# What's in the "Blue Book"?

*Sediment Basin and Channel Design*

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## Sediment Basin Selection

- Sediment basin test
- If required, consider location(s)
- Basin design criteria
- Basin maintenance requirements
- Basin design depends on sediment type
- Different basin designs and maintenance regimes for Types C, F and D basins
- BB Reference Section 6.3.3

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## Purpose

- Collect sediment-laden stormwater runoff and retain pollutants
- Probably the most effective of all sediment control devices due to their large water and sediment storage capacity
- Generally used on larger (>2,500m$^2$ construction sites)
- Types C and F (non-dispersive) and D (dispersive)

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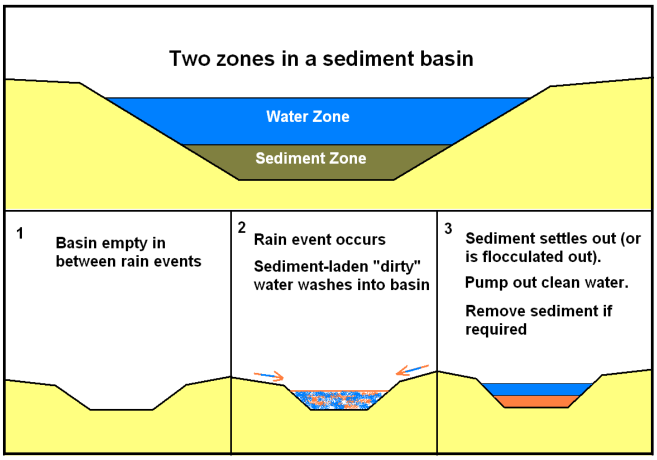


## Sediment Basin Design Criteria

- Settling zone (Type D) = 10 x Cv x A x R, where:
  - Cv = (Volumetric runoff coefficient) (proportion of rainfall that runs off catchment as stormwater) – typically 0.5 for Australian sites
  - A = catchment area of basin (ha)
  - R = design rainfall depth (mm)
- Storage (soil) zone design = 50% of settling volume or 2 months soil loss (RUSLE)

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## Example – Wet basin

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## Mine Site problem

- Construction of an equipment storage and maintenance hardstand at Dubbo site
  - Total Catchment Area = 1.5ha
  - Disturbance Area = 1.0ha (200m x 50m)
  - R (2,000) K (0.045) P (1.3) C (1.0)
  - Average annual soil loss = 240 t/ha/year
  - Average slope = 8% (13:1) 80m
  - Sediment type = 'D' (dispersible)
  - Hydrologic group = C (fine clay)

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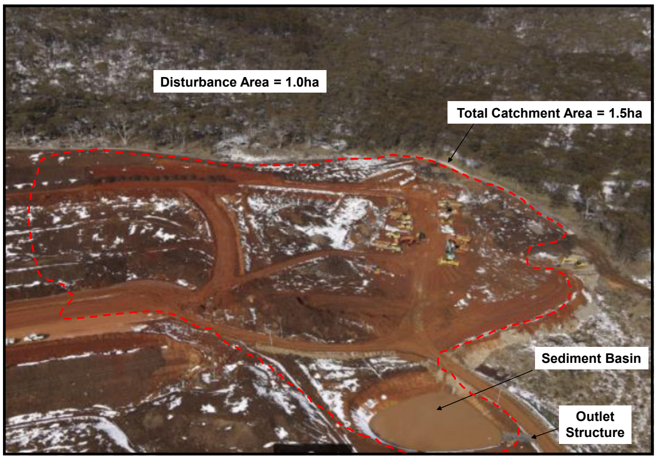


## Settling Zone capacity – Type D/F basins

BB Reference Table 6.3 (pages 6-24 and 6-25) and Appendix L (spreadsheets)

- 5 day, 75$^{th}$ percentile is default design parameter
- 80$^{th}$ percentile for highly sensitive receiving waters, OR where rehabilitation to take longer than 6 months
- 85$^{th}$ percentile (or higher) if receiving waters are highly sensitive AND rehabilitation to take longer than 6 months

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## Design Rainfall depth

*Table 6.3a 75th, 80th, 85th, 90th and 95th-percentile 2 and 5-day rainfall depths for 59 sites in New South Wales*

| Location | 2-day rainfall depths (mm) | | | | | 5-day rainfall depths (mm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 75th %ile | 80th %ile | 85th %ile | 90th %ile | 95th %ile | 75th %ile | 80th %ile | 85th %ile | 90th %ile | 95th %ile |
| **Northern Tablelands and Northwestern Slopes** | | | | | | | | | | |
| Armidale | 12.4 | 15.2 | 19.3 | 25.0 | 35.3 | 19.8 | 24.1 | 29.2 | 37.4 | 52.9 |
| Gunnedah | 14.2 | 17.3 | 21.3 | 27.7 | 39.2 | 20.0 | 24.1 | 30.2 | 38.4 | 53.0 |
| Tamworth | 15.2 | 18.3 | 22.2 | 27.7 | 39.6 | 21.6 | 25.2 | 30.8 | 39.2 | 54.2 |
| Tenterfield | 18.8 | 22.3 | 26.7 | 33.8 | 46.0 | 26.7 | 31.4 | 38.1 | 47.4 | 63.3 |
| **Central Tablelands and Central Western Slopes** | | | | | | | | | | |
| Bathurst | 10.7 | 13.2 | 16.5 | 21.4 | 30.4 | 16.8 | 20.6 | 24.9 | 31.4 | 43.7 |
| Cowra | 12.0 | 14.7 | 18.0 | 22.9 | 32.8 | 18.1 | 21.6 | 26.1 | 32.5 | 44.9 |
| Dubbo | 12.7 | 16.0 | 20.2 | 26.1 | 36.0 | 18.8 | 22.8 | 28.4 | 35.6 | 50.7 |



## "Coefficient of Runoff"

- "C" is a calibration term
- Each term only suitable on catchment of similar characteristics to those from which it was derived
  - $C_v$ = Volumetric Runoff coefficient
  - $C_{10}$ = 'Peak' Flow Runoff coefficient
- Based on 'soil hydrologic group' and 'design rainfall' Blue Book Reference Appendix F



## "Coefficient of Runoff"

*Table F2. Runoff coefficients (Cv) for volumetric data in disturbed catchments (adapted from USDA, 1996)*

| Soil Hydrologic Group | Design Rainfall depth (mm) | | | | | | | Runoff potential |
|---|---|---|---|---|---|---|---|---|
| | <20 | 21-25 | 26-30 | 31-40 | 41-50 | 51-60 | 61-80 | |
| A | 0.01 | 0.05 | 0.08 | 0.15 | 0.22 | 0.28 | 0.37 | very low |
| B | 0.10 | 0.19 | 0.25 | 0.34 | 0.42 | 0.48 | 0.57 | low to moderate |
| C | 0.25 | 0.35 | 0.42 | 0.51 | 0.58 | 0.63 | 0.70 | moderate to high |
| D | 0.39 | 0.50 | 0.56 | 0.64 | 0.69 | 0.74 | 0.79 | high |

## Mine Site problem – solution

- Design Criteria:
  - Design rainfall depth = 5-day, 75th percentile (Dubbo) = 18.8mm
  - R-factor = 2,000 (nominated)
  - Volumetric runoff (Cv) = 0.25 (mod-high)
- Design Solution:
  - Settling zone (Type D) = 10 x Cv x A x R
    = 10 x 0.25 x 1.5 x 18.8 = 70.5m$^3$
  - Storage Zone = 36m$^3$ (or 46m$^3$)

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## Maintenance

- Pump out wet basins after sufficient settling time / flocculation has occurred, to restore design capacity in time for the next storm
- Inspect / test the quality of outlet waters to assess performance
- Remove sediment once the sediment storage zone is full
- Regularly check the integrity of the basin, particularly inlet/outlet structures, and repair any damage

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## Channel Design

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## Channel Design

- Drainage channels (catch drains, table drains, slope drains, diversion banks etc.) are an important tool for managing both clean and dirty water in and around construction sites
- Critical design characteristic for channel is 'design discharge' or "Q"

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## Channel Design Criteria

- All 'waterways, drains, spillways and their outlets' should be constructed to be stable:
  - In the 10-year ARI time-of-concentration storm event (default)
  - The 5-year ARI (1 in 5) event may be used when duration of use is <12 months (with appropriate stabilisation)

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## Design Discharge "Q"

- The estimated 'peak' discharge ($m^3$/sec) for a given storm ARI (Y)
- ARI – Average Recurrence Interval
- For example, $Q_{10}$ is the peak discharge from a 1 in 10 year design storm event
- "Q" can be estimated many ways

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## Design Methods

- Complex numerical models:
  - DRAINS
  - RORB
  - RAFTS
- The 'Rational Method' – simple empirical formula, 50-200% of real values, but tends to overestimate.
- OK for temporary structures

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## "Rational Method"

- Uses key hydraulic parameters to estimate peak discharge Q=CIA/360

Where:

- Catchment Area – (A) (ha)
- Design Rainfall Intensity – (I) (mm/hr)
- Coefficient of Discharge – ($C_{10}$)
- Critical Storm duration – ($t_c$) (mins)

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## Catchment Area (A)

- "A" is the effective catchment area upstream of the point of interest (i.e. discharge point)
- Should be calculated for each sub-catchment area feeding to individual structures
- Remember to divert all unnecessary water

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## Design Rainfall Intensity (I)

- "I" is compound function for a given storm duration ($t_c$) and storm frequency (Y)
- Typically selected from Intensity-Frequency-Duration (IFD) charts developed for specific locations
- Design storm selection is task specific

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## Time of Concentration ($t_c$)

- "$t_c$" is the theoretical time required for runoff to flow from the furthest part of the sub-catchment to the point of interest (where discharge is being calculated)
- Determines the shortest storm duration that will contribute flow from the whole sub-catchment at one time
- Can determine from tables/graphs

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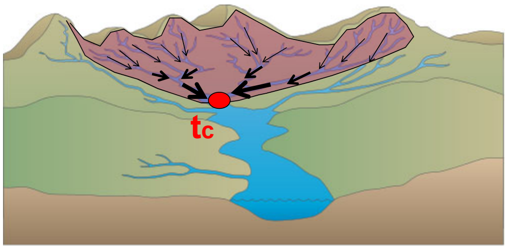
## Time of Concentration

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## Time of Concentration

- Can be calculated by formula:

  $t_c$ (hrs) = 0.76 x (A x 100)$^{0.38}$
- For Urban Areas, either reduce rural $t_c$ values by 50% or undertake detailed calculations:
  - Sheet flow estimate
  - Kerb flow estimate
  - Pipe flow estimate
  - Channel flow estimate

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## Design Application

- Assume we are to design a temporary catch drain to collect and transfer 'dirty water' from a 1.5ha compound area to the sediment basin
- The sub-catchment is heavily disturbed
- Assume the drain will be used throughout the 18-month construction period

What is the Design Storm Event (Y)?

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## Design Storm Event (Y)

- "Y" is a fictitious, isolated storm event of varying frequency and duration
- Selection based on the expected design life of the structure, typically:

| Drainage Structure | Design Life (months) | | |
|---|---|---|---|
| | <12 | 12-24 | >24 |
| Catch drains, flow diversion berms etc. | 1 in 5 year | 1 in 10 year | 1 in 10 year |

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Peabody

What's in the "Blue Book"?

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## Design Application

- Assume the catchment is highly compacted, with slopes between 2-5% and the distance from the furthest point to the discharge location is <50m

What is the Time of Concentration ($t_c$)?

- ~9 minutes (estimated)

What is the average rainfall intensity for the design storm duration?

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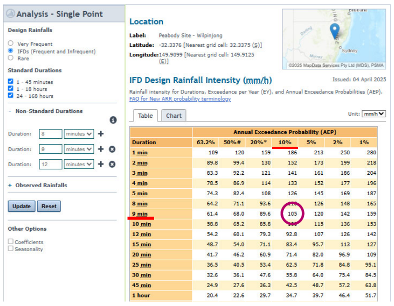
## Design Storm Duration/Intensity




| | Annual Exceedance Probability (AEP) | | | | | | |
|---|---|---|---|---|---|---|---|
| Duration | 63.2% | 50%# | 20%* | 10% | 5% | 2% | 1% |
| 1 min | 109 | 120 | 159 | 186 | 213 | 250 | 280 |
| 2 min | 89.8 | 99.4 | 130 | 152 | 173 | 199 | 218 |
| 3 min | 83.3 | 92.2 | 121 | 141 | 161 | 186 | 204 |
| 4 min | 78.5 | 86.9 | 114 | 133 | 152 | 177 | 196 |
| 5 min | 74.3 | 82.4 | 108 | 126 | 145 | 169 | 187 |
| 8 min | 64.2 | 71.1 | 93.6 | [illegible] | 126 | 148 | 165 |
| 9 min | 61.4 | 68.0 | 89.6 | 105 | 120 | 142 | 159 |
| 10 min | 58.8 | 65.2 | 85.8 | [illegible] | 115 | 136 | 153 |
| 12 min | 54.2 | 60.1 | 79.3 | 92.8 | 107 | 126 | 142 |
| 15 min | 48.7 | 54.0 | 71.1 | 83.4 | 95.7 | 113 | 127 |
| 20 min | 41.7 | 46.2 | 60.9 | 71.4 | 82.0 | 96.9 | 109 |
| 25 min | 36.5 | 40.5 | 53.4 | 62.5 | 71.8 | 84.8 | 95.1 |
| 30 min | 32.6 | 36.1 | 47.6 | 55.8 | 64.0 | 75.4 | 84.5 |
| 45 min | 24.9 | 27.6 | 36.3 | 42.5 | 48.7 | 57.2 | 63.8 |
| 1 hour | 20.4 | 22.6 | 29.7 | 34.7 | 39.7 | 46.4 | 51.7 |

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## Coefficient of Discharge

*Table F3 Runoff coefficients (C10) for peak flow data in disturbed catchments*

| Soil Hydrologic Group | Rainfall intensity (mm) in the design storm | | | | | | Runoff potential |
|---|---|---|---|---|---|---|---|
| | <20 | 21-40 | 41-60 | 61-80 | 81-100 | >100 | |
| A | 0.20 | 0.37 | 0.55 | 0.64 | 0.68 | 0.75 | very low |
| B | 0.46 | 0.58 | 0.70 | 0.75 | 0.78 | 0.82 | low to moderate |
| C | 0.69 | 0.76 | 0.83 | 0.85 | 0.86 | 0.88 | moderate to high |
| D | 0.80 | 0.86 | 0.89 | 0.90 | 0.90 | 0.90 | high |

- Enter this value into the BB design spreadsheet (Flow Calculations)

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## Design Solution

- Now we can solve for the peak discharge in the 1 in 10 year ($Q_{10}$) event, remembering:
- Q = C.I.A / 360 ($m^3$/sec)
- Q = (0.88) x (105) x (1.5) / 360
- Q = 0.385 $m^3$ per second or (385 L/sec)

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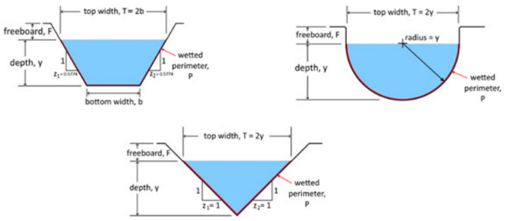
## Channel Geometry

- Multiple channel forms common, trapezoidal most efficient

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## Open Channel Flow

- In simple form velocity (V) can be calculated as:

  V (m/sec) = Q ($m^3$/sec ÷ cross-sectional flow area)
- Flow velocity (V) in a constructed channel can be calculated using Manning's equation:

  $$V\ (m/sec) = 1/n \times R^{2/3} \times s^{1/2}$$
- Where:
  - n = Manning's roughness coefficient
  - R = channel hydraulic radius
  - S = channel slope (%)

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