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Groundwater Vulnerability, Hazard and Risk Mapping for Present and Future Land Use Management of Canadian Armed Forces Bases

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The discovery of the impact of training activities on groundwater (GW) quality at Camp Edwards (Massachusetts, USA) has initiated a large scientific effort to predict groundwater alteration by military training activity. In order to reduce the impact of military training on GW resources around training areas, scientific support is needed for decision making to insure sustainable land-use. A conceptual framework for an integrative GW vulnerability and risk assessment is presented and applied to a case study at Canadian Armed Forces Bases. The conceptual framework combines mapping and modeling approaches which take into account: (i) the GW vulnerability and (ii) the estimated hazard of training activities.

The GW vulnerability is based on (i) Downward Advective Travel time (DAT) of infiltrating water through the unsaturated zone below source zones and (ii) the advective horizontal travel time within the aquifer between the source zones and the receptors. The thickness of the unsaturated zone used in DAT is calculated as difference between soil surface elevation based on LIDAR data and a hydraulic head map of the first aquifer meet. A three-dimensional (3D) geological modeling software (gOcad) was used to take into account geological units in the estimation of DAT and to provide the base for GW flow modeling with the Feflow software. The parameters for DAT calculations and hydrogeological modeling are the effective porosity, hydraulic conductivity in unsaturated and saturated conditions and recharge that were obtained from field data and laboratory measurements. The calculated GW vulnerability indexes are grouped into five classes extended from very low to very high. In conclusion, the combined travel times within the unsaturated zone and the aquifer provide a quantitative estimation of the spatial variability of the GW vulnerability.

The hazard map (ii) is based on characteristics of the ranges (e.g. their size), the mass of ammunition residues deposited, (number of fired ammunition and dud rate or propellant deposition rate and ammunition composition) and the environmental dangerousness (e.g. toxicity, solubility, degradation parameters). As for the vulnerability, obtained values for hazard are grouped in five categories going from very low to very high.

As a final step, the risk map is produced by performing a weighed summation of the hazard map and the GW vulnerability map and the obtained values are grouped into five classes going from very low to very high. With this combined information critical zones are visualized providing a valuable tool for decision making in present and future land-use management.

KEYWORDS: Aquifer vulnerability, hydrogeological modeling, regional planning