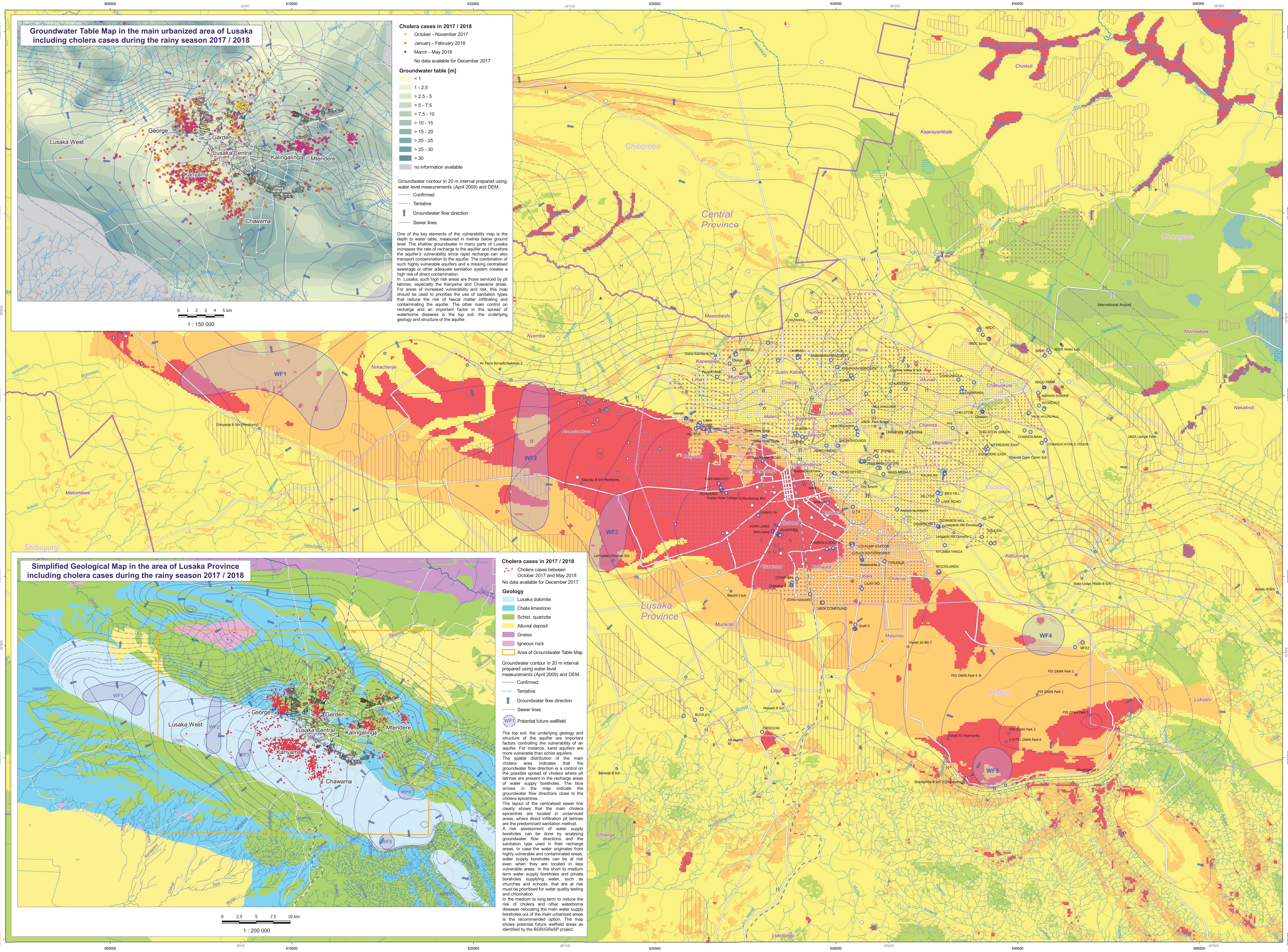
Groundwater Vulnerability Map of Lusaka Province / Zambia

Modified and partly updated, with additional information on waterborne diseases

german cooperation
DEUTSCHE ZUSAMMENARBEIT

WARMA Water Resources Management Authority

BGR Bundesanstalt für Geowissenschaften und Rohstoffe



One of the key elements of the vulnerability map is the depth to water table, measured in metres below ground level. The shallow groundwater in many parts of Lusaka increases the rate of recharge to the aquifer and therefore the aquifer's vulnerability since rapid recharge can also transport contamination to the aquifer. The combination of such highly vulnerable aquifers and a missing centralised sewerage or other adequate sanitation system creates a high risk of direct contamination.

In Lusaka, such high risk areas are those serviced by pit latrines, especially the Kanyama and Chawama areas. For areas of increased vulnerability and risk, this map should be used to prioritise the use of sanitation types that reduce the risk of faecal matter infiltrating and contaminating the aquifer. The other main control on recharge and an important factor in the spread of waterborne diseases is the top soil, the underlying geology and structure of the aquifer.

The top soil, the underlying geology and structure of the aquifer are important factors controlling the vulnerability of an aquifer. For instance, karst aquifers are more vulnerable than schist aquifers.

The spatial distribution of the main cholera area indicates that the groundwater flow direction is a control on the possible spread of cholera where pit latrines are present in the recharge areas of water supply boreholes. The blue arrows in the map indicate the groundwater flow directions close to the cholera epicentres.

The layout of the centralised sewer line clearly shows that the main cholera epicentres are located in unserviced areas, where direct infiltration pit latrines are the predominant sanitation method.

A risk assessment of water supply boreholes can be done by analysing groundwater flow directions and the sanitation type used in their recharge areas. In case the water originates from highly vulnerable and contaminated areas, water supply boreholes can be at risk even when they are located in less vulnerable areas. In the short to medium term water supply boreholes and private boreholes supplying water, such as churches and schools, that are at risk must be prioritised for water quality testing and chlorination.

In the medium to long term to reduce the risk of cholera and other waterborne diseases relocating the main water supply boreholes out of the main urbanised areas is the recommended option. The map shows potential future wellfield areas as identified by the BGR/GReSP project.

VULNERABILITY OF GROUNDWATER

The numbers in brackets express the final values of the PI vulnerability index.

- Extreme (0-1)
- High (>1 - 2)
- Moderate (> 2 - 3)
- Low (> 3 - 4)
- Very low (> 4 - 5)

AREA WITH INCREASED RISK OF GROUNDWATER QUALITY DETERIORATION

Sanitation system
- Pit latrine
- Septic tank
- Sewer system
- T Trickling filter
- S Stabilization pond

Landuse
- Industrial and commercial area
- Graveyard
- Landfill
- Commercial agriculture
- Q Quarries

Explanation:

The vulnerability classes were derived in 2011 using a modified version of the PI method (Goldschneider, 2002). The classification was based on raster cells with an extent of 91.1 m x 91.1 m for a scale of 1:75 000 (Nick, 2011).

The PI method was developed to reflect characteristics of both karstic and non-karstic aquifers and considers the P- and the I-Factor. The P-Factor describes the effectiveness of the protective cover resulting mainly from the thickness and hydraulic properties between the surface and the groundwater table. Categorized influence factors for topsoil water storage capacity, recharge, subsoil, lithology, fracturing as well as the artesian pressure are taken into account. The I-Factor characterises the infiltration conditions, particularly the degree to which the protective cover can be bypassed due to lateral surface and subsurface flow. It is classified depending on the depth to a low permeability layer, dominant flow process, saturated hydraulic conductivity, land use, slope and surface catchment type.

The groundwater vulnerability, which is grouped in five classes, results from the multiplication of the P- and the I-Factor. The Lusaka Dolomite Aquifer is classified as the most vulnerable area mainly due to very thin soil cover, high groundwater tables and fast groundwater transport. Yet also in areas with moderate vulnerability groundwater quality can deteriorate because of unsafe onsite sanitation options. Areas of high anthropogenic risks are therefore marked in the map. In general, it has to be considered that at local level the vulnerabilities only present approximations due to the map scale. Especially in the urban center of Lusaka, conditions are constantly manipulated (e.g., by removal of soil cover, quarrying), causing changes in the vulnerability assessment. Further, the PI method considers contaminations emanating from the surface. Potential pollution sources located underground (e.g., septic tanks, leaking sewer lines) present stronger threats to groundwater quality than indicated in the map.

GROUNDWATER FEATURES

- Spring perennial
- Spring intermittend or seasonal
- Chawama Monitoring borehole

Public water supply of the Lusaka Water and Sewerage Company (LWSC)

- CHELSTON Operational production borehole of LWSC
- WF1 Potential future wellfield

HYDROLOGY

- Reservoir
- Pond
- Dambo (Type of shallow wetland)
- Swamp
- Large river with perennial / seasonal or intermittent runoff
- River or stream with perennial / seasonal or intermittent runoff
- Stream or creek with perennial / seasonal or intermittent runoff
- Small stream or creek with seasonal or intermittent runoff
- Groundwater flow direction

Piezometric surface (April 2009), contour line in meters [a.s.l.], contour interval 50 m
- Validated
- Tentative

TOPOGRAPHY

- Village
- Mission, agricultural station
- Research institute
- Basic school
- H Health facility
- Airport runway area
- Railway
- Kafue District boundary
- Lusaka Province Provincial boundary
- Contour line in meter [a.s.l.], 20 m interval
- Nyemba Ward
- Major road

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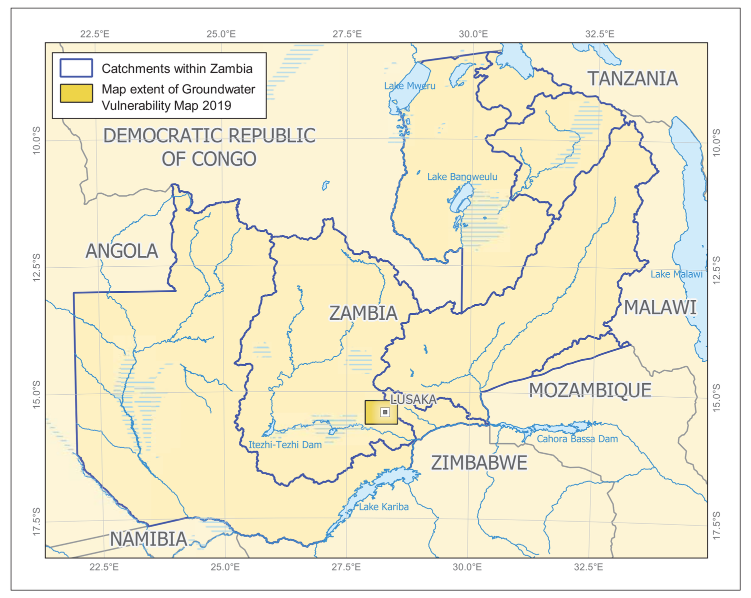
Wards: Central Statistical Office of Zambia (http://www.zamstats.gov.zm)
Sewer Lines & Production Boreholes: Lusaka Water and Sewerage Company Limited (LWSC)
Potential wellfields: Kang'omba and Bäumle (2013)
Cholera data: Zambia National Public Health Institute, Right to Care Zambia

Download BGR references at www.bgr.bund.de/zambia-lusaka-vm

Geometry: Transverse Mercator Projection Zone 35; Spheroid Modified Clarke 1880 (Arc1950)



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