WRA Bulletin 67

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UK WORK

Quantum Gravimeter Trials for Groundwater Survey and Monitoring

WRA was commissioned to review the application of gravimetry in groundwater and to set up field-trials of a new quantum gravimeter for use in groundwater survey and monitoring in the Thames valley.

M-Squared Lasers Ltd developed a quantum gravimeter in 2021 for subsurface mapping, and Oxfordshire County Council Innovation Hub [OCC] required WRA's support in evaluating its potential use in groundwater survey and monitoring. Demonstration of the prototype was required through field trials and groundwater level measurement.

Working with Andy Dixon at GMD and Dr Andres González-Quirós at BGS, Paul Holmes investigated three locations offering suitable layouts of production wells and boreholes with 37 years of data, associated with sand and gravel extraction in the Upper Thames between Lechlade and Oxford. Stonehenge Farm at Standlake was selected for trials, with Cassington and Gill Mill Quarries as alternative options. Private wells were surveyed prior to trials, and borehole data were kindly made available by Hansons Aggregates.

Piezometers and Well Monitoring at Stonehenge Farm

The improvement of precision in the second prototype to 10 µGal positioned the instrument among, or above, other commercial absolute gravimeters used in field applications in geophysics. Viability of the instrument was dependent on off-road mobility, data acquisition procedure, stabilization, measuring time & positioning. These aspects were explored during the field trials.

The final report reviewed published use of microgravity measurements in groundwater applications, mainly relating to water level changes and aquifer storage variation with different spatial and temporal scales.

The new quantum gravimeter addresses the need for greater precision [<10µGal] for use in hydrogeology where gravity changes are in the order of 1 to 100 µGal.

Gravity data may in future be used to complement hydrological information to reduce uncertainty and provide parameter estimates for numerical models, filling in gaps from borehole-derived data.

Microgravity Data Acquisition with a Scintrex CG-5 during an aquifer test at source Abstraction Borehole

Beaumont Creek V-Notch, Suffolk

WRA installed staff gauge and InSitu Troll-100 loggers at a V-Notch weir in Beaumont Creek adjacent to a winter storage reservoir near Harkstead, Suffolk. This formed part of compliance with licence conditions to identify conditions when abstraction may occur.

Stream valley mapping was done using LiDAR data and WINFAP5 software was used to obtain flood frequency curves and water level range at the V-Notch weir. The catchment area is 5.23 km^2, mean annual rainfall 552 mm and 100-year peak flow 0.75 m^3/s, rising to 0.85 m^3/s with 13% climate change factor.

The client was given training and demonstration of the use of Win-Situ software.

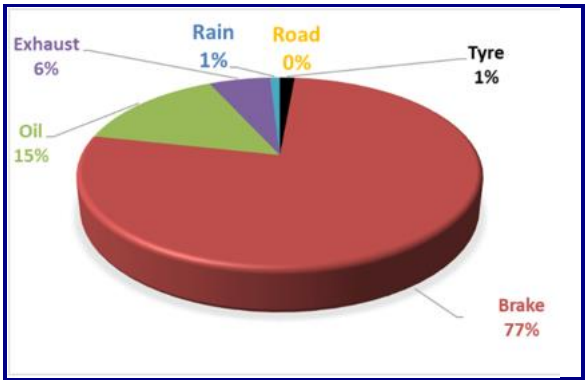
The job also involved levelling between the V-Notch and abstraction intake to determine the flow depth at which pumping can start. A temporary wooden flume was placed in the stream to allow low flow gauging, as the stream has a high Baseflow Index of 0.66 to 0.72, indicating the importance of groundwater contribution.

Staff Gauge and Stilling Tube on upstream wingwall, with 90 degree V-Notch plate removed

OVERSEAS WORK

Source of Metals in European Sewage Treatment Plants

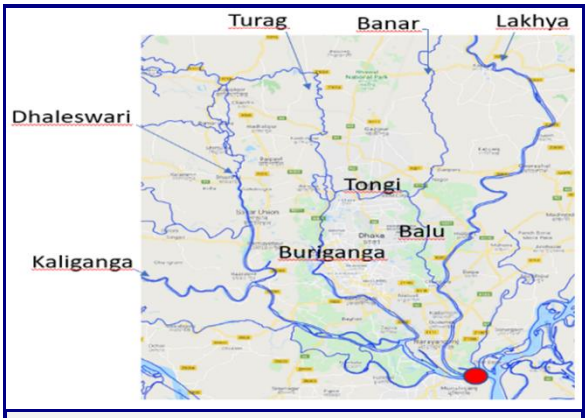
A project undertaken by Prof Sean Comber has focused on delivering an understanding of metals (Al, As, Ag, Cd, Cu, Mo, Ni and Zn) into wastewaters which are attributable to different urban sources. The significance of background levels was also assessed as well as assessing the fate of metals during sewage treatment. Sources were split into domestic (mains tap water, faeces, urine and other sources including plumbing and activity-related discharges), urban runoff (brake, tyre and road abrasion, exhaust emissions and oil loss and atmospheric deposition), service industry discharges, industrial emissions. Key specific sources included copper from brake lining abrasion, zinc in vehicle tyre abrasion, Significant variations were observed between countries depending on for example patterns of use of copper in plumbing and architecture and metals from industrial discharges tending to be more significant in eastern Europe. For many of the other elements the distribution of emissions between the sources was more evenly distributed reflecting their ubiquitous presence within the urban environment.



An example of the breakdown of molybdenum for runoff from urban areas in Germany

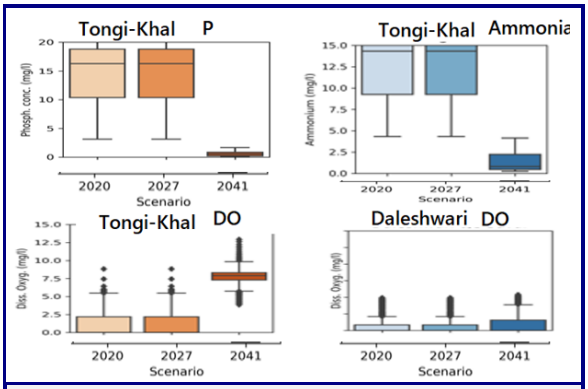
Modelling Dhaka River Systems for Pollution Control

As part of the WRA-Oxford REACH programme, https://reachwater.org.uk/ , a major modelling study of flow and water quality has been undertaken on the Multiple River Systems in Dhaka, Bangladesh, by Paul Whitehead, Gianba Bussi, Li Jin and colleagues in Bangladesh. A new version of the INCA Phosphorus, Sediments, Ecology, DO/BOD model has been applied to the river system, together with models on nitrate, ammonium, pathogens, and metals. The new version of the INCA software package has been built on the existing INCA framework code written in C++ language with links to all the INCA graphics systems and editing systems so that scenarios can be evaluated. The models have been calibrated using a five-year water quality data base developed by the Professor Abed Hossain at the Bangladesh University of Engineering and Technology (BUET) and Oxford Labs.



Map of the Dhaka Rivers modelled using INCA

The model has been used to evaluate a major clean-up program involving the construction of 12 new STPs. The results of the clean-up, as estimated by the model for 2027 and 2040 are shown below, indicating lower phosphorus and ammonia in many reaches, and higher DO. However, very low DO is shown in certain reaches downstream of hotspots. There are also problems with high metal concentrations downstream of Tanneries.



Impacts of STPs Construction to 2027-2040- results for Phosphorus, Ammonia and DO

Partner/Associate News

New WRA Associate – Dr Cordelia Rampley.

Cordelia Rampley has joined WRA as an associate after 2 successful projects applying biosensor technology in a new European Space Agency Project (see next bulletin) and in the Oxford REACH project in Bangladesh. Cordelia has great skills in microbiology, water quality and data analysis and has worked with Paul Whitehead to apply the biosensors to monitor water Toxicity in UK, China and Bangladesh.

The WRA Bulletin is a quarterly publication, and relies on contributions submitted by Partners, Associates and Consultants. The document is circulated by email, and published on the WRA web-site, aiming to keep the WRA network up-to-date with respect to current activities. Please email contributions for future issues to Paul Whitehead: paul.whitehead@watres.com

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