TECHNICAL NOTE:

DATE:	01 July 2022	**CONFIDENTIALITY:**	Confidential
SUBJECT:	Spatone Hydrogeological Impact Assessment		
PROJECT:	70086304	**AUTHOR:**	Iain Storey
CHECKED:	Richard Cheal	**APPROVED:**	Angelo Papaioannou

INTRODUCTION

Context

Spatone produces liquid iron dietary supplements for customers globally. Operating since 2002, demand for the sachet product has increased steadily with annual production in 2020 totalling approximately 40 million sachets. Situated on the edge of the Snowdonia national park in North Wales, Spatone collects natural ferrous iron-rich water that emerges at the base of a steep glacially carved valley.

Up until 2019 Spatone was abstracting below 20 m^3/day with a range of between 11 – 17 m^3/day (8-12 lpm[1]), however following the installation of a new borehole, the abstraction potential has increased to over 20 m^3/day (13 lpm); with periods of high groundwater flow (generally coinciding with periods of very wet weather) resulting in over 36 m^3/day (>25 lpm) at the abstraction point. As part of the Water Act 2003 and outlined in Natural Resources Wales (NRW) guidance (NRW, 2022a), any abstractions within Wales that is above 20 m^3/day requires an abstraction licence from the regulatory body. Prior to 2017, Spatone was informed by NRW that groundwater abstractions within the Conwy catchment were exempt from these regulations. This exemption has now been lifted and following consultation with NRW, Spatone requires an abstraction licence for the production borehole.

Nelsons Spatone is currently processing the application for an abstraction licence with NRW, during initial discussions Spatone supplied NRW with the WSPs previously completed Catchment Assessment Report (WSP, 2022) as a supporting document to the pre-application. NRW responded to Nelsons Spatone indicating that the supporting documents needs to include more information on potential resource implications of the abstraction, assessing any potential impacts on local water features including potential connectivity with surface water features (Hydrogeological Impact Appraisal).

To address the comments by NRW and complete the gaps in the existing catchment assessment report, a Hydrogeological Impact Appraisal (HIA) has been undertaken. Nelsons Spatone, instructed WSP to undertake the technical aspects of the HIA for the abstraction licence process (which Spatone are otherwise completing directly).

Site location and source history

The site lies on the eastern boundary of the Snowdonia national park in Northeast Wales (SH 77817 65307) and immediately east of the River Conwy flood plain (**Figure 1**). The hills to the west of Spatone, comprising both mudstone and volcanics, are rich in metals and minerals supporting a productive history of mining. As a result of groundwater interacting with exposed Pyrite (FeS_2) within the hillside and coupled with complex microbial activity, iron-rich spring waters emerge at the base of the escarpment. Since the 1850's, these waters have been bathed in or consumed to aid with a variety of medical ailments. In 2002 the development

[1] Litres per minute

was bought by Nelsons, upon which large scale collection facilities and automated packaging infrastructure were built.

From 2002 until 2019, spring water at Spatone was collected from within a shallow man-made cave dug into the steeply rising escarpment on the western edge of the Conwy valley. The cave split into a 'T' shape at the entrance with the two ends of the cave approximately 30 metres apart collecting hydraulically independent groundwater flows; Well 1 has a largely ferrous state (Fe3+) compared to Well 2 which is predominantly ferric (Fe2+). It is Well 1's ferrous source that was used for the production of Spatone's aqueous iron supplement. In 2017 a sub-horizontal production borehole was drilled 37 m into the hillside below Well 1. The borehole intersects (at least) two groundwater fractures within the Dolgarrog Volcanic Formation and passively drains groundwater via the borehole back to surface with flow rates dependant on antecedent rainfall conditions. Following a period of robust provenance testing the borehole became operational in 2019. The 'Spatone – Exploratory Drilling and Testing Investigations' report produced by WSP in 2017 details the development of the source and method of construction (WSP, 2017).

Spatone has a history of hydrogeologically-focussed work which has refined the hydrogeological understanding of the source. This work includes:

- Hydrogeological Remediation Strategy for Spatone (SWS-UK, 2015). Spatone instructed SWS-UK Ltd (acquired by WSP in 2016) to undertake a hydrogeological assessment of the catchment with a remit to develop a conceptual hydrogeological model of the site, optimize the current use of both spring sources and enhance current yields from the springs or find additional sources of spring fed water. The recommendation of this assessment was the drilling of additional boreholes.
- Exploratory Drilling & Testing Investigations (WSP, 2017). Following the hydrogeological remediation strategy drilling of a production borehole was undertaken. The report covers the drilling, testing and completion of a single exploratory pilot hole. It undertakes a review of the findings recorded during the site operations and how these have refined the conceptual site model for Spatone.
- Geophysics (Terradat, 2021). During 2021 geophysical surveying was undertaken across the site. The geophysics involved a number of Electrical Resistivity Tomography and Seismic Refraction surveys cross-cutting the area within Spatone's land boundary. The cross-sections further refine the conceptual site model for Spatone.
- Catchment Assessment (WSP, 2022). The report was produced to ensure compliance with the Federal (US) and Local (UK/EU) regulations and requirements for spring water collection. The report conducted a watershed survey, further refining the conceptual model of the site and identifying any potential impacts on the abstraction source from within its surface and groundwater catchment.

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HYDROGEOLOGICAL IMPACT APPRAISAL

Methodology

The HIA methodology adopted in this report takes into account guidance from the Environment Agency's Hydrogeological Impact Appraisal for Groundwater Abstractions (EA, 2007) and NRW Water Abstraction and Impounding Licences (NRW, 2022a).

The HIA will carry out the following tasks:

1. Establish the regional water resource status;
2. Develop and refine the conceptual model for the groundwater regime surrounding the production borehole (using previous reports as outlined above), including the potential zone of influence resulting from the production borehole;
3. Undertake a water features survey to identify all relevant water features which may be impacted by the production borehole;
4. Assess potential flow and drawdown impacts from the production borehole on the identified water features;
5. Assess all water quality impacts from the production borehole on the identified water features; and
6. Summarising the findings in a succinct conclusion section, outlining any recommendations including appropriate mitigation and monitoring strategies if required, focussing on the features likely to experience impacts.

Assessment

TASK 1: REGIONAL WATER RESOURCE STATUS

The Spatone production borehole is located within the Conwy Catchment Abstraction Management Strategy (CAMS) Area (NRW, 2015). A review of the licencing strategy for the Conwy CAMS confirms the following water resource status:

"*If an abstraction from groundwater (water stored in rocks) in the Conwy catchment is likely to reduce the flow in a nearby river, a licence is required. In this case, water availability is the same as for the corresponding river catchment*"

The Spatone abstraction borehole is located within an area of the Conwy catchment which was not assessed for surface water (NRW, 2015).

Review of NRW's online mapping (NRW, 2022b) confirms that the production borehole is within the Conwy groundwater body (GB41002G203000). The groundwater body has in both the 2015 and 2021 Water

Framework Directive (WFD) cycles achieved a Groundwater Quantitative status of 'Good'. A 'Good' groundwater quantitative status means that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction. The corresponding surface water body is unmapped with no classification. However, the adjacent Ddu surface water catchment has a Moderate overall status, designated as being heavily modified (NRW, 2022b).

As part of the catchment assessment (WSP, 2022), the surface water catchment area for the Spatone source was identified by a watershed analysis using a 1 m resolution Digital Elevation Model. The boundary (Blue line in **Figure 1**) defines the area within which surface water is likely to recharge into the shallow sub-surface and potentially contribute to the flow captured by the production borehole at Spatone.

TASK 2: CONCEPTUAL MODEL

The conceptual model for Spatone was produced in the Catchment Assessment Report (WSP, 2022). The report combined information gained from literature review, desk study, geochemical analysis, site visits and a geophysical survey (see below). A corresponding graphical representation of the conceptual model is displayed in **Figure 2**.

Locally, rainfall is high, ranging from approximately 1000 to 1500 mm annually. The relatively small catchment comprises an upper flat plateau and a steep escarpment leading to a lower flat flood plain level. The majority of rainfall captured within the upper plateau and escarpment percolates through the top-soil and flows horizontally through shallow unconsolidated media. Some rainfall will migrate vertically via discrete fractures into the underlying bedrock, however, the low primary porosity of the geology local to Spatone limits groundwater recharge rates. The Trefriw Tuff provides an exception and displays modest fluid flow potential as well as potential to behave as a confined aquifer. However, the distribution of the Tuff formation is limited within the local geology and therefore plays a limited role across the site.

As water descends the escarpment, surface run off and shallow groundwater flow will tend to converge into small ephemeral streams. Flow from smaller streams tend to be managed via artificial drainage channels along forestry tracks and diverted into culverts. Flow within the underlying mudstone is likely to be conveyed predominantly by secondary porosity, i.e., fracture flow, down gradient to lower elevations. Within the shallow man-made cave dug into the escarpment that houses the two wells at Spatone, contact with the underlying Dolerite formation was observed close to the containment chamber for the Well. Drilling undertaken in 2017 by Drillcorp logged the geology and fracture density and undertook CCTV of the production borehole now operating at Spatone. The borehole data, which is supported by the geophysical surveys undertaken in 2021, suggests that Well 1 is situated on a lithological boundary and has numerous groundwater-yielding faults in both the high density Talus overburden and the underlying mudstone and volcanics. Flow rates into the historic Well ranged between 5 and 7 litres per minute whereas the flow collected from the production borehole has, on occasion, recorded close to 40 litres per minute.

The fracture network is likely to be mainly associated with faulting related to the Conwy valley fault and potentially also aided by natural weathering processes. This is supported by observations of strong hydraulic

connectivity between the historic Well 1 and the current production borehole during the 2017 drilling works. Water quality obtained during these works was recorded to be similar between the two sources.
A complementary series of geophysical surveys undertaken in 2021 by Terradat informed development of a refined conceptual model locally to Spatone. The Electrical Resistivity Tomography (ERT) surveys (used to infer sub-surface fluid dynamics) suggest that consolidated bedrock at higher elevations (further west) of the historic cave system appear to be dry and not saturated with groundwater within the depth of investigation of the ERT survey (c.25mbgl). Closer towards the base of the escarpment (more or less under the production building at Spatone) mineralised groundwater is inferred closer to surface (c. 10mbgl). This may imply that fracture density decreases further away from the Conwy valley fault thereby restricting shallow groundwater at higher elevations from infiltrating into the bedrock.

SPATONE PRODUCITON BORHEOLE RADIUS (ZONE) OF INFLUENCE

The production borehole at Spatone is uncommon in that it is a sub-horizontal borehole which passively drains groundwater via gravity, with no pump the flow rate from the borehole is reliant on the hydrogeological conditions of the aquifer in conjunction with the completion characteristics of the borehole. The nature of the abstraction makes it difficult to use conventional methods to calculate a Radius of Influence (ROI) as a drawdown measurement cannot be numerically gained and the borehole is not vertical. However, the geophysical surveys undertaken in 2021 have provided graphical data that is likely to be showing the influence the production borehole has on the surrounding groundwater. As the abstraction of the well is seldomly stopped or restricted, it has been assumed that the groundwater conditions at the time of the survey were in steady state.
Figure 3 is an annotated drawing of the Geophysical survey that illustrates the resistivity values close to the production borehole, it shows an inferred zone of influence near the end position of the borehole where resistivity values are higher (less mineralised), at this point the borehole has 3.69 m of open hole section in which water flows into the borehole. This inferred zone of influence is largest around the open hole section of the borehole and extends down gradient by a maximum of 50 m as indicated in the section and plan view section of **Figure 3**. The inferred drawdown within this zone of influence is approximately 3.5 m as illustrated on **Figure 3**. The area of influence horizontally (i.e. perpendicular to the borehole roughly parallel with the topographic contours) from the production borehole is more difficult to determine. No geophysical surveys were undertaken with a suitable orientation therefore professional judgement has been used to estimate a 20 metre horizontal extent. The estimated maximum 50 m down gradient length and 20 m width of the area of influence is likely to narrow and thin, downgradient as natural groundwater levels are reached, giving a tear-drop shape to the ROI.
In should be noted that these geophysical surveys are non-intrusive and in order to derive a cross-sectional model of true ground resistivity, the measured data are subject to a finite-difference inversion process via RES2DINV (ver 5.1) software. The outputs of inversion modelling are subject to potential sources of errors that can affect the readings and inversion outputs which can therefore affect the interpretation of survey results. However, the data obtained via these surveys represent the best available sub-surface site-wide data

and, with an appropriate conservative approach, forms the most reliable data from which to base our assessments.

TASK 3: WATER FEATURES SURVEY

As illustrated in **Figure 1**, an area with a 100 m radius (red circle) from the open hole section of the abstraction borehole (red cross: NGR SH 77766 65306) is viewed as an appropriately conservative search area.

SURFACE WATER FEATURES

A number of surface water features fall within the search area, the lettering of each surface water feature corresponds to the locations shown on **Figure 1**:

- *Unnamed stream* (A)- There is an unnamed stream which flows downslope within the escarpment west to east (passing the abstraction open hole section 20 m south), the stream becomes culverted beneath the gravel road of the escarpment then flows further east, discharging at a modest waterfall behind the Spatone's production facility.
- *Unnamed stream (B*) - 70 m south of the abstraction open hole section. The stream is fed by several tributaries high on the plateau and extends east, discharging into the River Conwy. On the escarpment the stream is discharging at around 5 L/s (WSP, 2022).
- *Surface land drains* (C)- The flood plain east of the main road is drained via surface land drains which feed water eastwards into the adjacent River Conwy. These drains are located approximately 80 - 100 m east of the abstraction open hole section. NRW surface water flood maps indicate the flood plain area east of the main road has a 'high' risk of surface water flooding.
- *Swales adjacent to the gravel road* (D) – There are swales adjacent to the north south trending gravel road located within the escarpment (90 m west of the abstraction open hole section) alter the natural pathway of surface water run-off from the escarpment and conveys water northwards out of the catchment to the north.

Outside of the source catchment and search area, the River Conwy is a notable surface water feature. Located 300 m east of the abstraction open hole section and beyond the base of the source catchment within its associated flood plain. The river runs for approximately 44 km and drains 678 km^2 of catchment including the abstraction location.

GROUNDWATER DEPENDENT TERRESTRIAL ECOSYSTEMS (GWDTE)

No GWDTE data was found in relation to the search area. As the search area is on relatively steep ground, there are multiple streams and ditches draining the area and the geophysical survey indicates that the shallow sub-surface is relatively dry, it is unlikely that any GWDTE occur within the search area or would have a high groundwater dependency.

AQUIFERS

The aquifers which have potential to be impacted by the abstraction are the superficial (Talus material) overburden which is designated a Secondary (undifferentiated), and the underlying bedrock Cadnant Mudstone and Dolgarog Volcanics which is designated a Secondary A aquifer (**Figure 2**). Secondary A aquifers comprise permeable layers that can support local water supplies, and may form an important source of base flow to river. Secondary undifferentiated are aquifers with variable characteristics of the rock type and have only a minor value.

The open hole section of the production borehole is entirely located within the Dolgarog Volcanics however there may be some natural vertical migration of shallow groundwater from the overburden into the bedrock fractures.

ABSTRACTIONS

NRW's water abstractions dataset (data.gov.uk, 2022) indicates that there are no licenced abstractions within the search area. The closest licenced abstraction is located 2.2 km south of the abstraction open hole section at Trefriw. No Private Water Supplies (PWS) have been identified within the search area, the closest PWS was identified during a site walkover from 23/09/2021 to 24/09/2021 as part of the Catchment Assessment Report. The supply is an abstraction borehole adjacent to the Rhibo Cottages, 500 m west of the abstraction open hole section.

TASK 4: POTENTIAL FLOW AND DRAWDOWN IMPACTS

The potential flow and drawdown impacts to the water features which have been identified above (**Figure 1**) have been assessed based on the conceptual model, interpretations derived from the geophysical data, and professional judgement. The water features are assessed in **Table 1** using the same methodology adopted in the Catchment Assessment (WSP, 2022) and provide a sensitivity of a water feature, the magnitude of change (impact) of that water feature and the overall significance.

It should be noted that Spatone's current abstraction rates are modest and relatively constant from a natural gravity fed supply. As no pumping from the aquifer takes place, it is expected that the stress on the aquifer is minimal and that any zone of influence will not fluctuate greatly. Quantitatively no individual feature can be impacted, in flow terms, by more than the flow rate at the abstraction, when flow rates are high at the abstraction, they will be high at the corresponding water features. Furthermore, allowing for proportionality of effect due to distance, orientation and connectivity to the abstraction, impacts at individual features could be significantly less than those presented in **Table 1**.

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Table 1. Likely flow and drawdown impacts and any mitigation measures

Water Feature	Distance & orientation from borehole	Sensitivity of water feature	Magnitude of change (impact)	Significance	Justification
Unnamed Stream (A)	30 m - upgradient	Low	Negligible	Neutral	Stream is ephemeral with small catchment due to forestry road swales higher upslope (see feature D). Predominantly surface water run-off with limited connectivity to bedrock due to low permeability of strata.
Unnamed Stream (B)	75 m – parallel contour	Low	Negligible	Neutral / Insignificant	Majority of stream catchment in adjacent sub-catchment to abstraction borehole therefore no interaction between abstraction and stream is expected.
Surface land drains (C)	80 m – down gradient	Low	Negligible	Neutral	Down gradient of abstraction at boundary of conservative zone of influence extent. Limited connectivity between surface water captured in land drains and groundwater flow within bedrock.
Swales adjacent to forestry road (D)	80 m - upgradient	Low	Negligible	Neutral / Insignificant	Up gradient of abstraction at extent of search area, swales fed by surface run off and shallow groundwater flow. All flow conveyed out of catchment.
GWDTE	N/A	N/A	N/A	N/A	No identified GWDTE within search area.
Aquifers	N/A	Low	Negligible	Neutral	Abstraction is gravity fed with no active pump. Zone of influence footprint is small, with approximate drawdown of 3.5 m that attenuates back to baseline in c.50 m downgradient (**Figure 3**)
Abstraction	N/A	N/A	N/A	N/A	No licenced or PWS within 500 m of abstraction.

TASK 5: POTENTIAL WATER QUALITY IMPACTS

There are no known issues associated with contaminated land or contaminated groundwater at the abstraction borehole. Water quality sampling within the catchment, notably at lower elevations, show elevated Nickel and Lead probably related to the local geology/mineralisation and not a function of any recent contamination issue. In addition, there are no anticipated water quality impacts associated with the abstraction borehole. The abstracted water undergoes robust testing (quarterly and annually for full suite laboratory analysis) with no water quality issues being identified within the samples. The abstracted water is consumed as a commodity with only occasional overflow that is discharged back to the environment (via ground infiltration) east of the Spatone production facility. The discharged water undergoes no treatment or processing and therefore is the same quality as when it was abstracted, negating any risk of pollution.

Conclusions and recommendations

This Hydrogeological Impact Appraisal was required as part of Spatone Nelsons application for an abstraction licence for their production borehole which has an abstraction potential of over 20 m^3/day (13 lpm); with periods of high groundwater flow producing over 36 m^3/day (>25 lpm) at the abstraction point. The HIA has used information from previous reports on the Spatone groundwater supply to develop the conceptual model and aid in the estimation of the Radius (Zone) Of Influence for the production borehole. An appropriately conservative zone has been applied, supported by data from recent surface geophysical surveys, in a roughly tear-drop shape around the production borehole. The zone has approximate maximum dimensions of 50 m (length) x 20 m (width) and a localised estimated drawdown of 3.5 m.

For the water features survey a further conservative buffer was added to the zone of influence extent. A search area of a 100 m radius (centred on the 3.69m open hole section of the production borehole) was used for identifying water features that may be impacted by the production borehole. Within the search area, four surface water features were identified. No Groundwater Dependent Terrestrial Ecosystems (GWDTE) and no licensed groundwater abstractions or private water supply abstractions are recorded (or have been observed) within the search area.

Potential impacts to flows, drawdown and water quality were assessed for the water features as a result of drawing full yields passively from the production borehole. Accordingly, it was concluded that there are no significant impacts on the surface water features from operating the production borehole; as a result, there is no requirement for mitigation measures or recommendations.

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Date Modified: 10/12/2021

Drawn By: INSG01380

File: \\uk.wspgroup.com\Central Data\Projects\70086xxx\70086304 - Spatone Catchment Assessment\03 WIP\03 GIS\Figure 1- Location map.mxd

Legend

100 m Search Area

Catchment Boundary Surface Water

Escarpment

Plateau

Spatone Production Facility

Flood Plains

River Conwy

A

B

C

D

Coed Gwydyr

Blaen-Y-Wern

Cae Côch Farm

0 25 50 75 100

Meters

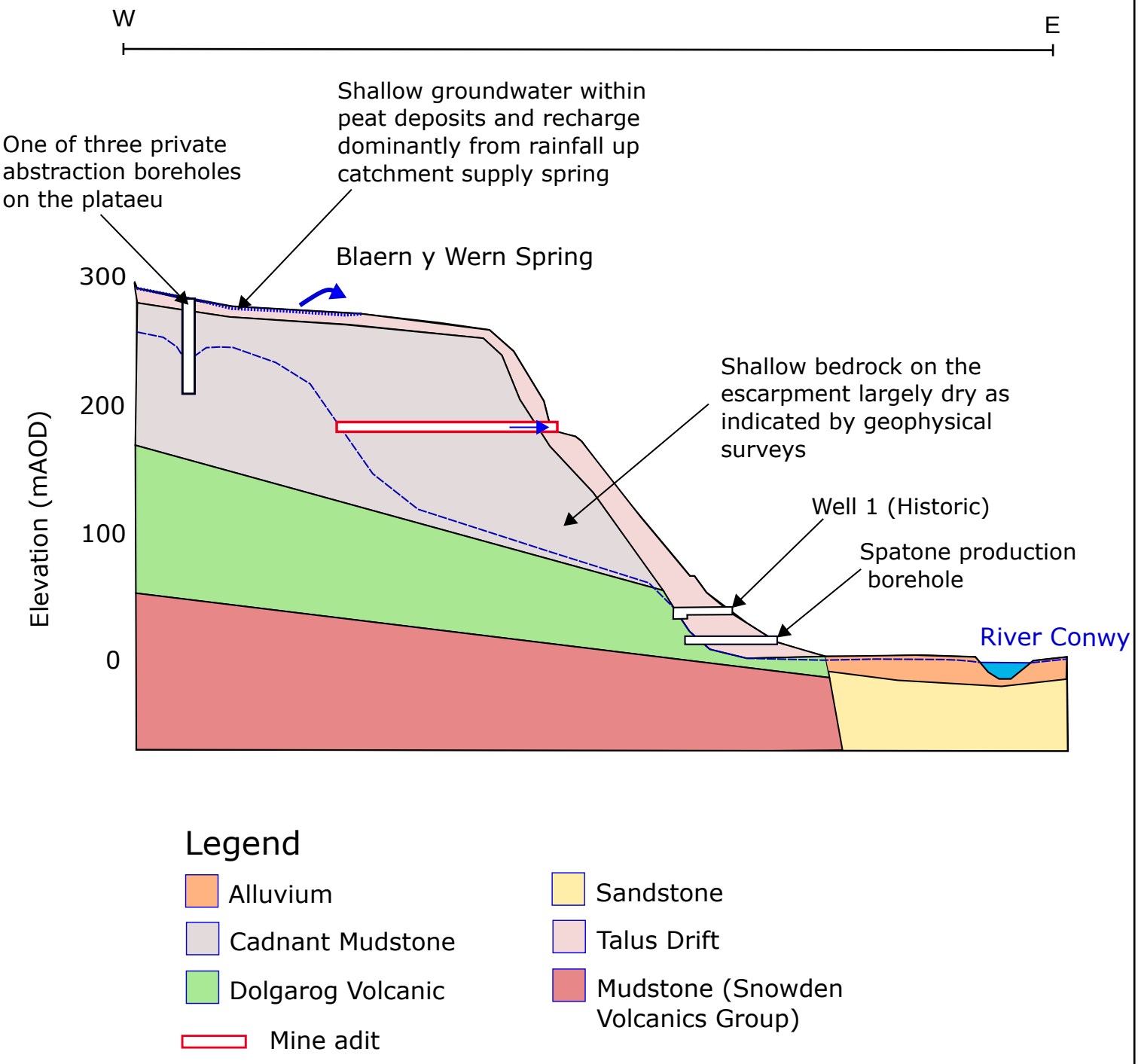
wsp

TITLE:

Spatone
Site Location map

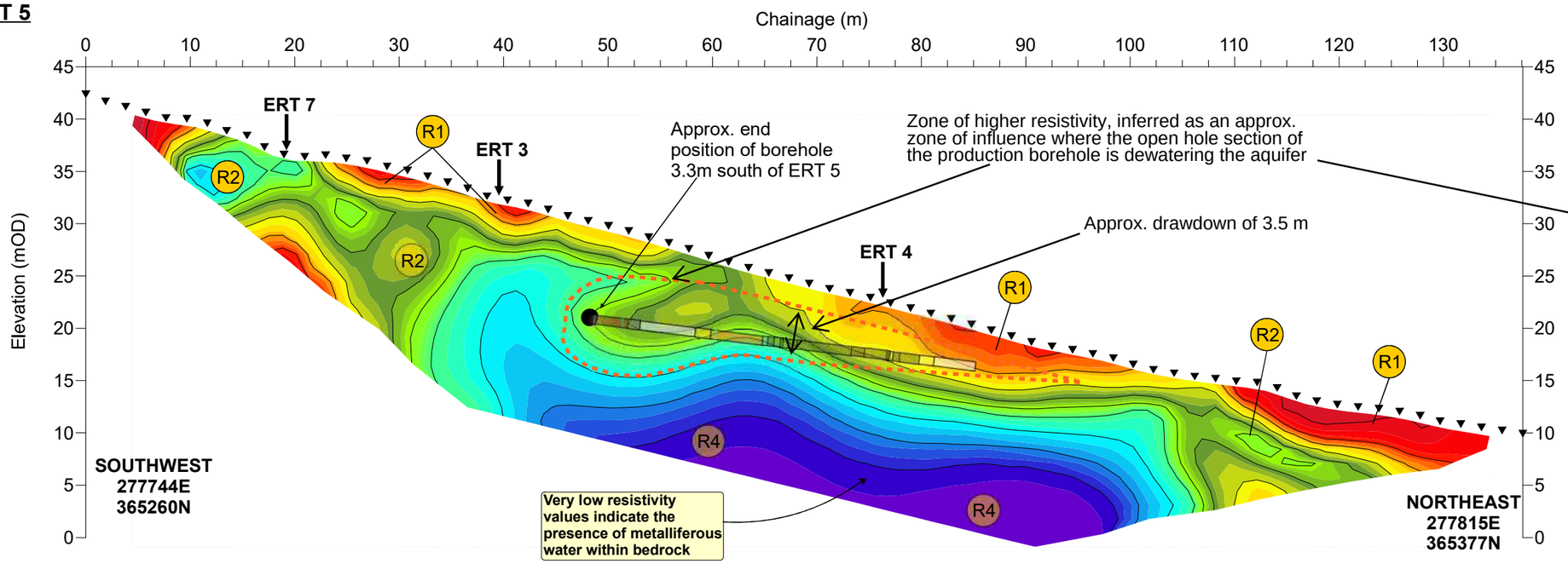
FIGURE No:

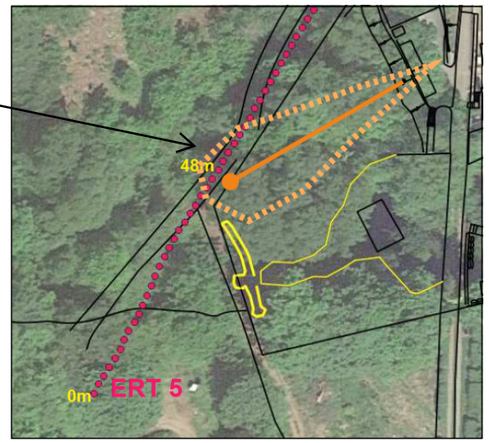
70086304 - FIGURE 1



	Title: 2D Geological Cross Section of Spatone
	Figure No: 70086304 - Figure 2

4A) ERT 5





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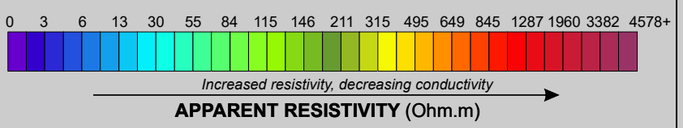

ERT UNIT KEY:

- R1 — Surface resistive material - loose blocky/gravelly material associated with comparatively recent slip material (colluvium)
- R2 — Relatively low resistivity material - associated with more clay rich/water saturated/mineralised sediments likely to be associated with Head deposit (colluvium) overlying the bedrock
- R3 — Relatively high resistivity bedrock - dry competent volcanic bedrock
- R4 — Extreme low resistivity values within bedrock - high mineralised water content with possibly associated with weathered/highly fractured volcanic bedrock

BH KEY

Sand (Colluvium)
Gravel (Colluvium)
Cobbles (Colluvium)
Clay (Colluvium)
Breccia (Colluvium)
Sand (Glacial)
Mudstone (Bedrock)
Dolerite (Bedrock)

wsp

Title: Annotated figure of Terradat Geophysical survey ERT 5 and ERT 7

Figure No

70086304 - Figure 3