Session 3

Erosion Hazard Assessment

Soil Loss Estimation using RUSLE

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Erosion Hazard

- On some construction projects the risk of erosion is low, but in other cases it can be high
- So how can we make a quantitative assessment of erosion hazard?
- The susceptibility, or risk of land to erosion, depends on a combination of factors and varies from site to site
- On larger projects, the risk can vary across the project site

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Assessing Erosion Hazard

What factors do you think affect erosion hazard?

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Slope?

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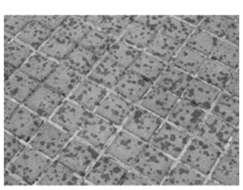
Rainfall intensity?



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Surface protection?

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Degree of cover?

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Erosion Factors

The following factors are significant:

- **Rainfall** erosivity/intensity
- **Soil** type and erodibility
- **Slope** length/steepness
- **Conservation practice**
- **Cover** type

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RUSLE

These factors form the basis for the <u>R</u>evised <u>U</u>niversal <u>S</u>oil <u>L</u>oss <u>E</u>quation (RUSLE)

- Empirical equation used to estimate erosion hazard for a location
- Only applies to non-channelised erosion
- Does not take into consideration soil dispersibility

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RUSLE and Soil Loss

- RUSLE provides a measure of erosion hazard or risk
- Can use RUSLE to estimate soil loss and identify high risk construction projects at planning and design stage
- Also use RUSLE to determine the need for and size of a sediment basin
- Helps assess relative performance of E&SC procedures

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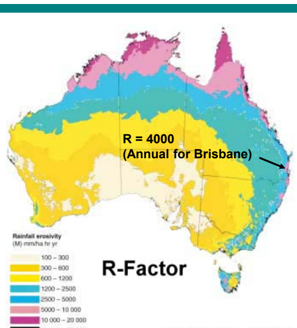
Rainfall Erosivity (R-factor)



Courtesy: Landcom (2004)

- A measure of the ability of rainfall to cause erosion
- Related to the energy and intensity of rainfall
- Varies throughout Australia and throughout the year
- Range in QLD 600->30,000

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Rainfall Erosivity (R)

- Predominant rainfall droplet size (energy)
- Based on average annual rainfall data
- Ignores prevailing soil moisture

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Soil Type and Erodibility (K)

- A measure of the susceptibility of soil particles to erosion
- Affected by soil texture, structure, organic matter, profile permeability and other parameters
- Generally, fine sands and silts are most erodible, but dispersible clays can be highly erodible

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Soil Texture

- Sand grains
  - Visible to the eye
  - Roll between fingers
- Silt grains
  - Not visible to the eye
  - Roll between the fingers
- Clay grains
  - Not visible to the eye
  - Smooth to the touch

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Slope Length/Steepness (LS)

- A measure of the combined effect of slope length and gradient on soil loss
- Increases with gradient and length
- Gradient has greater influence

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Slope Length

- Long slope shortened by use of berms and cross-drainage

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Slope Steepness

- Slope gradient more significant than length

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Conservation Practice (P)

- Measure the combined effect of supporting practices and management variables
- Reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill, e.g.
  - Track walking up/down slope rather than across slope
  - Straw crimping
  - Loose soil surface to 300mm depth

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Track Walking

- Creates furrows which reduces downslope movement of soil

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Cover Type (C)

- A measure of the amount and effectiveness of ground cover
- Reduce the erosion hazard by maintaining good ground cover (lower C-factor) – a key erosion control practice!
- Proper rehabilitation should ensure C-factors drop to below 0.15 (50% cover) within 20 days of completing work

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Cover Type (C) for Grass

Grass Cover	C-Factor
No cover, soil smooth and compacted	1.0 **(High)**
20%	0.45 **(Med)**
50%	0.15 **(Low)**
70%	0.05
100%	< 0.01

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No Cover

- No cover, C-factor 1.0

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100% Cover

- Well covered site, C-factor 0.01

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Discussion

Which of the previous erosion factors can be readily manipulated to reduce the erosion hazard on your construction site, and how?

- Rainfall, soil type – NO
- Slope length, cover type – Possible
- Conservation practice – YES

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Discussion

When should you aim to work on sensitive sites or sites with high erosion hazard that may be difficult to manage?

- Timing (rain / wind probability?)
- Available resources?
- Previous disturbance?

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Erosion Hazard Assessment

RUSLE can be used to assess erosion hazard and considers the following factors:

- Rainfall erosivity/intensity
- Soil type and erodibility
- Slope length/steepness
- Conservation practice
- Cover type

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Erosion Hazard Assessment

Some of the factors in RUSLE are things which we cannot control:

- Rainfall erosivity/intensity
- Soil type and erodibility
- Slope steepness

Some of the factors in RUSLE are things we can control:

- Slope length
- Conservation practice
- Cover type

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Exercise

- In this exercise we are going to consider the RUSLE factors for a typical construction job to see to what extent we can have a positive influence on the outcome by controlling the factors that are within our control

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The Project

- 800 metres of two-lane road is going to be duplicated to four-lane dual carriageway. The pavement is going to be sealed but the shoulders will only be graded
- The gradient of the road is 4%
- The soils are 20cm of clay loam topsoil overlying light clay subsoil

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RUSLE

RUSLE Equation:

$$A = R \times K \times LS \times P \times C$$

Where:

A = Computed soil loss (tonnes/ha/year)
R = rainfall erosivity factor
K = soil erodibility factor
LS = slope length/gradient factor
P = erosion control practice factor
C = ground cover and management factor

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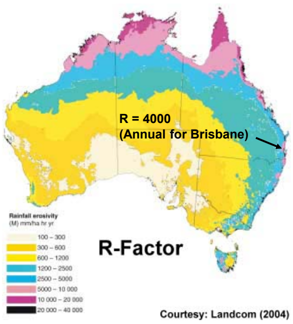
Rainfall Erosivity (R-factor)



- A measure of the ability of rainfall to cause erosion
- Related to the energy and intensity of rainfall
- Varies throughout Australia and throughout the year
- Range in QLD 600->30,000

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Low or High Hazard Sites

- Comparison R-factor and Slope can be used to determine if a site is Low Erosion Hazard (below the A-line), or High Erosion Hazard (above the A-line)

At what slope (gradient) does a site in Brisbane become a High Hazard site?

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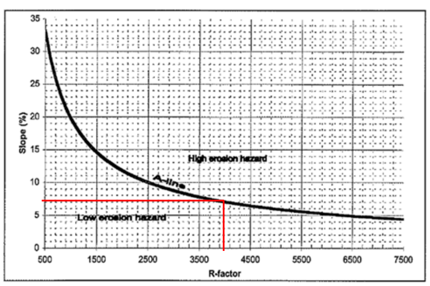
Low or High Hazard Site?



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High Hazard Sites

- Standard erosion controls typically apply to all sites:
  - Stabilised access
  - Water management
  - Stockpile management
  - Stabilisation requirements
- High erosion hazard sites also require:
  - Timing of works should be undertaken in drier months
  - Management of batter gradients

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Rainfall Erosivity (R-factor)

Which months would you choose to work in Brisbane?

BRISBANE REGIONAL OFFICE - Mean rainfall (mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
159.6	158.3	140.7	92.5	73.7	67.8	56.5	45.9	45.7	75.4	97	133.3

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Soil Type and Erodibility (K-factor)

- A measure of the susceptibility of soil particles to erosion
- Affected by soil texture, structure, organic matter, profile permeability and other parameters
- Generally, fine sands and silts are most erodible, but dispersible clays can be highly erodible
- Ref Table E4 or Lab test results

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K-factors (after Rosewell 1993)

Table E4 – Default soil erodibility K-factors based on soil texture class

Soil texture	Symbol	Estimated clay content (%)	K-factor [1]
Sand	S	< 10	0.015
Clayey sand	CLS	5–10	0.025
Loamy sand	LS	5–10	0.020
Sandy loam	SL	10–15	0.030
Fine sandy loam	FSL	10–20	0.035
Sandy clay loam	SCL	15–20	0.025
Loam	L	about 25	0.040
Loam, fine sandy	Lfsy	about 25	0.050
Silt loam	SiL	about 25 and more than 25% silt	0.055
Sandy clay loam	SCL	20–30	[0.043]
Clay loam	CL	30–35	0.030
Silty clay loam	SiCL	30–35 and more than 25% silt	0.040
Fine sandy clay loam	FSCL	30–35	0.025
Sandy clay	SC	35–40	0.017
Silty clay	SiC	35–40 and more than 25% silt	0.025
Light clay	LC	35–40	0.025
Light medium clay	LMC	40–45	0.018
Medium clay	MC	45–55	0.015
Heavy clay	HC	> 50	0.012

Note: [1] Rosewell (1993)

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Soil Type and Erodibility (K-factor)

What is the K-factor for clay loam topsoil? 0.030

What is the K-factor for light clay subsoil? 0.025

- The subsoils are generally of more significance in construction and will be exposed in this example
- (Increase by 20% for dispersive soils)

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Slope Length/Steepness (LS-factor)

- A measure of the combined effect of slope length and gradient on soil loss
- Increases as slopes get steeper and longer
- Gradient has greater influence

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LS-factor

Table E3 – Slope–length, LS-factors for RUSLE

Slope gradient (%)	Slope length (m)												
	5	10	20	30	40	50	60	70	80	90	100	150	200
1	0.09	0.11	0.13	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.20	0.23	0.24
2	0.14	0.18	0.24	0.28	0.31	0.34	0.36	0.39	0.41	0.43	0.44	0.52	0.58
3	0.17	0.24	0.34	0.41	0.47	0.52	0.57	0.61	0.65	0.69	0.72	0.87	1.00
4	0.21	0.30	0.44	0.54	0.63	0.71	0.78	0.85	0.91	0.97	1.03	1.26	1.47
5	0.24	0.36	0.54	0.68	0.80	0.91	1.01	1.10	1.19	1.27	1.35	1.70	2.00
6	0.28	0.42	0.64	0.81	0.97	1.11	1.24	1.36	1.47	1.58	1.68	2.14	2.54
8	0.34	0.53	0.83	1.08	1.31	1.51	1.70	1.88	2.05	2.21	2.37	3.07	3.70
10	0.42	0.68	1.09	1.44	1.75	2.04	2.31	2.56	2.81	3.04	3.27	4.06	4.94
12	0.52	0.85	1.39	1.85	2.27	2.66	3.02	3.37	3.70	4.02	4.33	5.77	7.07
14	0.62	1.02	1.69	2.26	2.79	3.28	3.74	4.18	4.61	5.02	5.42	7.27	8.95
16	0.71	1.19	1.98	2.67	3.31	3.90	4.46	5.00	5.52	6.02	6.51	8.78	
18	0.80	1.35	2.27	3.07	3.82	4.51	5.17	5.81	6.42	7.02	7.59		
20	0.89	1.50	2.55	3.47	4.32	5.12	5.88	6.61	7.32	8.01	8.68		
25	1.09	1.88	3.23	4.43	5.54	6.59	7.60	8.57	9.51				
30	1.28	2.23	3.86	5.32	6.69	7.99	9.23						
40	1.61	2.83	4.98	6.92	8.74								
50	1.88	3.33	5.89	8.22									

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Slope Length/Steepness (LS)

- Assume slope is 4% and slope length is 50 metres

What is the LS-factor?

0.71

- As we can control this factor, we will shorten the slope length to 20 metres using temporary earth banks

What is the LS-factor?

0.44

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Temporary Earth Banks

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Conservation Practice (P-factor)

- Relates to surface condition rather than cover
- Reduced by practices that reduce both the velocity of runoff and the tendency of runoff to flow directly downhill, e.g.
  - Track walking up/down slope rather than across slope
  - Straw crimping
  - Loose soil surface

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Conservation Practice (P)

Table E11 – Erosion control practice, P-factors

Surface condition	P-factor
Compacted and smooth (default construction phase condition)	1.3
Trackwalked along the contour	1.2
Trackwalked up and down the slope	0.9
Straw punched into loose ground by disc harrow	0.9
Loose to 300 mm depth	0.8

Note: [1] Straw mulch has been punched into a loose ground surface with a disc harrow.

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Conservation Practice (P)

- Now assume the surface has been track walked along the contour

What is the P-factor? 1.2

- Now assume the surface has been track up and down the slope

What is the P-factor? 0.9

Why would track walking up and down the slope be better?

To reduce the P-factor

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Cover Type (C-factor)

- A measure of the amount and effectiveness of ground cover
- Reduce the erosion hazard by maintaining good ground cover (lower C-factor) – a key erosion control practice!
- Proper rehabilitation should ensure C-factors drop to below 0.15 within 20 days of completing work

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Cover Type (C-factor) for Grass

Grass Cover	C-Factor
No cover, soil smooth and compacted	1.0 (High)
20%	0.45 (Med)
50%	0.15 (Low)
70%	0.05
100%	< 0.01

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Cover Type (C-factor)

- Assume there is no grass cover and the surface is smooth and compacted

What is the C-factor?

1.0

What effect would 20% cover of newly established grass have on the C-factor?

0.45

- Tables E6 to E10 list C-factors for various surface treatments

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Cover Type (C-factor)

- Reduce the erosion hazard by maintaining good ground cover (lower C-factor) – a key erosion control practice!
- Proper rehabilitation should ensure C-factors drop to below 0.15 within 20 days of completing work
- So, how do we achieve a suitable C-factor?

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Estimates of Soil Loss

Estimates of soil loss helps to:

- Assess erosion hazard
- Identify measures to overcome erosion risk
- Compare effectiveness of erosion control measures
- Estimate capacity of sediment basins

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RUSLE

Equation:

$$A = R \times K \times LS \times P \times C$$

Where:

- A = Computed soil loss (tonnes/ha/year)
- R = rainfall erosivity factor
- K = soil erodibility factor
- LS = slope length/gradient factor
- P = erosion control practice factor
- C = ground cover and management factor

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RUSLE

Limitations:

- Only predicts sediment entrained by erosion
- Predicts average annual soil loss, not soil loss for one storm event
- Effective for sheet and rill erosion on slopes <300 metres but not concentrated flow or long slopes
- Does not adequately take into consideration dispersibility in K-factor

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RUSLE

We can now calculate the soil loss using the values given as examples

Equation:

$$A = R \times K \times LS \times P \times C$$

$$A = 4{,}000 \times 0.025 \times 0.71 \times 1.2 \times 1.0$$

$$A = 85.20 \text{ tonnes/ha/year}$$

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Discussion

Which of the previous erosion factors can be readily manipulated to reduce the erosion hazard on your construction site, and how?

- Rainfall, soil type – NO
- Slope length, cover type - Possible
- Conservation practice – YES

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RUSLE

Now calculate the soil loss with improved management practices used in the examples

Equation:

A = R x K x LS x P x C

A = 4,000 x 0.025 x 0.44 x 0.9 x 0.45

A = 17.82 tonnes/ha/year

or, if grass cover is 50% after 20 days

A = 4,000 x 0.025 x 0.44 x 0.9 x 0.15

A = 5.94 tonnes/ha/year

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Conclusion

We can make a significant difference to the erosion risk of projects by carefully managing those factors that we can control

In this case we reduced the computed soil loss initially from:

A = 85.20 to 17.82 tonnes/ha/year

And after 20 days to:

A = 5.94 tonnes/ha/year

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