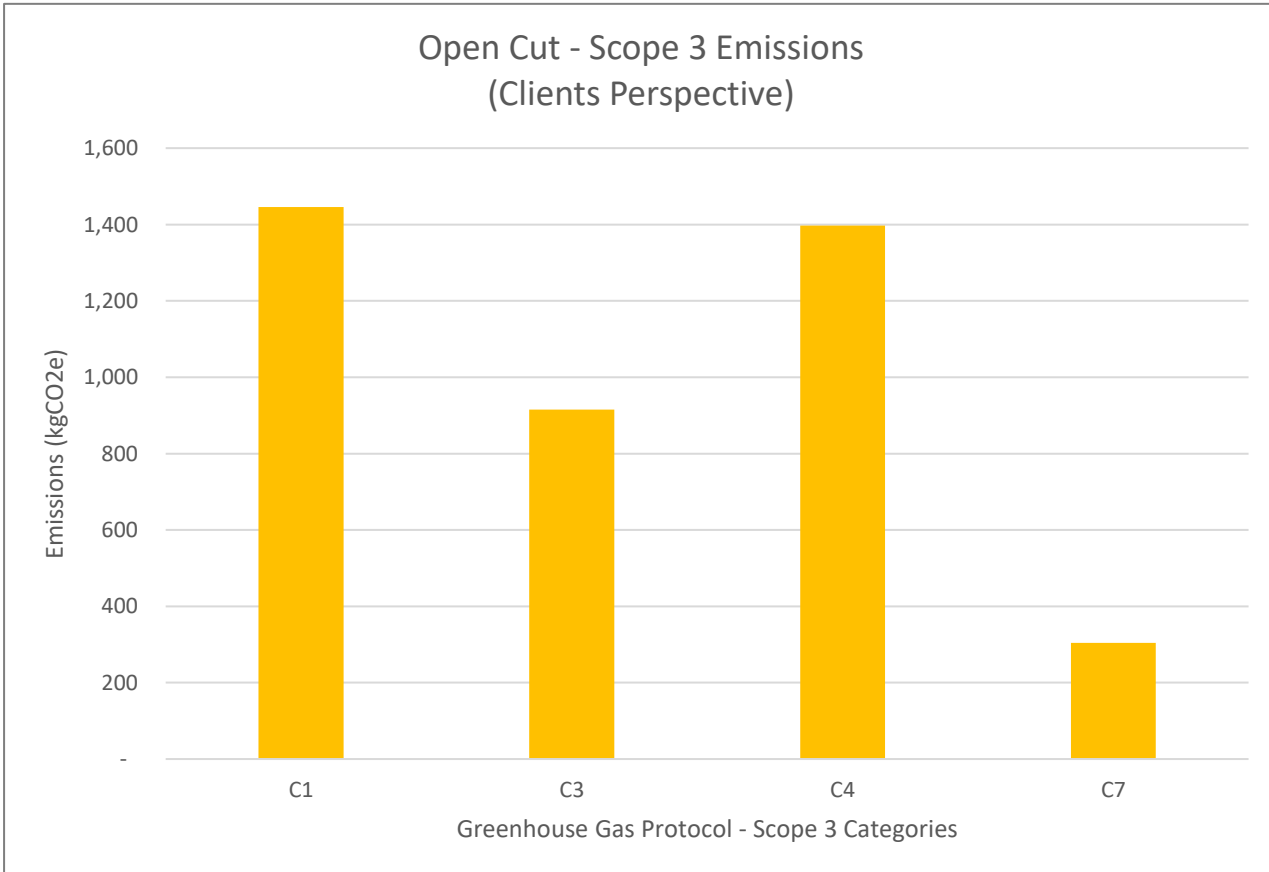
Select calculation approach

Collect data and choose emission factors

Calculate GHG Emissions

Roll Up data / Reporting

Scope 3 - GHG Protocol Scope 3 (Clients Perspective)			
Scope 3	C1	Direct GHG Emissions and Removals - Fuel	1,446
	C3	Fuel and Energy Related Activities (kgCO2e)	915
	C4	Upstream Transportation and Distribution (kgCO2e)	1,398
	C7	Employee Commuting (kgCO2e)	304
		kg(CO2e)	4,064



# Complexity of Carbon Accounting

**1. Why measure Carbon Emissions?**

**2. Carbon Framework**

**3. Construction/ Engineering Process**

**4. Carbon Accounting**



- **The need for 2 inventories –**  
1 for the contractor and 1 for the client
- **Cost of upskilling and education to start measuring Carbon emissions.**
  - Stages of the life cycle assessment
  - Basic life cycle assessment (embodied and operational carbon)
  - Education on Carbon Standards (Scope 1, 2, and 3)
  - ISO 14064 – Categories 1 to 6
  - GHG Protocol Scope 3
  - Emission factors and EPDS

- **Pre-contract (Methodology)**
- **During Construction (Collect Data)**
- **Payment Claim/Reporting (Quantity)**

# Carbon Accounting in Construction – Implementation

## Pre-contract

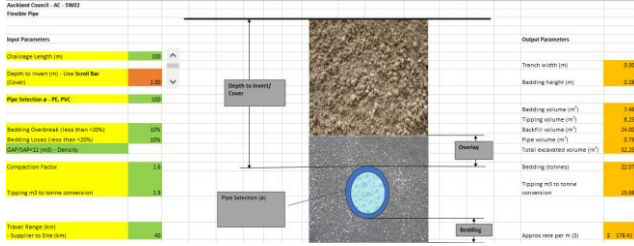
Estimator  
Quantity Surveyor  
Project Engineer

## During Construction

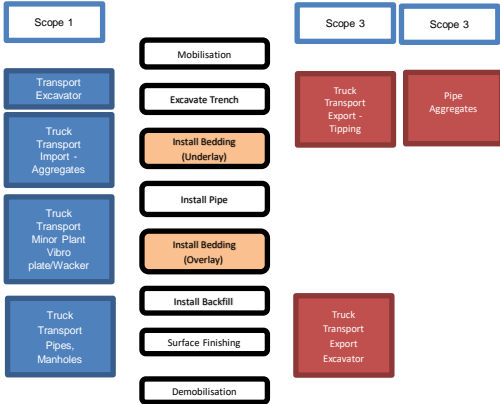
Site Engineer/Project Engineer

## Payment Claim/Reporting

Project Engineer  
Quantity Surveyor



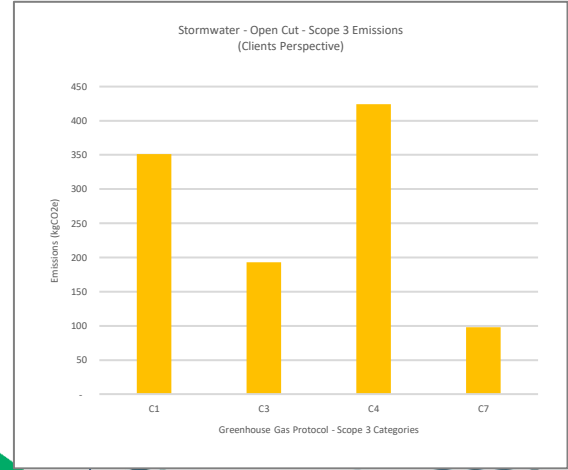
			Unit	Qty	Emission Factors (kg CO2e/unit)	Calculated Emissions (kg CO2e)
AC-SW03 - Concrete Pipe (OD)	Diameter (ø)	Stormwater - DA160	m	100	2.720	272
GAP/SAP-12 (m3) - Density	tonnes (t)		t	22.07	3.590	79
						351
Excavator Fuel			L	48	2.690	129
Small Plant - Wacker			L	9	2.690	24
Small Plant - Vibro			L	16	2.460	40
						193
Mobilisation			km	160	0.624	100
Aggregates			km	360	0.624	225
Demobilisation			km	160	0.624	100
						424
Employee Commuting			km	309	0.317	98
						98



**Environmental Product Declaration**  
For Aggregate and Sand Products

**Measuring emissions: A guide for organisations**  
2022 summary of emissions factors  
Using data from the 2020 calendar year

Winstone Aggregates logo and a yellow dump truck (7736) are visible.

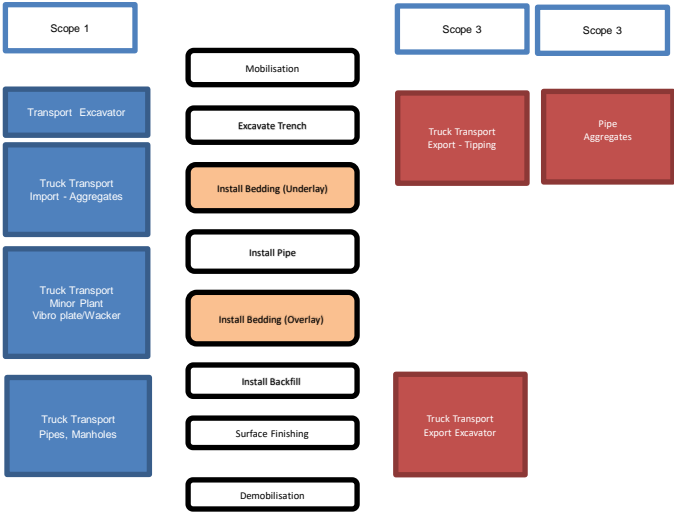
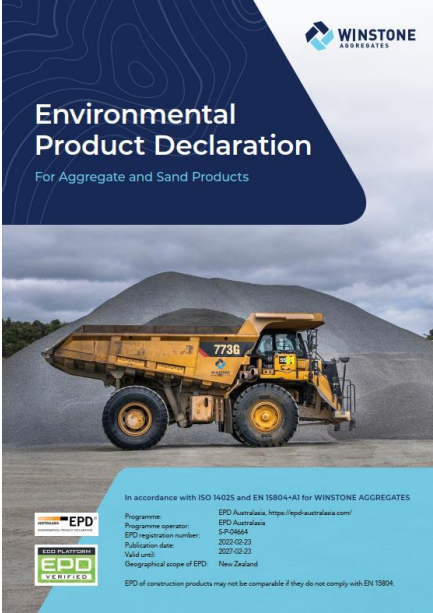
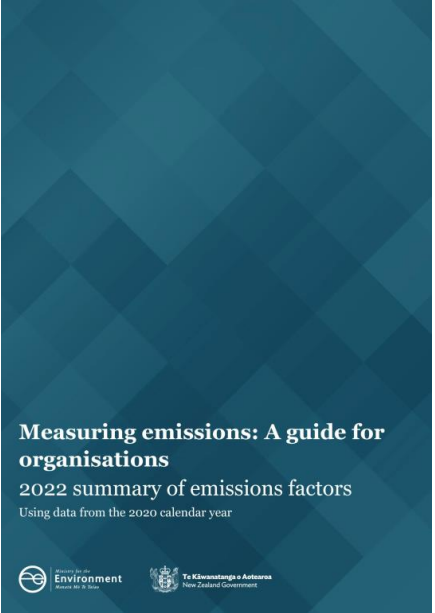
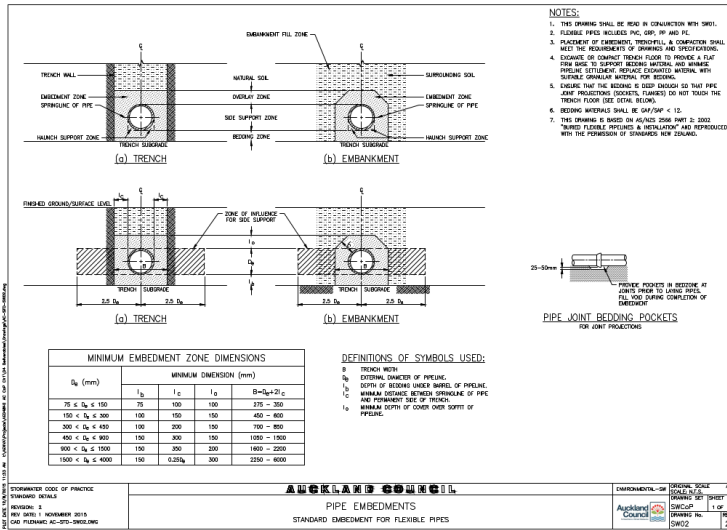


Identify Sources

Quantify Activities  
Search & Apply Emission Factors

Compile/Calculate and Report

## Designers – Identify Emission sources



Complex Project = Complex Carbon Accounting

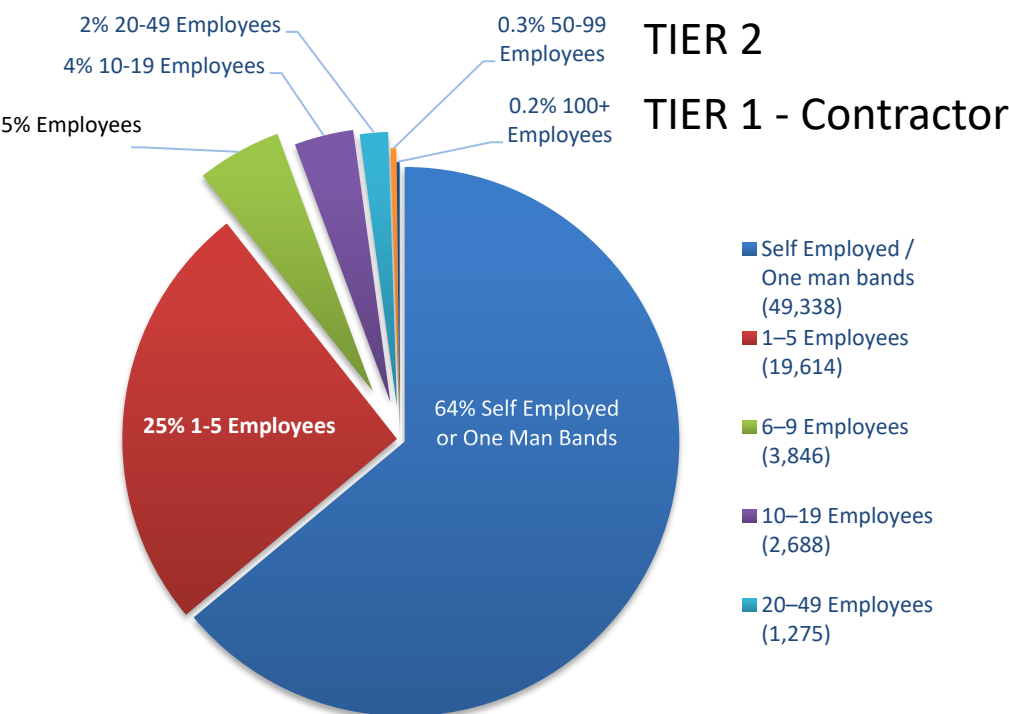
Clients interact with key players

Award Contracts – Contractors drive emissions

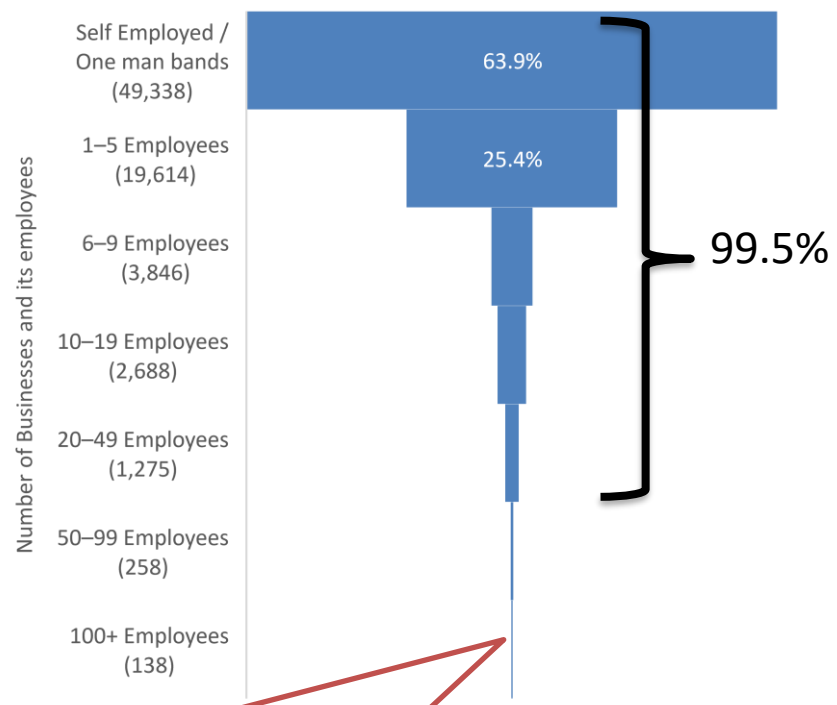


Flow down effect to supply chain

## Construction Companies/ Enterprises and their Employee Count (%)



## Number of construction companies and its employees



**TIER 1/2 CONTRACTOR – MAY EMPLOY OTHERS (99.5%)**

How can WE make small changes in our industry to meet net zero by 2050?

Let's start with the design - **Designers**

**YOUR SMALL CHANGES CAN MAKE BIG**  
Reduce fuel (petrol/diesel) burn – **Contractors**  
**CHANGES HAPPEN!**

Material sources - buy local! – **Contractors**

Select willing partners - **Clients**

**Thank you!**  
**Questions? Patai?**