



# Tellus Border and West Stream Water Data Analysis and Interpretation



Geological Survey Ireland is a division of the Department of the Environment, Climate and Communications

# Executive summary

Baseline geochemical analysis of stream water samples, collected from streams in the northern and western regions of Ireland, has been completed as part of the Tellus programme.

Data analysis has been carried out to explore spatial and statistical patterns in the data relating to geology and human activity. Univariate and multivariate analysis techniques, including Exploratory Data Analysis, Principal Component Analysis, Cluster Analysis and Random Forests have been undertaken and they demonstrate that there are coherent geochemical patterns related to underlying bedrock geology, subsoil composition and the influence of agriculture on water quality. The findings are relevant for the assessment of substances of concern in the environment, including Specific Pollutants, Priority Substances and nutrients. They also show that stream water chemistry has the potential to be employed in mineral exploration.

#### **Geological signature**

The geochemistry of stream waters reflects the contact that the water has with geological materials (soil, rock, sediment) as well as inputs from precipitation, groundwater and human activities. The Tellus survey targets first- and second-order streams, i.e. small up-catchment tributaries, and they are sampled during the drier summer months. As such, their chemical composition is considered to be influenced primarily by geology, i.e. bedrock and subsoil, since the sampling sites are typically upstream of significant human influences such as industry and urban environments. Multivariate analysis techniques show that there are strong associations between specific element assemblages in water geochemistry and particular rock and subsoil types, most notably limestone and granite, and tills derived from those rocks.

#### Nutrients

Data analysis shows that areas of intensive crop cultivation are characterized by higher nitrate and phosphorus concentrations than areas of other land uses. The median nitrate concentration for Tellus stream water draining arable land (21.2 mg/L) is over 18 times higher than for pastureland (1.19 mg/L) and almost 80 times higher than for other land uses. Similar, if less stark, distinctions were observed for phosphorus. Stream water draining well-drained soil had significantly higher concentration of both nitrate and phosphorus than stream water draining soil in other drainage classes. 4% of nitrate concentrations observed as part of this survey fall within the EPA's unsatisfactory category, compared to 47% of samples taken from larger watercourses as part of the EPA monitoring programme. Of these 'unsatisfactory' observations in the Tellus dataset, 96% occur in areas of agricultural land use, including pasture and arable types.

The association between agricultural activity and nitrate and phosphorus levels in stream waters is well known from EPA monitoring programmes. However, Tellus data provide a



more detailed picture of the impact of agriculture on water quality since the samples were collected from first- and second-order streams. They demonstrate that these impacts are pervasive, detectable even in the upper parts of catchments, with highest nutrient levels in areas of improved agricultural land (tillage and pasture).

### Potentially harmful substances

In Ireland national monitoring programmes coordinated by the Environmental Protection Agency aim to support the reduction or elimination of contamination of surface water by Priority Substances, Priority Hazardous Substances and Specific Pollutants as listed in the Surface Water Regulations 2009 (European Commission 2009). Substances listed that are also part of the Tellus stream water data set are arsenic (As), cadmium (Cd), chromium (Cr), copper (Cu), fluoride (F-), lead (Pb), nickel (Ni) and zinc (Zn).

The environmental quality standards (EQSs) for metals are specified in relation to different levels of water hardness and natural background concentrations. To date in Ireland, in the absence of regional data for water hardness and background concentrations, the most conservative EQSs have been applied by default. Here Exploratory Data Analysis is used to assist with the derivation of natural background concentrations for As, Cr, Cu and Zn. For As, the estimated background concentration is  $10 \ \mu g/L$ , for Cr 1.8  $\mu g/L$  and for Cu 10  $\mu g/L$ . In the case of Zn, the distribution is complex, reflecting its widespread dispersion in stream water across the region, and two threshold levels can be observed: one at  $6.5 \ \mu g/L$  and a second at  $34 \ \mu g/L$  that reflects widely dispersed samples in the 95-99<sup>th</sup> percentile range, which may be related to complexation by organic matter and mineralization, among other factors. Results indicate that there is good potential to use Tellus stream water data to compute background levels for relevant metals, allowing potential refinement of the EQSs at a national level when Tellus is complete.

The EQS values for Cd, Cu and Zn depend on the hardness of the water, reported as mg/L calcium carbonate (CaCO<sub>3</sub>). Calculated water hardness derived from the Tellus data appears to be of high importance in assessing exceedances of Zn EQS values. Without hardness data it is likely that the degree of Zn exceedance of the EQS will be significantly overstated where the lowest EQS value is used as part of a conservative approach. The review of Tellus data for Cd and Cu suggest that for these elements, application of water hardness data would have a more limited impact on EQS assessment. Tellus high-resolution baseline stream water data allow reliable mapping of water hardness in areas where water monitoring stations are sampled.

#### **Mineral exploration**

Stream water chemistry has attracted attention in recent years as a potential mineral exploration tool. This analysis explores the potential of the stream waters dataset to identify existing base metal (zinc, lead) deposit locations and predict sites that may be of mineral exploration interest.



Base metal anomalies are evident in the Tellus waters data in the vicinity of known mineral deposit localities, both exploited and unworked. Not all of these observed anomalies occur downstream of the mines and thus may be reflective of the presence of bedrock mineralization in the general area rather than representing contamination by mining. Although waters in peat areas are relatively depleted with respect to many elements, apparent anomalies of Zn and Cd in those areas may reflect enrichment following complexation within organic-rich subsoils and sediments. Anomalous concentrations linked with known mineralization generally have low organic carbon concentrations – an observation which may be useful for base metal mineral exploration strategies.

Mineralization signatures in stream water chemistry are not confined to base metals. Gold pathfinder elements As and antimony (Sb) are enriched in streamwaters draining known gold deposits in counties Donegal, Monaghan and Mayo. Comparison of maps for stream sediment and stream water indicate that stream water geochemistry may identify known base metal and gold mineralization as readily as stream sediment geochemistry.

In addition, at a time of increased exploration interest in Rare Earth Elements (REEs), the possibility of using stream water data as a geochemical tool for critical element exploration is assessed. REEs are not readily mapped in Tellus soils and stream sediments owing to relatively high detection limits achieved in analysis but the stream water data provide a first insight into the spatial distribution of these elements in Ireland.

## Conclusions

The nature of Tellus water samples, sampled at relatively high-density and collected upcatchment with minimal anthropogenic inputs, provides a unique opportunity to support the refinement of EQSs for certain metals and the use of waters data for mineral exploration in Ireland. This has been demonstrated for a limited region of Ireland and the methods used here may be extended to national coverage on completion of the Tellus survey.



3