Guideline for hydropedological Assessments and Minimum Requirements

Introduction

This guideline was developed by Prof Johan van Tol and colleagues all scientists in the field of hydropedological sciences. It culminated after various WRC and other research projects where DWS were involved at different levels. The authors of this document *Van Tol, J.J., Bouwer, D. & Le Roux, P.A.L., 2021* are at the cutting edge of the developments in the field of Hydropedology, all of them either from the University of the Free State (UFS) or previously from UFS. DWS had various interactions with the research team, even people not mentioned, and this eventually culminated in this approach where DWS as regulator can now adopt these methods of assessing the relevant aspects of hillslope hydrology that can influence decision making positively in a consistent and standardized method.

Background

Hydropedological surveys aim to characterise dominant surface and sub-surface flowpaths of water through the landscape to wetlands and streams or groundwater. The objective of these guidelines is to standardise hydropedological survey methodology to identify dominant hydrological drivers and responses of landscapes in order to quantify the impact of new development on water resources. This will assist decision makers to understand the hydrological system and thereby make sensible decisions with regards to sustainable water management. These guidelines were developed from numerous scientific and consultancy projects (van Tol, 2020) and are divided into four steps:

1) Identification of dominant hillslopes.
2) Conceptualising hillslope hydropedological responses.
3) Quantification of hydraulic properties and flowrates.
4) Quantification of hydropedological fluxes.

The first two steps should be conducted for any impact assessment requiring a hydropedological survey. Step 3 and 4 will typically be required where drastic land-use change or planned e.g. open-pit mining, large developments which will obstruct lateral flowpaths.

Guidelines

Step 1: Identification of the representative hillslope/s

- Identify land types (Land Type Survey Staff, 1972 – 2006) within the study area.
- Identify dominant hillslopes (from crest to stream) of the study area using terrain analysis.
    - There should be at least one hillslope in each land type of the study area.

- Hillslopes should be representative of the topography (e.g. slope, aspect and curvature) and land types.
    - For example, where the site is divided by a stream, a representative hillslope should be identified on both sides of the stream.

Step 2: Conceptualize hillslope hydropedological responses

Transect survey

- Transect soil survey should be conducted on each of the identified hillslope (Le Roux et al., 2011).
- Soil observations should be made at regular intervals, not exceeding 100 m, on the transect.
- Profile pits of representative soil forms should be opened to proper description, photographs and collection of undisturbed samples.
- Observation depth should be until refusal. Where the soil depth exceed 2 m, auger observations must be made in the bottom of the pit in order to describe soil/saprolite/bedrock transition.

Soil description and classification

- Soils should be described and classified in accordance with the South African Soil Classification system up to family level (Soil Classification Working Group, 2018).
- The following morphological properties should be described:
    - Thickness of horizons
    - Structure (size, grade, type)
    - Estimated texture
    - Matrix Munsel colour (moist and dry)
    - Mottles (colour, size, frequency, prominence and type)
    - Concretions (colour, size, frequency, prominence and type)
    - Precipitaion of carbonates, gypsum or salts
    - Roots (abundance)
    - Macropores (frequency and size)
    - Nature of transition between horizons/bedrock/saprolite
- Profile should then be regrouped into one of the seven hydropedological groups (van Tol & Le Roux, 2019).

Conceptual hillslope hydropedological response

- The occurrence, sequence and coverage of the different hydropedological groups on a transect must then be used to describe the hydrological behaviour of the hillslope (van Tol et al., 2013).
- This will include a graphical representation of the dominant and sub-dominant flowpaths at hillslope scale prior to development. This will include:

    - Overland flow
    - Subsurface lateral flow
    - Bedrock flow and
    - Return flow
    - Storage mechanisms
- The impact of the proposed development on the hydropedological behaviour should also be graphically presented. This should typically include the location of the development on the hillslope and the anticipated impact of the development on water flows.

Step 3: Quantification of hydraulic properties and flowrates

- From the transect survey (step 1 and 2) representative soil forms and horizons should be identified.
- Soil physical/hydraulic properties should then be measured for representative horizons using standard procedures. This should include (but is not limited) to:
    - Particle size distribution
    - Porosity/bulk density
    - Conductivity/permeability
- Measurements should then be related to the conceptualised hydropedological response model to provide a quantitative description of flowrates and storage.

Step 4: Quantification of hydropedological fluxes

- Hydropedological fluxes of water before and after development can be quantified using:
    i. Long term hydrometric measurements
    or
    ii. Modelling/simulations of the hydropedological response
- When the fluxes will be quantified using modelling, it is important that selected model is capable of reflecting hydropedological processes (especially lateral fluxes) at hillslope scale. Suggested models are
    - SWAT+ (Bieger et al., 2017; van Tol et al., 2020a).
    - Catchment Modelling Framework (Kraft et al., 2011; van Tol et al., 2020b).
    - Hydrus 2/3D for small hillslopes (Simunek et al., 2006; van Zijl et al., 2020).
- Model should be configured using the actual soil distribution and parameterized using measured properties (step 3) under realistic climatic scenarios.
- Model runs should include a pre-development set-up (baseline) as well as one or more runs where the proposed development is included in the model configuration (post-development).
    - Post-development modelling should preferably consider more than one scenario such as different size buffers or more than one developmental layout.

- Model outputs that should be considered and compared to the baseline include (but not limited to):
  - Impact on streamflow
  - Impact on wetland water regimes
  - Impact on lateral flow to the wetland
  - Impact on overland flow and associated risk of water erosion.

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