SANBWA requirements for the Hydrogeology and Vulnerability report

4.1 Purpose of the Hydrogeology and Vulnerability Report

The purpose of the hydrogeology report is to convey to the reader as complete a picture as possible of the:

- The physiography, geology and hydrogeology of the resource.
- The quantity of water available.
- The water quality, both chemical and microbiological.
- An assessment of the vulnerability of the water resource to contamination as well as the location of known possible contamination points.

This report is to be written by a professional hydrogeologist. After submission to SANBWA as a requirement for membership, this report will be reviewed by a SANBWA appointed hydrogeologist.

4.1.1 Surface Water Vulnerability report

When a bottler is using Municipal Water in order to bottle Prepared Water, then obviously there is no need for a Hydrogeology Report. There does however, remain a need for a Vulnerability report. This aspect is discussed in Section 4.7.4 Protection of Surface Water Supplies and Section 4.8 Vulnerability Assessment, Monitoring and Corrective Actions

4.2 Minimum required information in the Hydrogeology and Vulnerability Report

The table below lists the specific items that are required for a complete report. Note that these are the minimum requirements, and if the hydrogeology investigation indicates that more information is required for completeness, this must be included.

Table 4.1 List of minimum requirements of information required for the hydrogeology and vulnerability report

1	Where the source is. Two maps are required, one at a regional scale, and the other at a local scale.
2	What is the nature of the catchment? Describe the physiography, the vegetation, the usage of the catchment, activities in the catchment, and any man-made structures.
3	What the geology of the area is, including a map at a suitable scale.

4	What is the groundwater regime, including a description of the aquifer being exploited and the local and regional groundwater flow directions.
5	An assessment of the flow rate of the source if a spring, and if a borehole, an evaluation of the sustainable yield. The drilling report and the test-pumping report should be included, if available. The actual abstraction rates must be given.
6	Catchment study: Delineate the catchment, describe recharge to the aquifer and the recharge zones, and delineate the capture zones for the borehole. Note that an exhaustive and intensive study is not required; the hydrogeologist must use available data and provide his/her interpretation.
7	Department of Water Affairs: Record the various water resource points that have been registered and also the licensing of these. The hydrogeologist must specifically note whether or not the proposed source has been licensed for the proposed commercial use, and include copies of the various licences.
8	What is the microbiological composition and chemical character of the water, as well as an evaluation of these results? The laboratory results must be included in the report. See reference table 1 A, B and 2 A, B in the SANBWA Standard.
9	A detailed description of the borehole or spring protection in the immediate surrounds of the abstraction point. Include a note on water flow measuring and water level measuring.
10	Who else is exploiting the aquifer in the near vicinity, and who might have an impact on the source being described. A map showing these points of extraction must be included.
11	An assessment of the vulnerability of the aquifer to any form of contamination, taking into account the aquifer type and catchments morphology*.
12	A review of all potential polluting activities in the area, including an assessment of the potential impact of these activities on the source. A map showing the location of these activities must be included.

For further discussion on some of these aspects see Chapter 4.4

4.3 Suggested outline of chapters for the Hydrogeology and Vulnerability report for the Bottled Water Source – for SANBWA membership

1 Introduction
2 Terms of Reference
3 Location and Physiography
4 Geology and Hydrogeology

4.1 Regional Geology
4.2 Local Geology
4.3 Local Hydrogeology
4.4 Catchment and recharge to the aquifer
5 The abstraction point
5.1 Description of the abstraction point
5.2 Yield of the resource: water quantity
5.3 Abstraction rates
6 Water quality of the untreated product
7 Resource vulnerability
7.1 Borehole protection
7.2 Regional vulnerability
8 Conclusions and recommendations
9 References

Tables and Figures and Photographs as required
Appendices as required

4.4 The abstraction point(s)

The ideal scenario and the basic philosophy of water from subterranean origin: Natural Water is to capture the water into a bottle in the same state as that in which it occurs underground, i.e. no contact with air or any other contaminants. The only allowed processing for Natural Water is filtration to remove insoluble components. No sterilization is allowed to remove microbiological contamination for the category Natural Water. For this reason the utmost care must be taken not to allow pollutants or contamination to enter the abstraction area.

Should the source water require antimicrobial treatment, the final product category would be “Water defined by origin”.

The various sources of extraction on the property should each be named and clearly identified. Reference to the specific source in use should be included in all documentation i.e. quality control, production data and labels.

4.4.1 The Borehole

The source and borehole are the very foundation of the business. It is critical to start off with a correctly drilled borehole, the pump correctly installed and the source protected from subsequent contamination, whether accidental or deliberate. Leakage of surface water or contamination by insects and animals into the aquifer must be eliminated by a proper sanitary seal down to the solid rock formation.

The borehole and pump must be in an enclosed, lockable room to exclude animals, pests, unauthorized persons and the area must be maintained clean and sanitary. The borehole shall be constructed according to the following requirements: SANS 2003: Development, maintenance and management of groundwater resources – Part 2: The design, construction and drilling boreholes; SANS 10299-2: 2003

The casing

The borehole casing is installed to prevent soil and loose rock from the upper part of the borehole collapsing. Casing is normally made from either mild steel or PVC. One of the considerations for a bottled water borehole is to ensure that the casing does not influence the water quality. SANBWA strongly recommends the use of a stainless steel casing instead of mild steel.

The drilling

Most drilling is performed by either the air-percussion method or by mud-rotary drilling. A percussion hammer driven down the hole by compressed air is used to break the rock and the compressed air flushes the borehole and cleans the borehole of rock cuttings. Mud rotary drilling is used when loose sand or other collapsing ground conditions are encountered. Both drilling methods will introduce microbiological contamination. Additionally, the drill rods get covered with soil and are handled by the crew, which can lead to further contamination. Proper borehole design is aimed at reducing this contamination of the borehole.

Borehole design

The great majority of boreholes will penetrate a number of layers of rock, generally as follows:

- The upper soil layer, a few metres thick
- The highly weathered zone, often clay-rich, which can be tens of metres or more thick
- The weathered rock zone, which can be up to fifty metres thick
- The weathered and fractures zone which is usually the water-bearing zone
- The fresh rock zone which can have the odd fracture yielding water

In general boreholes vary from 30 and up to 120 m deep, depending on local circumstances. A proper borehole will have a casing installed to the water-bearing zone, and the casing will be well-seated into the rock. The purpose of ensuring a well-seated casing is to prevent contamination from entering the borehole along the annulus between the casing and the drilled hole.

A recommended borehole design is as follows:

- Drill at 12” (300 mm) for six to ten metres and install a temporary 10” (250mm) casing.
- Drill at 8” (200mm) to rock sufficiently hard to seat the casing.
- Extend the borehole another half to one metre at 6½” (160mm) drill diameter.
- Install the 6” (150mm) casing and properly seat the casing into the rock.
- Inject a bentonite-cement grout along the outside annulus of the casing and allow hardening and setting.
- Continue drilling at 6” and complete to final depth.
- Do a thorough air-lift cleaning so that the water is clean and all trace of muddiness has been removed.
- Add a kilogram of HTH chlorine granules down the borehole.
- Mix 2 kg of chlorine granules in a 20ℓ bucket of water and pour down the borehole so that the liquid runs down the casing to sterilize as much of the inner surface of the casing as possible.
- Cap the borehole and leave until needed for use.

The borehole must have a proper sanitary seal construction and well head protection system. This system must be inspected regularly and leaks rectified immediately before production commences. Boreholes not in use must be sealed properly.

Pump installation

Any pump that is installed must be sterilized before installing. Both the inside and outside of both the pump and the riser pipe must be sterilized. This will prevent contamination of the borehole.

The following procedure can be used:

- Fill a large drum with water and add a few kilograms of HTH chlorine or Oxonia.
- Attach the pump to the riser pipe, place in the bath and switch the pump on, letting the outlet discharge back into the bath. This circulating water sterilizes the insides of the pump and riser pipe. Switch off.

- Feed the pump down the borehole, ensuring that the pipe and electric cable gets a thorough washing by submerging the pipe in the chlorine solution.
- Ensure that all the workers hands and tools have also been sterilized.
- Complete the installation.
- Seal the borehole thoroughly and ensure a proper sanitary seal construction and well head protection system.
- Leave for a few hours and then pump the borehole to waste until no more chlorine smell and taste is present. Residual chlorine can also be tested for to ensure its absence.

4.4.2 The Spring

If the water is drawn from a spring, the water can be classified either as “Natural Water” i.e. Natural Spring Water or as “Water Defined by Origin” i.e. Spring Water.

For Natural Spring Water under the “Natural Water” category, SANBWA require that a borehole be sunk next to the spring, and the water be drawn directly from underground. This is to prevent any contamination resulting from a spring being open to the elements, and possible ingress of shallow groundwater and plant roots. The borehole is then treated in the same way as discussed above.

For Spring Water under the “Water Defined by Origin” category, antimicrobial treatments are allowed, thus the water can be tapped directly from the eye of the spring. However the following precautions should be taken to minimize contamination:

- The spring must be well sealed to prevent insects and animals from coming into contact with the water. Also, sunlight must be avoided, so do not install an “inspection window”. Light encourages the growth of algae, which must be avoided.
- The construction must be designed to avoid pooling of water. This prevents stagnant zones.
- Plant roots must be prevented from entering the spring, so all cracks in the rock must be cleaned and sealed.

4.4.3 Sampling points

It is a requirement of SANBWA that the source water be regularly tested for microbiology according to the schedule under 6.3. Fit a metal sampling tap close to the head of the borehole or spring. The tap must have a cap on the spout. The tap must be metal, so that when sampling, a flame can be used to sterilize the spout.

4.5 Water quantity, water meters and water-levels

After a borehole has been successfully drilled, it is normal practice to carry out a test-pumping exercise on the borehole. This should be a 4-stage multi-rate test, followed by a 48 hour constant discharge test, and in turn followed by a recovery test. These tests are then analysed, and a suitable and sustainable abstraction yield is recommended.

It is quite often the case that a borehole yield testing has already been undertaken which is not the above described test. The hydrogeologist must use his professional judgement as to whether the borehole must be re-tested as above or whether the data available is sufficient to evaluate the yield. Note that bottling plants actually use very little water, and the boreholes are often high-yielding, and the actual water required is a mere fraction of the potential yield. Similarly, if the air-lift yield indicates a high yielding borehole, then the borehole testing can comprise a 4-stage multi-rate test, followed by a 24 hour constant discharge test, and in turn followed by a recovery test.

Bottling plants do not often exploit the borehole at its maximum potential abstraction rate. Thus the actual abstraction rates must be recorded. The usual and simplest method is to fit a water meter to the water pipe from the water source. The quantity of water must then be read and recorded daily or weekly.

If the quantity of water being abstracted is near, (say more than 65%), to the maximum recommended abstraction rate as derived from the analysis of the pumping tests, then it is very advisable to also install a water-level monitoring system. This should be an automated system, as using manual measuring increases the probability of source contamination. The hydrogeologist, who carried out the pumping test analysis, will provide an “alert” and an “alarm” water-level. When either of these water-levels is approached, then suitable action as recommended by the hydrogeologist must be followed.

4.6 Water quality requirements

The water quality requirements for the source water are described in “SANBWA Bottled Water Standard”, i.e. this document.

The maximum levels for chemical elements present in untreated source water for:

1 Natural Water sources is listed in Table 2A
2 Water defined by Origin and Prepared Water is listed in Table 1A

The microbiological specifications for untreated source water for:

1 Natural Water sources is listed in Table 2B
2 Water defined by Origin and Prepared Water is listed in Table 2A

4.6.1 On-going water quality monitoring

Groundwater supplies must be analyzed regularly for constancy of microbiological, chemical, physical and where necessary, radiological characteristics. The frequency of testing is determined by the hydrogeological evaluation, the amount of water collected, and the historical constancy pattern of a particular water supply.

The minimum period for chemical analysis is once per year. If the hydrogeological circumstances indicate seasonal variations, then bi-annual or quarterly values must be analyzed. Good practice will be to test the EC (electrical conductivity) on a daily basis. Sources are tested for microbiological parameters on a weekly basis. Note that the water that must be tested is the source water, and the water samples must be collected before any filtration or other treatment. Hence the requirement that a metal sampling tap must be fitted at the head of the borehole (mentioned previously in section 4.4.3).

If unacceptable levels of contamination are detected, production shall cease until the water has returned to established parameters.

4.7 Protection of the water supply

There are two strong motivating factors as to why it is important to protect the source from polluting activities. Firstly the consumer of the bottled water must be provided with safe bottled water that is free of contamination and man-made chemicals including those which are harmful to humans. Secondly, the capital investment made in developing the infrastructure and brand image can be compromised due to insufficient attention to source protection.

4.7.1 Protection of Groundwater

Groundwater source protection means protecting both the abstraction point and the aquifer from any and all pollution. There are two focus areas in source protection. The first is the immediate technical surrounding of the well, borehole or spring. The second is the catchment area of the source.

For a bottled water from subterranean origin operation, the point of extraction is the borehole, well or spring from which the water flows or is pumped. This water originates from the aquifer through which the water flows and from which the water obtains its mineral make-up. This aquifer is recharged mainly by rain (and also by melted snow and hail) and less commonly in South Africa by infiltration from streams and other surface water bodies. The area where this recharge takes place is the catchment area for the source. Commonly in South Africa this is the valley or high ground above the point of abstraction. For some aquifers such as the dolomites of the Transvaal and Griqualand West Sequences and the quartzites of the Cape Supergroup, the recharge area may be further away, sometimes beyond the crest of the nearest ridge.

4.7.2 The immediate surroundings of the point of abstraction

The immediate surroundings of the point of abstraction are regarded as being the area of 50 meter radius around the point of abstraction. Entrance by pollutants must be eliminated in this area by the following precautionary measures: This area must be securely fenced off and access should be locked to prevent mischief. No other activities should be allowed in this area. The facility in which the spring, well or borehole is contained must be constructed in a manner to prevent all insects and animals from being able to enter. If the source is a spring, this should be sealed with airtight fittings to ensure no animal or insect access. Similarly, a borehole or well must be sealed with airtight and light-tight fittings. Surface and storm-water drainage in the immediate vicinity of the borehole, well or spring must be such that it drains away from the source. The borehole or well must have an impermeable slab at surface around the casing. This is to ensure that no surface water or leaking pumped water washes back into the borehole via the more permeable backfill around the outside of the casing, taking with it silt and other possible pollutants. Waste water drainage, sewerage and solid waste storage must be positioned and maintained so as not to contaminate the source.

4.7.3 The Catchment Area

The catchment of the spring, borehole or well must be protected from any and all contaminating activities. Activities that must not be allowed in this area are waste disposal, fuel storage, farming and industrial activities which have a high risk of pollution. This would also include septic tanks, grave yards, cattle feed lots and other concentrated live-stock activities. All other activities which could cause contamination of the source must also be avoided. These include intense farming activities which involve the use of pesticides and fertilizers, houses, roads, rail-lines and mining. The ideal situation is to have only indigenous bush in the catchment, with at most occasional grazing by livestock. Even better would be for the catchment area to be devoted to a nature reserve.

The high level of recognition of the importance of conservation in the catchment areas is shown by the following examples from Europe, as quoted from EFBW.

EFBW Sustainability Report 2010

http://www.spadel.com/userfiles/pdf/200_EFBW%20Sustainability%20Report%20Final.pdf

Bottled Water - Achieving a Sustainable Life Cycle

Environmental conservation is nothing new for the bottled water industry. In Europe, bottlers have been protecting catchment areas as early as the 19th century to safeguard the ecosystems through which water filters to its source. To best protect the natural environment, many producers have established long standing partnerships with local communities and authorities in order to raise awareness on natural habitats, to promote sustainable development and to advance environmentally-friendly agricultural practices. Protection efforts put in place include limiting human activity, banning the use of pesticides and improved farming techniques.

The Fagne Catchment Area, Belgium

The Fagne de Malchamps catchment area in the Ardennes is the largest in Europe and one of the oldest, established by the Spa Group in 1889. The protection zone comprises 13,177 hectares of deciduous trees, wetlands and rare flora and encompasses some 30 underground sources which feed the 3 Spa Springs (Reine, Barisart and Marie-Henriette). Since 1967, the Spa Group is in partnership with the region’s National Forestry and Waters Commission to optimise silviculture operations. The company has also initiated the use of sand to replace salt for snow removal, waterproofed parking lots and promotes sustainable development within local communities. In 2006 the company also rehabilitated its former Bru bottling site, investing 1.5 million euro to return it back to nature and the plantation of 400 indigenous shrubs and trees.

AGRIVAIR for Vittel, Hépar, Contrex, France

In 1992, Nestlé Waters established an independent agricultural advisory body, known as Agrivair, to help protect the catchment areas around the underground water sources of Vittel, Hépar and Contrex in France. For the last 17 years, Agrivair has collaborated closely with local farmers to promote environmentally-friendly farming techniques and encourage sustainable agriculture, such as eliminating the use of pesticides, reducing nitrates and promoting crop rotation. Agrivair also helps farmers with grants, research and technical assistance. Working with local communities, Agrivair has played an instrumental role in protecting the impluvium – some 10,000 hectares across 12 different communes - by the successful management of farming areas, forests, parks and railroads to help preserve the natural water quality.

Evian Mineral Water Catchment Area, France.

Evian has long been involved in water preservation. As early as 1926, the brand defined a protection zone around the Cachat groundwater source in France in order to limit human activity in the region. Preserving the catchment area composed of forests, meadows and wetlands atop the Gavot Plateau in the French Alps is a key priority for Evian, for this is where rain and snow seep into the ground to then collect and filter to its source. In 1992, the brand formally created the Association for the Protection of the

Evian Mineral Water Catchment Area (APIEME) to encourage cooperation between local farmers, communities and authorities, promoting sustainable development in the 35 square kilometers of impluvium and focuses on protecting the area's wetlands.

4.7.4 Protection of Surface Water Supplies

Protection of surface water supplies is a much more complicated activity. Surface water will typically be the source of water for prepared water and the supplier is the local Bulk Water Supplier, most often the local Municipality. Both National and Local Government are involved in the monitoring and protection of such a resource. The bottler of Prepared Water must thus be in contact with the responsible officials, know who they are, and regularly liaise with them. Mostly the bottler will not need to carry out extensive monitoring, but may wish to carry out regular control monitoring of the incoming water. There may be instances where the government monitoring is inadequate, and then the bottler will need to be more involved in order to ensure sustainability.

4.8 Vulnerability Assessment, Monitoring and Corrective Actions

4.8.1 Vulnerability Assessment

It is now a requirement for **the hydrogeological and vulnerability report** that a vulnerability assessment is carried out. Most, if not all, methods that are described in the literature for vulnerability surveys are directed towards regional assessment methods and have little application towards requirements for sources of water for bottled water. They are designed for large scale water supply projects with areally extensive aquifers such as found in North America and Europe.

For bottled water projects, and especially in the Southern African hydrogeological settings encountered, the vulnerability surveys will rarely cover areas of more than a few tens of square kilometers.

The document "Groundwater Vulnerability Assessments and Integrated Water Resource Management" (Ligget JE and S Talwar, 2009) http://www.forrex.org/sites/default/files/publications/articles/Streamline_Vol13_No1_Art4.pdf is a peer reviewed synthesis article, and provides a very good read on the subject. The following are some excerpts:

- *"Vulnerability" is the degree to which human or environmental systems are likely to experience harm due to perturbation or stress, and can be identified for a specified system, hazard, or group of hazards (Popescu et al. 2008). In hydrogeology (the study of groundwater), vulnerability assessments typically describe the susceptibility of the water table, a particular aquifer, or a water well to contaminants that can reduce the groundwater quality (e.g., nitrates, industrial chemicals, gasoline).*

- *As part of integrated water resource management, vulnerability assessments are integrated into a program of groundwater characterization and risk analysis, with tiered approaches for assessing vulnerability, hazard potential, and risk.*
- *No single standardized definition for groundwater vulnerability exists; however, the concept describes the relative ease with which the groundwater resource could be contaminated. This is based on the idea that the physical environment can provide the resource with some degree of protection from contamination.*
- *Within the scientific community, there is on-going debate about whether groundwater vulnerability is solely an intrinsic property of the land and subsurface, or whether it also encompasses properties of the contaminant type, loading, fate, and transport. Vrba and Zaporozec (1994), the Natural Research Council (1993), and the European community have recognized "intrinsic vulnerability" as the natural susceptibility to contamination based on the physical characteristics of the environment, and "specific vulnerability" as accounting for the transport properties of a particular contaminant or group of contaminants through the subsurface (Figure 2). To understand how vulnerability is characterized in an area, it is therefore important to be aware of the parameters used to assess vulnerability in a particular study.*

Vrba, J. and A. Zaporozec. 1994. Guidebook on mapping groundwater vulnerability. International Association of Hydrogeologists, Heise, Hannover. International Contributions to Hydrogeology No. 16.
National Research Council. *1993. Groundwater vulnerability assessment, contamination potential under conditions of uncertainty. National Academy Press, Washington DC.*

A source vulnerability assessment must be performed for the recharge area or zone of influence of the source. This survey should identify and evaluate actual and potential sources of contamination and be updated every ten years. This is the intrinsic vulnerability as described by Ligget and Talwar (2009) above.

Should an initial survey indicate a high risk for contamination of the untreated water, more specific tests should be performed on pesticides as listed by the Directorate Food Control (http://www.doh.gov.za/department/dir_foodcontr.html).

For surface water intended for bottling, i.e. for Prepared Water, The bottler must liaise with the Department of Water Affairs and Forestry person responsible for water supply and the Municipal officer responsible for pollution control when preparing the risk assessment. They will be able to provide valuable insight and cooperation.

4.8.2 Monitoring and Corrective Actions

Based on the risks identified by above mentioned survey, a plan for special monitoring of any significant contaminant source and for taking restrictive, preventative or corrective measures to protect the source water and final product shall be in place and available for inspection.

Regular monitoring of activities in the catchment area that has been delineated in the hydrogeological report must be done by the bottling plant personnel. Records must be kept. If there is an activity that appears to endanger the integrity of the resource, management must contact the hydrogeologist who will in turn evaluate the threat posed by this activity. This is <u>the specific vulnerability</u> as described by Ligget and Talwar (2009) above. Appropriate action will then be initiated.

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