Sustainable Earthworks – Mass Haul Analysis

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Sustainable Earthworks

Background

Ongoing research to identify opportunities for greater consideration of earthworks factors which influence sustainability, with a particular focus on Phase 2 and Phase 3.

Purpose

A well-considered Mass Haul analysis during option selection, planning and design can help mitigate ground risks, reduce potential waste, and reduce the need for reactive and less sustainable engineering solutions at subsequent project phases.

Objective

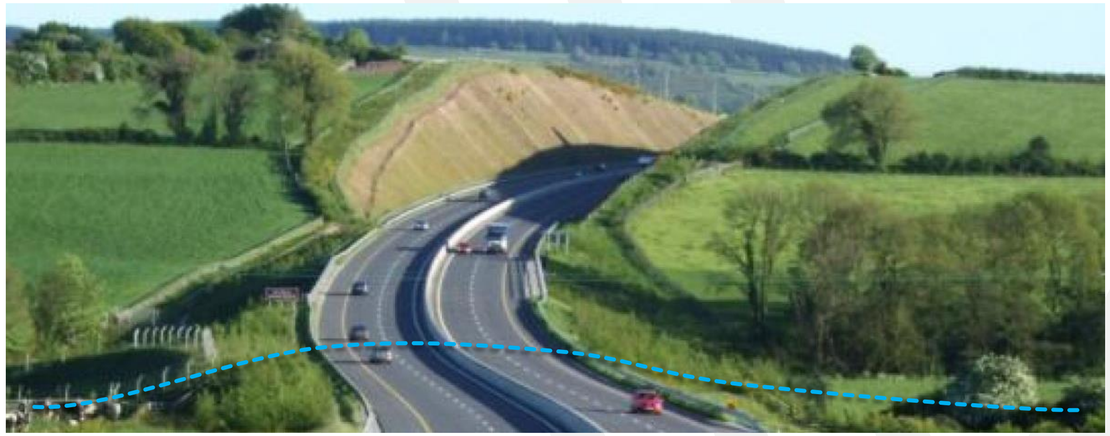
Identify the main principles that influence Mass Haul and develop a tool which would facilitate Mass-Haul analysis at Phase 2 and Phase 3

What is Mass Haul in this context?

Basic Definition:
Volume of Material ***x*** Transport Distance

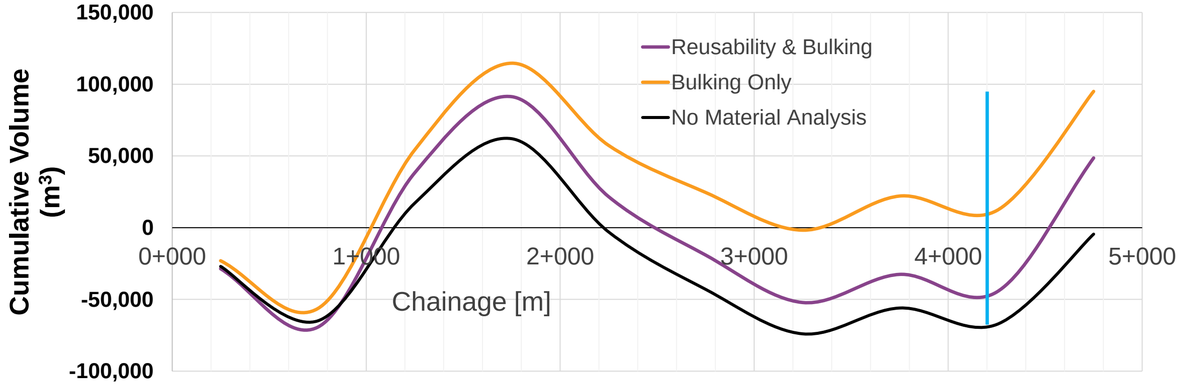
Accurate mass haul is also influenced by the following:

- material classification
- material acceptability
- material value
- source and destination of material
- material handling and construction practices
- haulage constraints
- haulage / extraction equipment
- programme



What is a Mass Haul Diagram?

A **Mass Haul Diagram** is a graphical representation of the material moved and facilitate investigation of material allocation and optimised haulage



What are the benefits of Mass Haul as part of Phase 2 & Phase 3?

Phase 2 Option Selection Process

- More ***considered comparison*** of options in terms of earthworks
- Optimised earthworks design when options at their ***most flexible***
- Facilitate ***identification of deposition and/or borrow areas*** much earlier in the process
- Increased likelihood of achieving a ***more balanced*** (earthworks) preferred option

Phase 3 Planning Design

- ***Reduced risk of unforeseen ground conditions*** which result in expensive, time-consuming and disruptive engineering solutions
- Allocation and re-use of material at its ***highest value***
- ***Reduces reactive design*** to deal with unbalanced preferred option

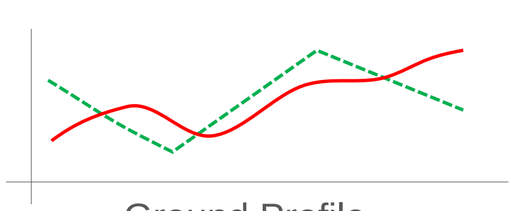
Phase 4 Statutory Process

- ***Quantitative and qualitative assessment*** of factors which influence sustainability (from concept stage)
- Shows ***stronger link*** between option selection process, sustainability and land required
- ***Evidence to support land acquisition***, particularly in terms of borrow areas and material deposition areas

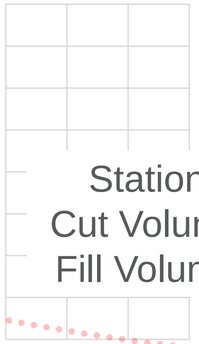
Phase 5 & Phase 6

- ***Greater cost certainty*** in terms of earthworks quantities and movement
- Optimised earthworks considerations will likely result in ***less reliance on natural / scarce resources***
- ***Localised balances*** which reduce works and cost associated with long or unsustainable haulage
- ***Reduction in claim costs and programme overrun*** due to improved consideration of material movements and allocation e.g. sourcing acceptable material, disposal of unacceptable material

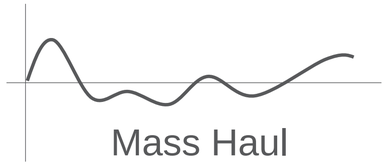
How can Mass Haul be incorporated?



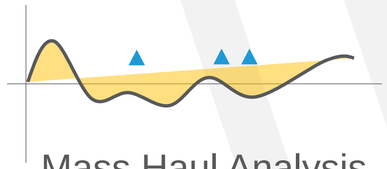
Ground Profile
Vertical Alignment
Horizontal Alignment



Station
Cut Volume
Fill Volume



Mass Haul
Development



Mass Haul Analysis

Identification of possible optimisation options

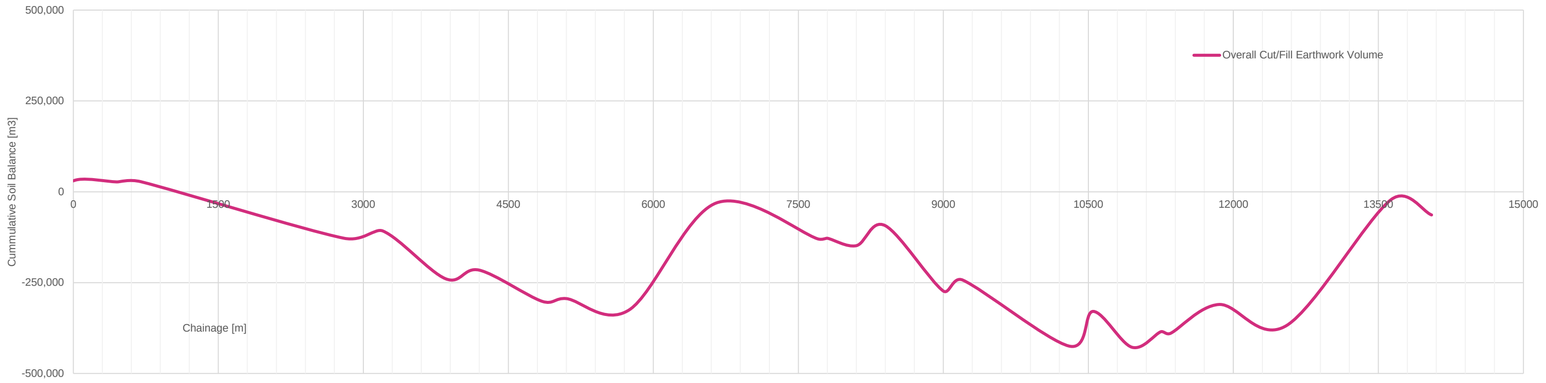
Original Objective

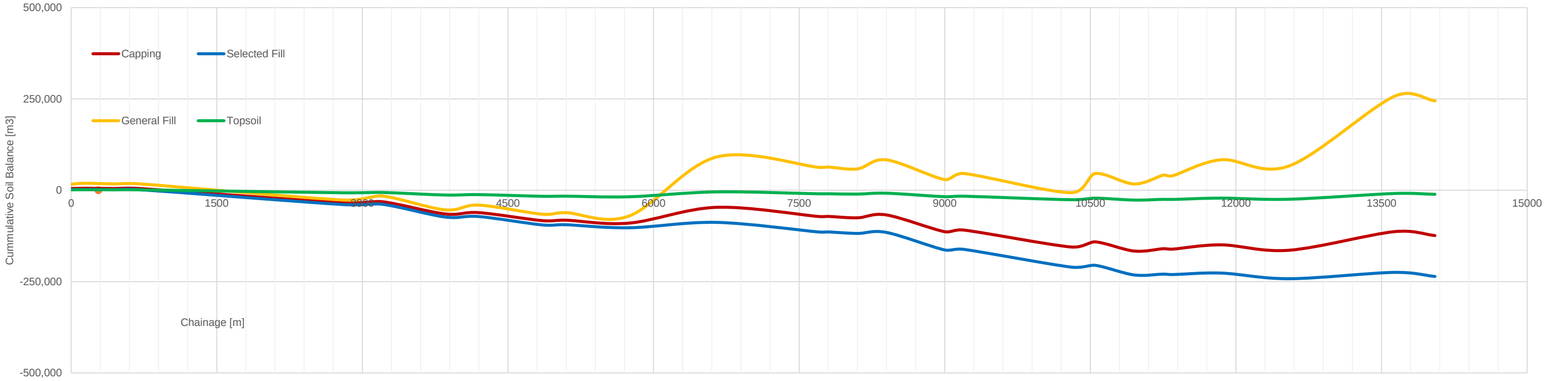
Create a mass haul diagram spreadsheet

Evolved Objective

Create a tool which directs and highlights opportunities for a more sustainable design through optimisation with respects to earthworks

Project Phase	Scope *(based on)*	Geometry & Volumes	Earthworks Analysis	Project Characteristics	Visualisation	Conclusions & Opportunities
Phase 2	Geological Description (e.g. Overburden, Rock)	• Geometry: ○ Chainage/Stations ○ Alignment Levels ○ Ground Levels • Volumes: ○ Cut (Unbulked) ○ Fill (Compacted)	• Volumes: ○ Cut (Bulked) ○ Fill (Uncompacted) • Reusability Analysis • Material Analysis	• Constraints • Material Deposition Areas • Borrow Areas	• Overall Mass Haul Diagram • Mass Haul Diagram per Material Type (as per Phase & Scope)	• Earthworks Balance • Haulage Gradient • Haulage Distance (freehaul vs overhaul) • Haulage Constraints
Phase 3	TII Material Classification (e.g. Class 1, Class 2, Class 6N etc.)					





Mass Haul Diagrams –

- Overall
- Detailed per material type or classification
- Automatically updated based on inclusion of material deposition areas and/or borrow areas

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Phase 3						

Haulage Analysis Summary –

- Earthworks balance as total and according to material designation
- Haulage summary per material designation:
  - Haulage volume in terms of freehaul and overhaul
  - Haulage distance in terms of freehaul and overhaul
  - Volume and total distance for uphill movements
- Haulage summary per earthworks area per material type, highlighting following impacts:
  - Gradient (uphill)
  - Constraints
  - Distance (over freehaul)
  - Two iterations of movements, both in forward and backward direction

	Topsoil	General Fill	Selected Fill	Capping	Subbase	Total
Haulage Deficit (m^3)	26,700	72,563	236,044	155,085	118,607	
Haulage Surplus (m^3)	15,631	317,329	0	31,202	5,435	

Haulage Volume (m^3)		Topsoil		General Fill		Selected Fill		Capping		Subbase	
	Overall	31,584		242,493		51,829		119,869		50,843	
	Freehaul	25,819	82%	184,966	76%	49,666	96%	102,750	86%	48,499	95%
	Overhaul	5,766	18%	57,526	24%	2,163	4%	17,119	14%	2,344	5%

				Topsoil															
				FORWARD MOVEMENT								BACKWARD MOVEMENT							
Chainage				To the 1st Next Fill Section				To the 2nd Next Fill Section				To the 1st Next Fill Section				To the 2nd Next Fill Section			
From	To			Gradient	Constraints	Volume	Distance	Gradient	Constraints	Volume	Distance	Gradient	Constraints	Volume	Distance	Gradient	Constraints	Volume	Distance
-190	50	CUT		0.27%	YES	164	320	0.55%	YES	1381	1820								
50	450	FILL																	
450	700	CUT		0.63%	NO	23	1175												
700	2800	FILL																	
2800	3200	CUT		-0.72%	NO	462	525					-0.74%	NO	462	1250				
3200	3850	FILL																	
3850	4200	CUT		0.04%	YES	541	500					0.86%	NO	541	500				
4200	4850	FILL																	
4850	5100	CUT		0.23%	NO	172	450					0.07%	YES	172	450				
5100	5750	FILL																	
5750	6650	CUT		0.48%	YES	5263	975					-0.50%	NO	1498	775	-0.29%	YES	3899	1675
6650	7700	FILL																	
7700	7800	CUT		1.84%	NO	36	200					-0.65%	YES	36	575				
7800	8100	FILL																	
8100	8400	CUT		0.18%	NO	1626	450					-1.22%	NO	832	300				
8400	9000	FILL																	
9000	9200	CUT		0.25%	NO	695	650					0.10%	NO	695	400				

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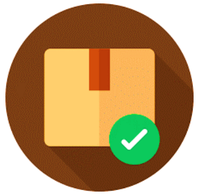
Current Tools

Excel-Based Earthwork Analysis Tools with User Manual

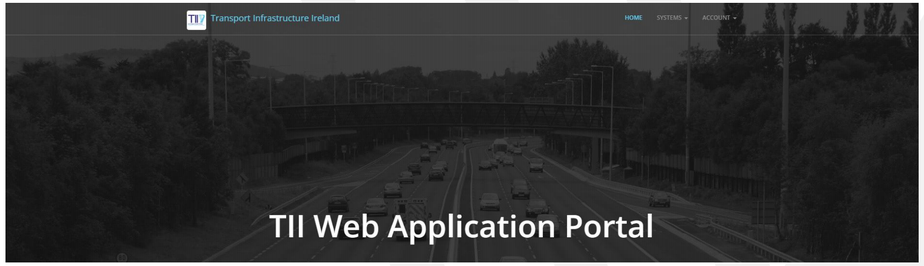
Ongoing

Pilot Trials on live Phase 2 and Phase 3 Projects



Update Tools and User Guide with feedback from project teams

Next Steps



- 1st November 2022 – Available for use on projects
- Technical support and guidance available to project teams
- Feedback and suggestions for further development welcome
- Regular updates of Tools and User Guide based on user experience and feedback

Bonneagar Iompair Éireann
Transport Infrastructure Ireland

Questions and Answers