

The background image shows a scene of destruction. In the upper half, several large shipping containers are stacked and tilted. One white container has "CCNI" written on it, a red one has "CAPITAL", and a green one has "CHINA SHIPPING" and Chinese characters. In the lower half, there is a large pile of debris, including twisted metal and broken concrete. Several people are visible in the background, some appearing to be working or observing the site. The overall scene suggests the aftermath of a major disaster, likely a tsunami.

Enhancing Tsunami-Borne Debris Velocity Estimation for Improved Risk Assessment

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Tsunami Damage

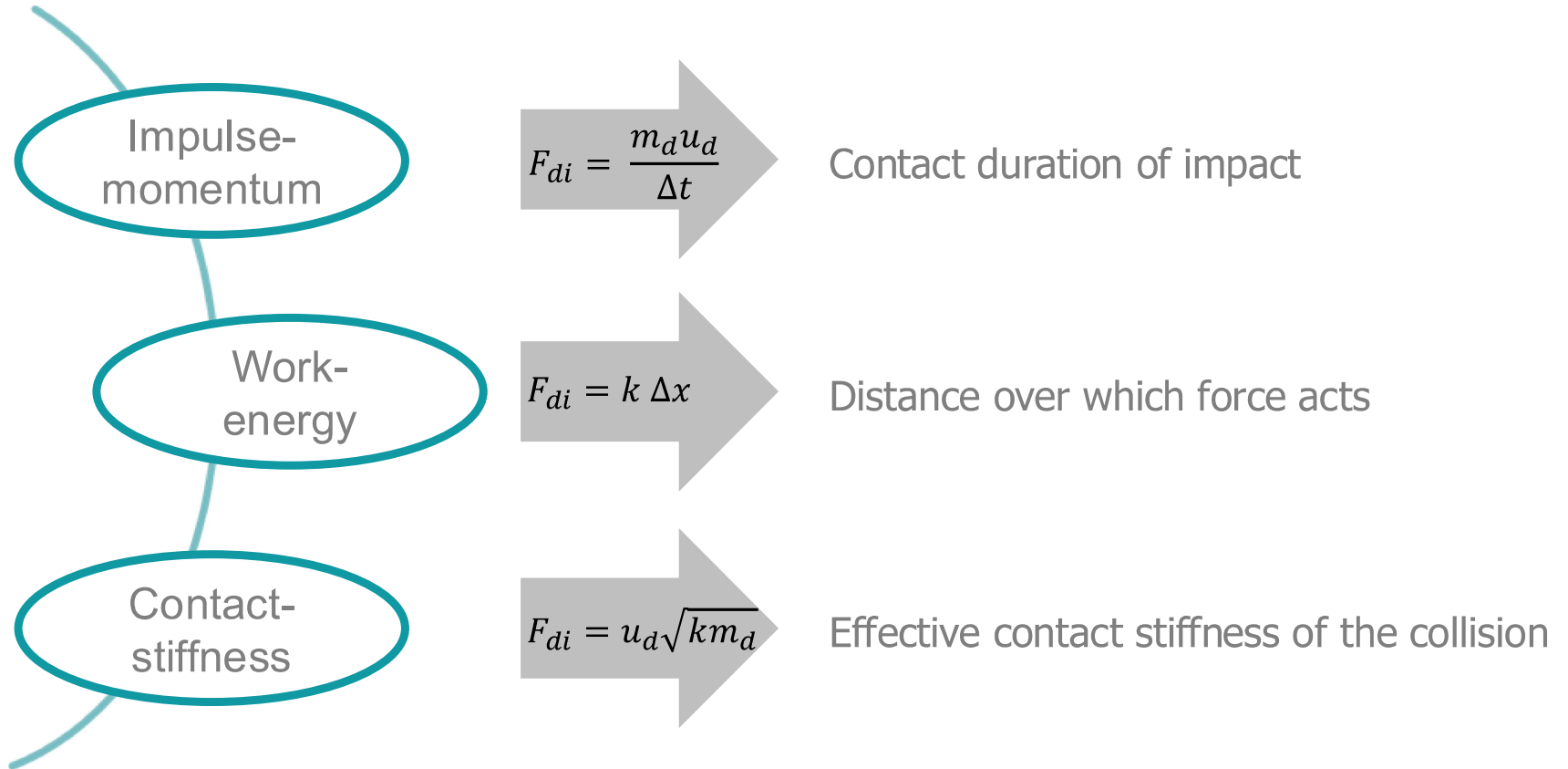
Talcahuano Harbour – Chile Tsunami



Kisenuma – Japan Tsunami



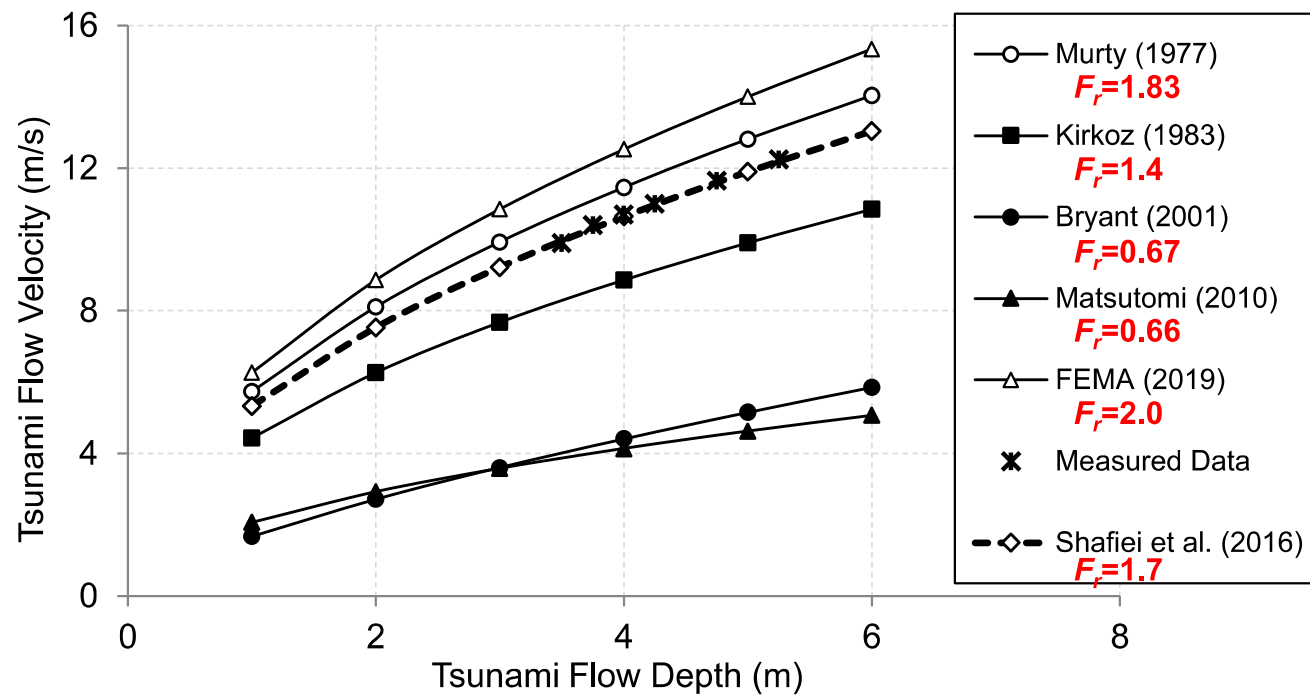
Approaches For Estimating Debris Impact Force



What are the challenges?

Contact-stiffness	$F_{di} = u_d \sqrt{k (m_d + C m_f)}$ <p>(Haehnel and Daly)</p>	$F_{di} = 1.3 u_d \sqrt{k m_d (1 + c)}$ <p>(FEMA P-646)</p>
Impulse-momentum	$F_{di} = \frac{\pi u_d m_d}{2 \Delta t}$ <p>(Haehnel and Daly)</p>	$F_{di} = C_{add} C_u C_{sh} C_{DD} C_{ss} \frac{\pi u_d m_d}{2 \Delta t}$ <p>(Shafiei et al)</p>
	$F_{di} = \frac{\pi u_d m_d C_l C_O C_D C_B R_{max}}{2 \Delta t}$ <p>(ASCE 7)</p>	$F_{di} = u_d m_d C_D C_B C_{Str}$ <p>(FEMA P-55)</p>
Work-energy	$F_{di} = \frac{m_d u_d^2}{S}$ <p>(Haehnel and Daly)</p>	
Other Approaches	$\frac{F_{di}}{\gamma_d D^2 L} = 1.6 C_M \left(\frac{u_d}{\sqrt{g_n D}} \right)^{1.2} \left(\frac{\sigma}{\gamma_d L} \right)^{0.4}$ <p>(Matsutomi)</p>	$\frac{F_{di}}{g m_d} = S C_M \left(\frac{u_d}{\sqrt{g \sqrt{D L}}} \right)^{2.5}$ <p>(Ikeno et al)</p>

Tsunami Flow & Froude Number



Debris Motion



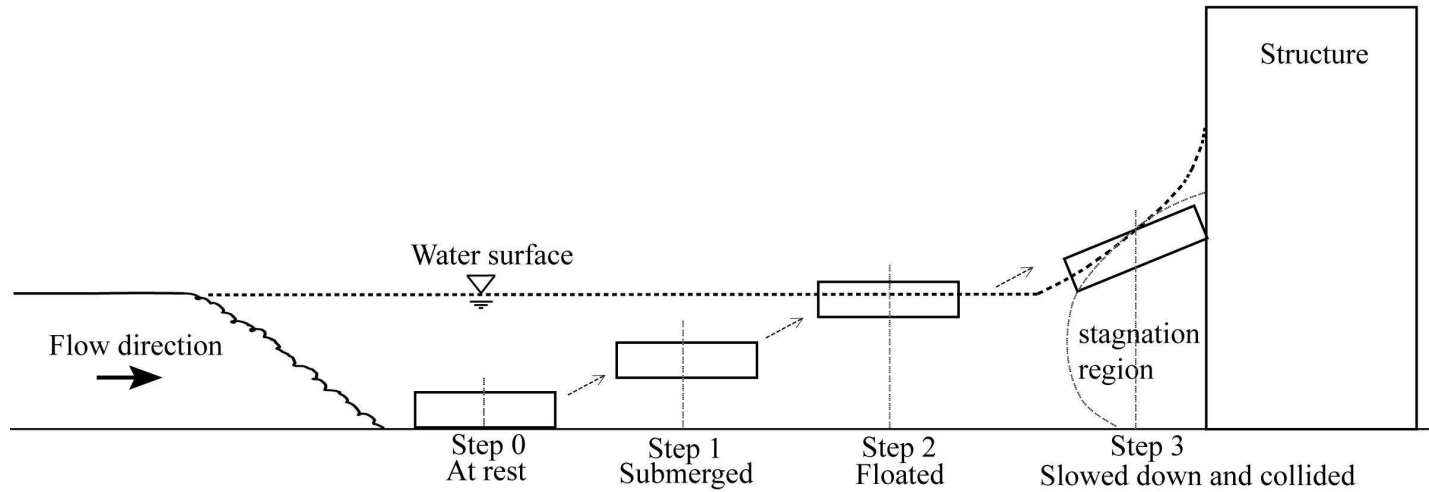
Steps 0 and 1



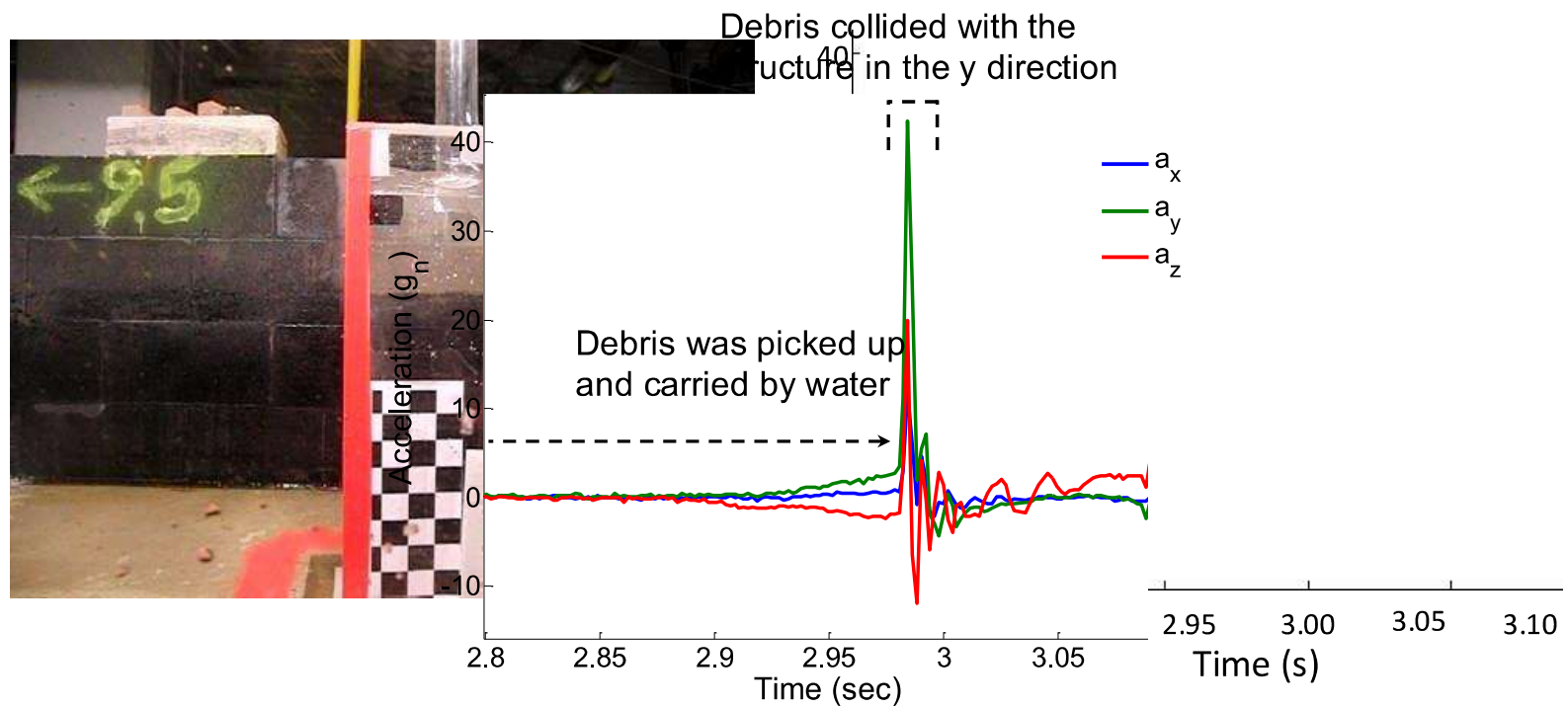
Step 2



Step 3



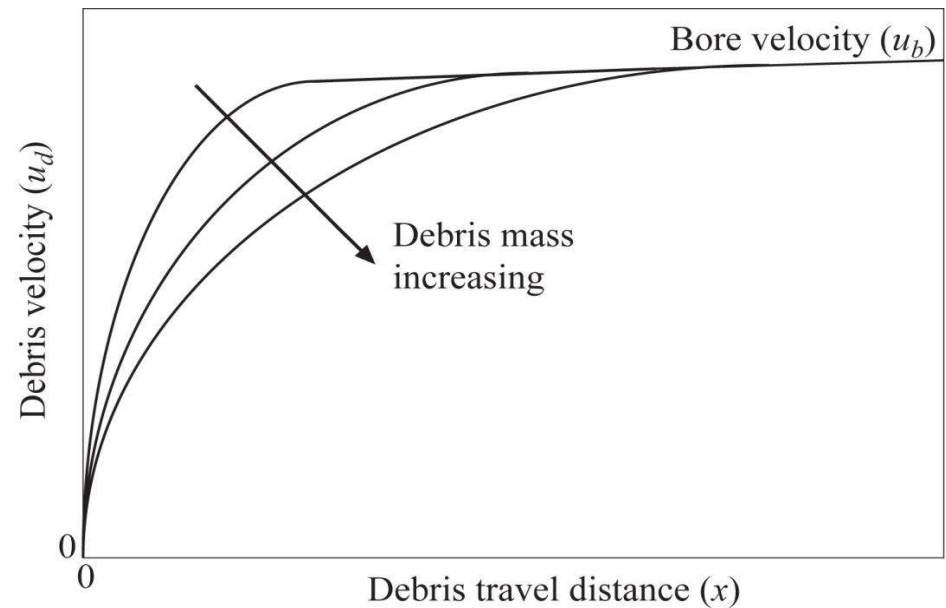
Data Collection Using The Smart Debris Device



Theoretical Debris Velocity

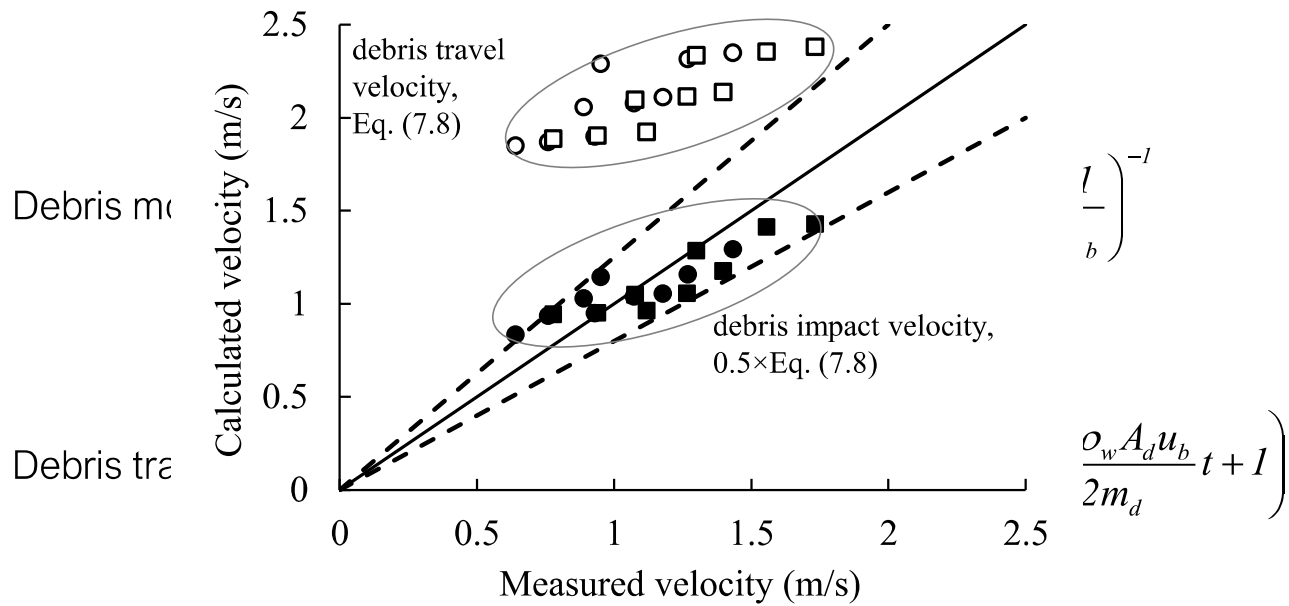
$$m_d \ddot{x} = 0.5 C_d \rho_w (u_b - \dot{x})^2 A_d$$

$$\begin{cases} \dot{x}(0) = 0 \\ x(0) = 0 \end{cases}$$



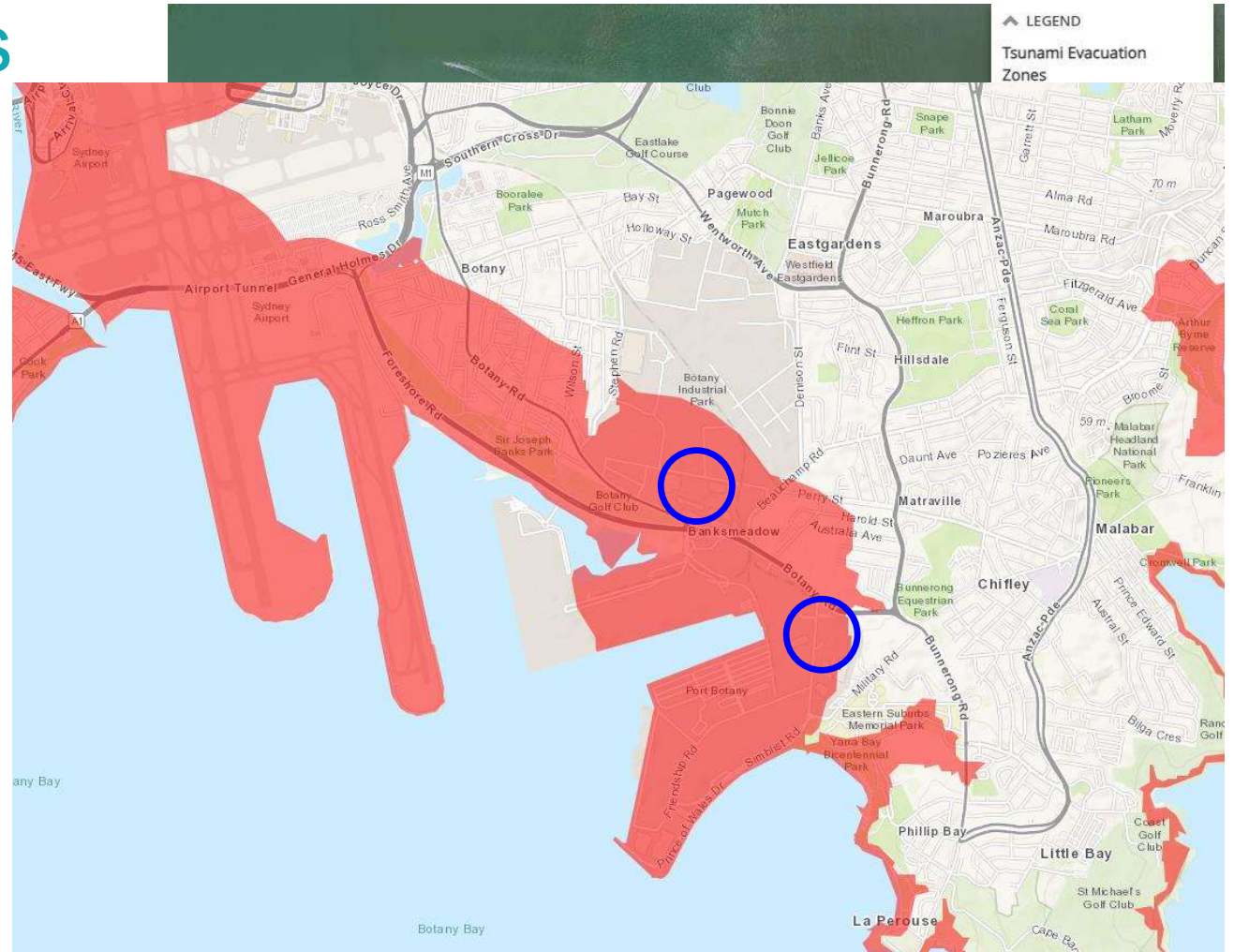
Schematic diagram of debris motion and the effect of debris mass on it

Debris Velocity



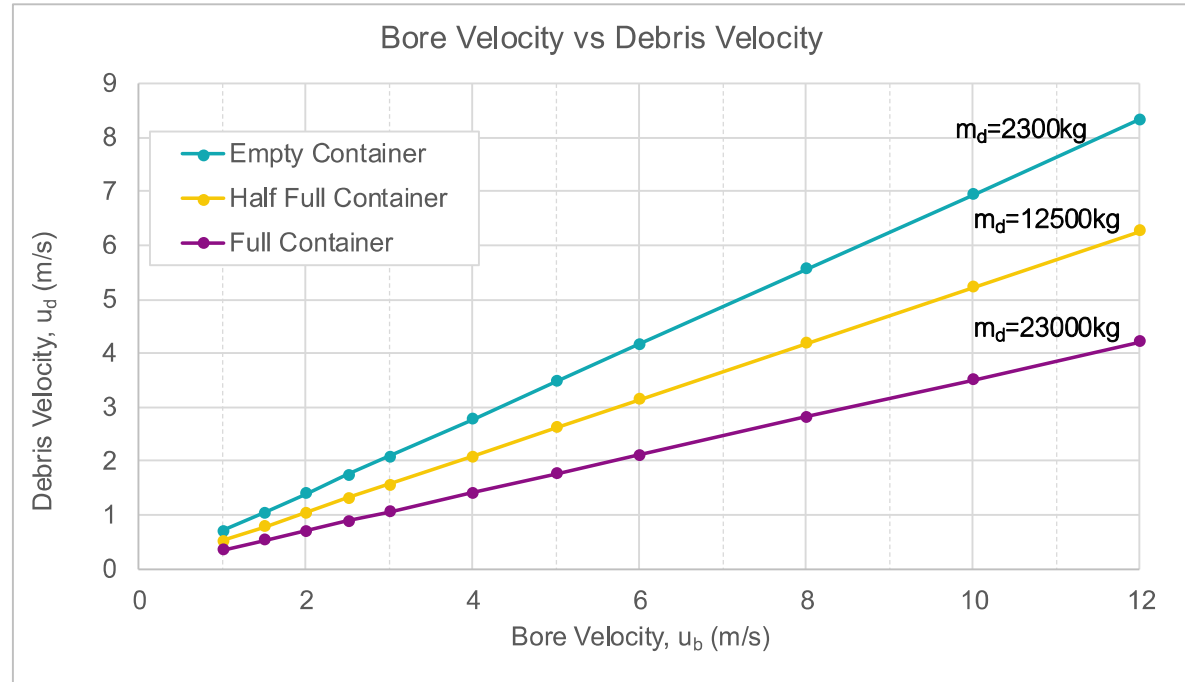
Case Studies

Australia



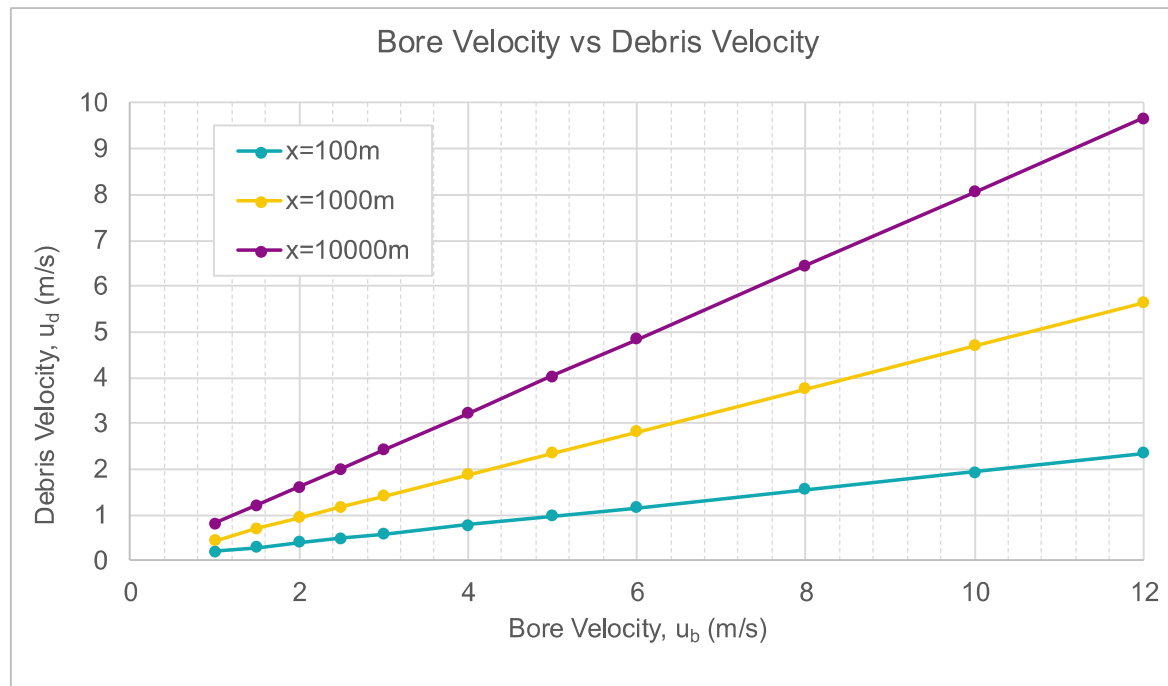
Debris Velocity vs Bore Velocity

Debris velocity (u_d) vs bore velocity (u_b) for various debris masses (m_d) travelling over $x=1000m$



Debris Velocity vs Bore Velocity

Debris velocity (u_d) vs bore velocity (u_b) for $m_d=10,000\text{kg}$ travelling over various distances (x)

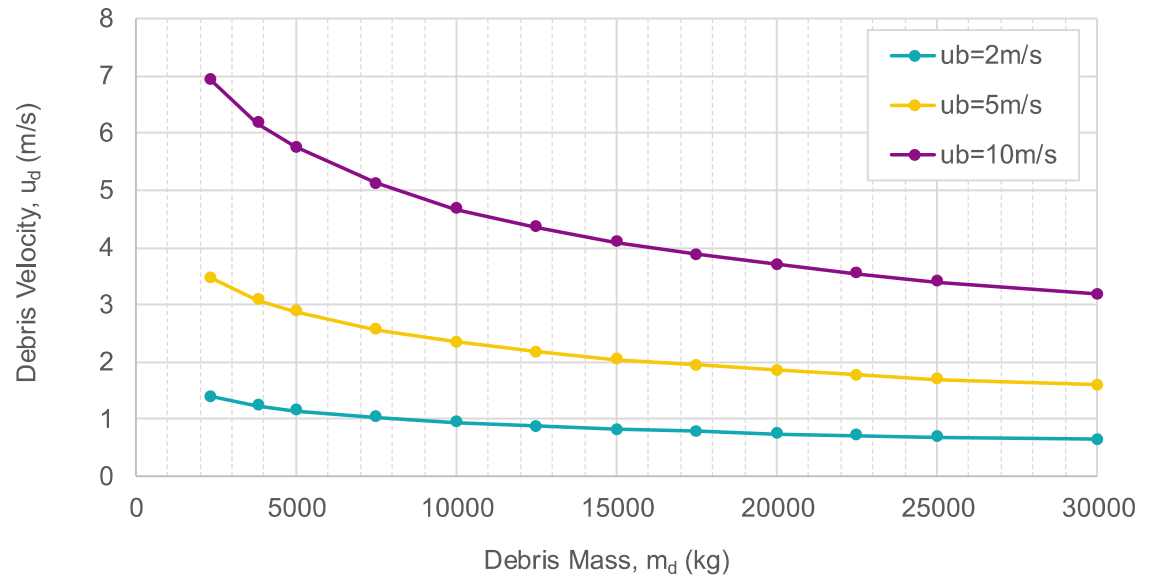


Debris Velocity vs Debris Mass

Utilising a range of weights of 20 ft standard containers the travel distance of 1000m with bore velocity of 2m/s and 5m/s

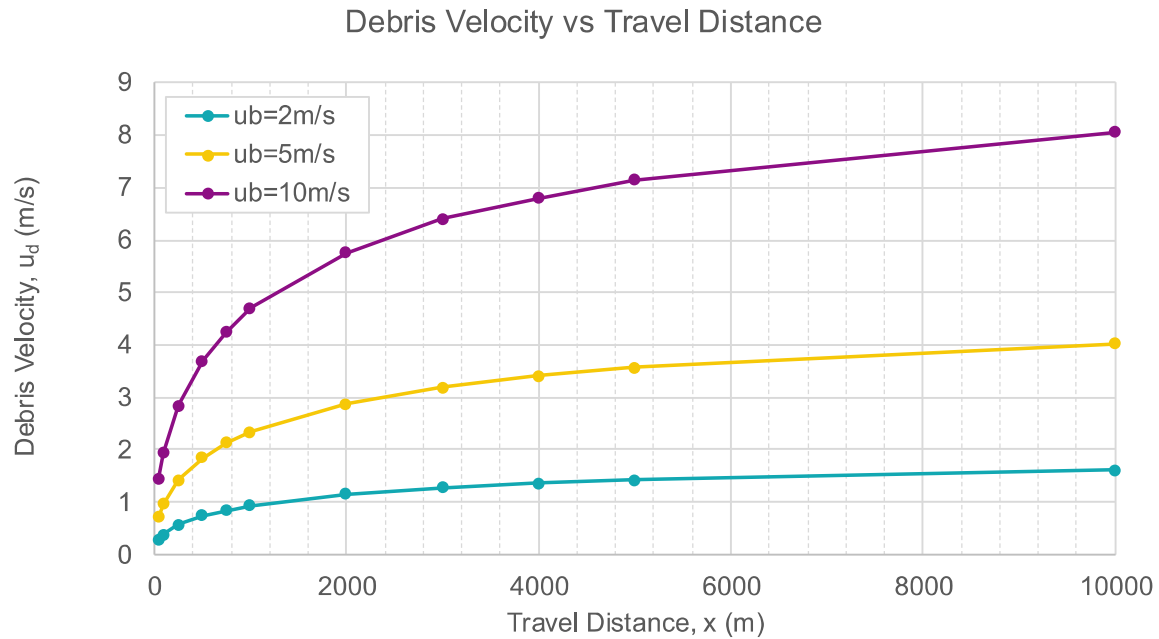


Debris Velocity vs Debris Mass

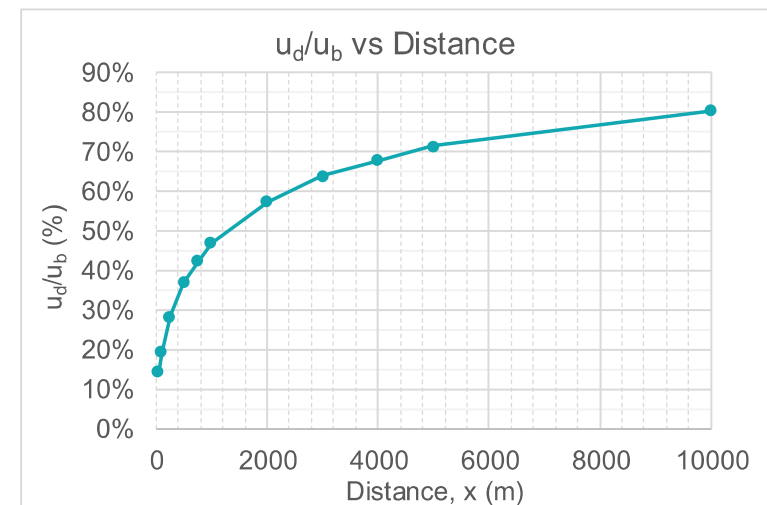
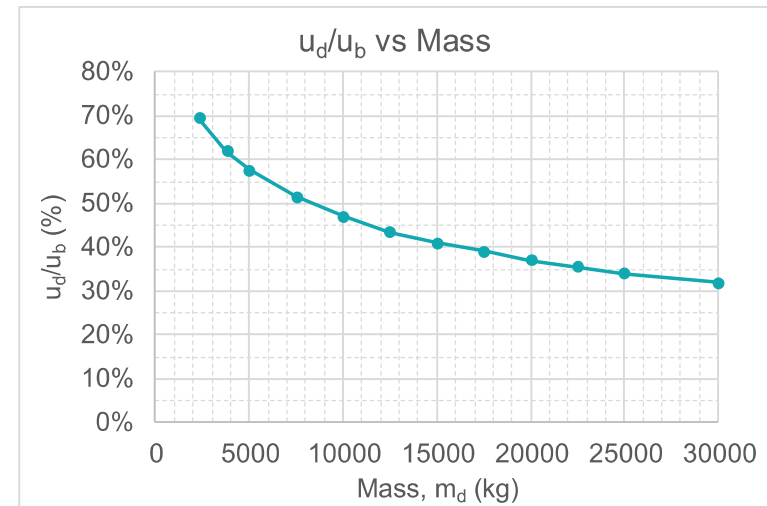
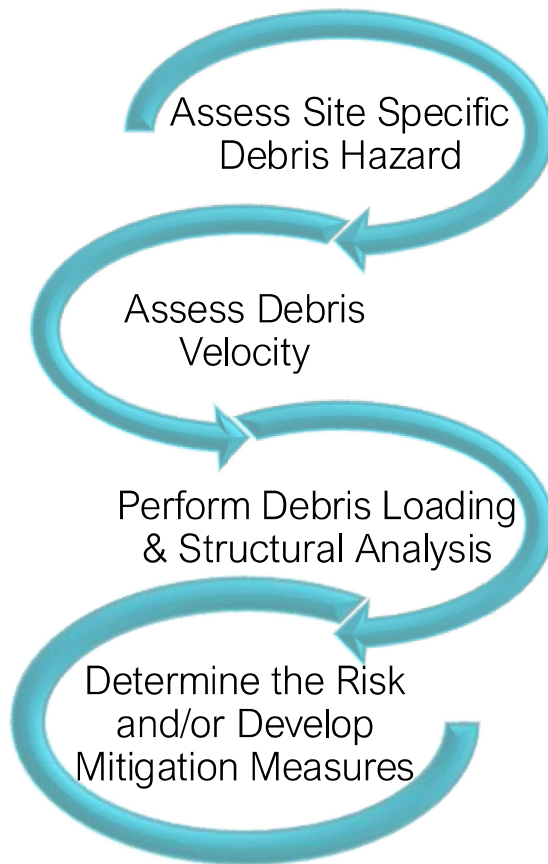


Debris Velocity vs Debris Travel Distance

Utilising a standard 10000kg containers with bore velocity of 2m/s and 5m/s



Tsummary



Thank You!



Debris Velocity

