

**Report**



Name

Location, Year

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# Introduction

It is now widely accepted that in arid regions, recharge occurs mainly indirectly (Hendricks & Walker 1997), i.e. via leakage from ephemeral streams. Originating in regions with higher rainfall – mountain areas of climatically different headwater basins – flash floods infiltrate into ephemeral channel beds. Stream flow characteristics

The Kuiseb River is an ephemeral stream that is dry for most of the year and sometimes even for whole years. Runoff is only generated in the upper part of the catchment. Only if the volume of runoff generated is large enough, it also reaches the Lower Kuiseb area without completely evaporating or infiltrating into the ground before. These so-called flash floods are relatively short and highly variable in size, duration and occurrence.



***Figure ‎3.1:*** *Hydrometric stations in the Kuiseb basin, from Morin et al. (2009) with their characteristics (rainfall, length, slope, width) per channel and rainfall per respective basin.*

Based on these data a first estimate of loss rates can be obtained. As shown in ***Figure ‎3.1*** the reaches between Gobabeb and Swartbank (e) and Swartbank and Roibank (f) have an average length of 30 and 33 km and respective widths of 68 to 74 m. The corresponding area is therefore 3\*104\*68=2.04E+06 m² or 2.04 km². If average flow durations of 10 days for Gobabeb, 5 days for Swartbank and 4 days for Roibank are assumed, the average loss rate per section can be calculated.

***Table ‎3.1:*** *Differences of flood volumes (Mm³). Grey fields- values are normalised to one kilometre*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Return period (a) | Schlesien- Gobabeb | Schlesien-Gobabeb per kilometre | Gobabeb -Swartbank | Gobabeb-Swartbank per kilometre | Swartbank -Roibank | Swartbank-Roibank per kilometre |
| 1,5 | 1,88 | 0,02 | 2,03 | **0,06** | 0,62 | **0,02** |
| 5 | 4,47 | 0,04 | 5,32 | 0,15 | 2,59 | 0,08 |
| 10 | 5,69 | 0,06 | 6,87 | **0,20** | 3,53 | **0,11** |
| 50 | 8,37 | 0,08 | 10,28 | 0,29 | 5,57 | 0,17 |
| 100 | 9,51 | 0,10 | 11,72 | **0,33** | 6,44 | **0,20** |
| > 100 | 13,26 | 0,13 | 16,48 | 0,47 | 9,30 | 0,29 |

It is already integrated and accounted for in the measured infiltration rates (Dahan et al. 2008), in routing models (Morin et al. (2009) and results obtained from volume differences (see ***Table ‎3.1***).

**References**

Hendrickx, M.H. & Walker, G.R. (1997): Recharge from precipitation. In: *Simmers, I. (Editor): Recharge of phreatic aquifers in (semi-) arid areas*, p. 21. Balkema, Rotterdam.

Hellwig, D. H. R. (1973): Evaporation of water from sand, 3: The loss of water into the atmosphere from a sandy river bed under arid climatic conditions. Journal of Hydrology, 18(3-4), 305-316.

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**Annex**

List of abbreviations and symbols:

|  |  |  |
| --- | --- | --- |
| 1-D |  | One-dimensional |
| 2-D |  | Two-dimensional |
| 3-D |  | Three-dimensional |
| DAFLOW |  | Diffusion analogy surface-water flow model |
| MODFLOW |  | Modular finite-difference groundwater flow model |
| m a.s.l. | [m] | Meters above sea level  |
| Q | [m³/s] | Discharge |
| x | [m] | Distance along channel |
| A | [m²] | Cross-sectional area |
| t | [s] | Time |
| u | [m/s] | Velocity |
| g | [m²/s] | Acceleration of gravity |
| y | [m] | Depth |
| Sf | [-] | Friction slope |
| So | [-] | Streambed slope |
| Df | [-] | Wave diffusion coefficient |
| Qs | [m³/s] | Flow under steady uniform conditions |
| C | [m/s] | Celerity of moving wave |
| A0 | [m²] | Average cross-sectional area at zero flow |
| B | [-] | Hydraulic geometry coefficient for area |
| C | [-] | Hydraulic geometry exponent for area |
| W | [m] | Top width of channel |
| E | [-] | Hydraulic geometry coefficient for width |
| F | [-] | Hydraulic geometry exponent for width |
| Kbe | [m/s] | Hydraulic conductivity of riverbed |
| Kaq | [m/s] | Hydraulic conductivity of aquifer |
| H or h | [m] | Head of aquifer |
| Be | [m] | Average elevation of riverbed |
| Bt | [m] | Thickness of streambed |
| Sep | [] | Seepage flow |
| V | [m³] | Volume |
| I | [m] | Additional change in aquifer head due to infiltration |
| Depth to WTable or DWT | [m] | Depth to water table |
| AqTh or AT | [m] | Aquifer thickness |
| Inf | [m³/s] | Rate of infiltration / rate of exfiltration |