Croydon Vineyard Estate: Assessment of groundwater quality

23 March 2018

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1. Introduction & Background

Mills Water was requested by Croydon Vineyard Estate to undertake an assessment of the potential uses for groundwater from two boreholes at the estate. In particular, they requested that Mills Water:

- Confirm whether the water is unsuitable for the irrigation of the vineyards.
- Confirm suitability for the watering of plants and lawns
- Confirm potential for non-potable domestic use, and potential issues related to piping into households.
- Confirm whether water is it suitable for domestic cleaning and showering.

2. Suitability for irrigation

To determine the suitability of the groundwater for irrigation use, the groundwater quality is compared to the *South African Water Quality Guidelines Volume 4- Agricultural Use: Irrigation* (DWAF, 1996d). The Guidelines specify Target Water Quality Ranges (TWQR) for a range of parameters, above which effects on yield may be observed. Expected yield decreases and other effects at a range of concentrations exceeding these TWQRs are also given.

The comparison of the borehole water data against the irrigation guidelines are given in Table 1. The following parameters exceed their respective TWQRs for irrigation:

- EC/total dissolved solids (TDS) (note that EC is a simple proxy for TDS)
- Chloride
- Sodium
- Langelier saturation index (LSI)
- Ryznar saturation index (RSI)
- Manganese

The LSI and RSI are indicators of the potential for waters to be scale-forming or corrosive. The three groundwater samples show similar results, and all indicate a tendency to corrosivity. Corrosion is most evident in copper pipes and mild steel, but can also affect stainless steel systems. Non-plastic irrigation systems could therefore be affected.

Manganese results are around 200 µg/L in the three samples. The TWQR is 20 µg/L is to ensure manganese does not concentrate to phytotoxic levels in soil that is irrigated at a rate of 1000 mm per annum for up to 100 years. A manganese concentration of up to 10000 µg/L is acceptable to ensure manganese does not concentration to phytotoxic levels in fine-texture neutral to alkaline soil that is irrigated at a rate of 1000 mm per annum for up to 20 years. In terms of toxicity, given the likely sandy soils, the concentration of 200 µg/L is not considered to be problematic for irrigation. The plant species being irrigated is also important as some plants are highly sensitive to manganese. Manganese can also be problematic in terms of clogging of irrigation equipment. At concentrations

of 100 µg/L, clogging problems are likely to be minor, becoming more moderate at manganese concentrations between 100 and 1500 µg/L.

EC or TDS provides an indication of the total salt concentration in water. Because the composition of the salts can vary, the toxicity effects of the same EC can be different, depending on the dominant cations and anions. The EC/TDS is used to assess the danger of causing salinization of soil over time, which can affect crop yield. The composition of the salts also needs to be assessed to determine potential toxic effects related to the salts.

Groundwater with elevated EC can be used for irrigation but an excess of irrigation water needs to be applied to flush salts through the soil and prevent them from accumulating. This excess is called the leaching fraction. The EC levels in the Croydon groundwater (>375 mS/m, average 430 mS/m) are well above the TWQR and fall into the range where moderately salt-tolerant crops generate only 80% of normal yield, as long as irrigation is frequent, and a high leaching fraction (0.2) is used. According to Fipps (2003), grapes require an EC of <150 mS/m in soil solution to generate 100% yield. A graph of various crops and their EC tolerance is given in Figure 1. Some grape rootstocks and varieties are more tolerant to salinity than others, but even tolerant varieties and rootstocks begin to show a yield decline by 330 mS/m (Walker, 2010).

The composition of the salts in the Croydon groundwater is dominated by sodium and chloride, both of which exceed their respective TWQRs. At the measured levels of chloride in the groundwater (>800 mg/L), it is likely that chloride will accumulate to toxic levels. Grapes are considered to be sensitive to foliar injury, with injury observed at chloride concentrations >175 mg/L. Similarly, the sodium levels of Croydon groundwater (>600 mg/L) are associated with decreased yields and foliar injury.

The groundwater quality therefore is likely to be unsuitable for irrigation of grapes. It may be possible to irrigate gardens and lawns if salt tolerant plants are selected. Figure 1 illustrates the degree of crop yield decrease with increasing EC. It is clear that some plants are significantly more salt tolerant than others. Examples of grasses that exhibit high tolerance to salinity are kikuyu and Bermuda grass (Cynodon dactylon). Plants adapted to coastal areas would be expected to show a degree of salt tolerance.

Figure 1: Crop yield related to EC of irrigation water (data from Walker, 2010)

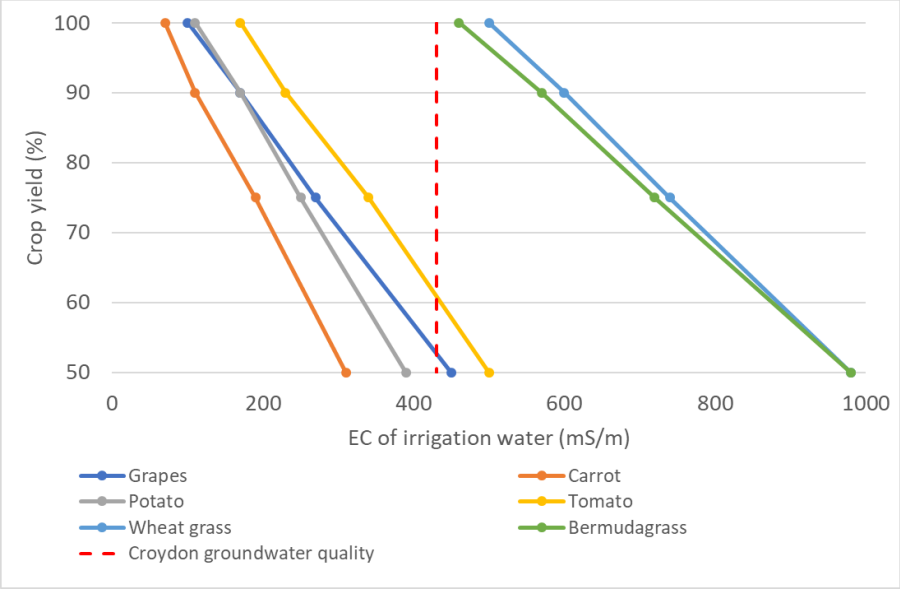

Table 1: Comparison of Croydon Vineyard Estate groundwater quality to various guideline levels

Results are colour coded as follows:

100	Exceeds DWAF Domestic standards Target Water Quality Range (TWQR) or SANS241:2015 standards
Underlined	Exceeds DWAF Recreation full contact TWQR
Blue fill	Exceeds DWAF Irrigation water TWQR

Analyte	Risk	Units	CE_BH1	CE_BH2	Boorgat	SANS 241:2015	DWAF Domestic	DWAF Industrial Category 4	DWAF Recreation Full contact	DWAF Irrigation
Microbial							TWQR	TWQR	TWQR	TWQR
E. coli or faecal coliforms	Acute health	Counts/100 mL				0	0	-	130	1
Total coliforms	Operational	Counts/100 mL				10	5	-	-	-
Heterotrophic plate count	Operational	Counts/mL				1000	100	-	-	-
Physical, aesthetic, operational and chemical determinants										
Colour	Aesthetic	mg/L Pt-Co	5	<1		15	15			
Conductivity at 25°C	Aesthetic	mS/m	528	387	375	170	70	250	-	40
Total dissolved solids	Aesthetic	mg/L	3377	2476		1200	450	1600	-	-
Turbidity	Operational	NTU	7.6	0.6		1	1		3	
	Aesthetic	NTU	7.6			5			3	
pH	Operational	pH units	7.1	6.9	6.8	5 - 9.7	6-9	5 - 10	6.5-8.5	6.5 - 8.4
Nitrate as N	Acute health	mg/L	0.70	2.80		11	6	-	-	-
Nitrite as N	Acute health	mg/L	0.02	0.01		0.9	6	-	-	-
Sulphate as SO42-	Acute health	mg/L	299	388	354	500	200	-	-	-
	Aesthetic	mg/L	299	388	354	250	200	-	-	-
Fluoride as F-	Chronic health	mg/L	1.3	0.6		1.5	1	-	-	-
Ammonia as N	Acute health	mg/L	<0.28	<0.28		1.5	1	-	-	-
Chloride as Cl-	Acute health	mg/L	1350	860	830	300	100	500	-	100
Sodium as Na	Acute health	mg/L	837.5	654.9	600.2	200	100	-	-	-
Zinc as Zn	Acute health	mg/L	<0.03	<0.03		5	3	-	-	1
Calcium	Aesthetic	mg/L	76.8	79.2	71.1	-	32	-	-	-
Magnesium	Acute health	mg/L	68.4	81.6	77.5	-	70	-	-	-
	Aesthetic	mg/L	68.4	81.6	77.5	-	30	-	-	-
Potassium	Acute health	mg/L	13.8	8.4	8.6	-	50	-	-	-
	Aesthetic	mg/L	13.8	8.4	8.6	-	50	-	-	-
Alkalinity		mg/L as CaCO3	347.0	399.0	428.9	-	-	1200	-	-
Langelier index	Aesthetic		-0.2	-0.3	0.1					-0.2 - 0.2

Results are colour coded as follows:

100	Exceeds DWAF Domestic standards Target Water Quality Range (TWQR) or SANS241:2015 standards
Underlined	Exceeds DWAF Recreation full contact TWQR
Blue fill	Exceeds DWAF Irrigation water TWQR

Analyte	Risk	Units	CE_BH1	CE_BH2	Boorgat	SANS 241:2015	DWAF Domestic	DWAF Industrial Category 4	DWAF Recreation Full contact	DWAF Irrigation
Ryznar index	Aesthetic		7.6	7.5	6.6					
Total hardness	Aesthetic	mg/L	473.5	533.9	496.8	120	120	1000	-	40
Sodium adsorption ratio			0.53	0.39	0.37					1.5
Chemical determinants - micro-determinants										
Antimony as Sb	Chronic health	ug/L	<2			20				
Arsenic as As	Chronic health	ug/L	<5			10	10	-	-	100
Boron as B		ug/L		<80	280	2400	-	-	-	500
Cadmium as Cd	Chronic health	ug/L	<3.1			3	5	-	-	10
Total chromium as Cr	Chronic health	ug/L	<27			50	50	-	-	100
Copper as Cu	Chronic health	ug/L	<20	<20		2000	1000	-	-	200
Cyanide (recoverable) as CN-	Acute health	ug/L	6			200	-	-	-	
Iron as Fe	Chronic health	ug/L	100	100	<40	2000	1000	10000	-	200
	Aesthetic	ug/L	100	100	<40	300	-	-	-	
Lead as Pb	Chronic health	ug/L	<7			10	10	-	-	200
Manganese as Mn	Chronic health	ug/L	200	190	190	400	5000	10000	-	20
	Aesthetic	ug/L	200	190	190	100	50	-	-	
Mercury as Hg	Chronic health	ug/L	<3.3			6	1	-	-	
Nickel as Ni	Chronic health	ug/L	6			70		-	-	200
Selenium as Se	Chronic health	ug/L	<12			40	20	-	-	20
Uranium as U	Chronic health	ug/L	<13.8			30		-	-	10
Vanadium as V	Chronic health	ug/L	1			-	100	-	-	100
Aluminium as Al	Operational	ug/L	33			300	150	-	-	5000

3. Suitability for non-potable domestic use

City of Cape Town (COCT) by-laws (2010) currently prohibit the use of alternative water sources for domestic purposes, which includes drinking, ablution (washing) and culinary uses. Proposed amendments to these bylaws (expected to be promulgated soon) allow use of alternative water sources for domestic purposes, as long as prior written approval has been obtained from the Director, and that any conditions required are met.

COCT *Guidelines for installation of alternative water systems in Cape Town* (2017) specify the quality limits to be used for assessing various water uses (Table 2). The Croydon groundwater quality is screened against these guidelines in Table 1.

Table 2: Water quality guidelines for various uses as specified by COCT (2017)

WQ-Agricultural use(irrigation) (DWAF, 1996d)	WQ-Industrial use (DWAF, 1996c)	WQ Recreational use (DWAF, 1996b)	WQ Domestic use (DWAF, 1996a)	SANS 241:2015	No guideline
Plant bed irrigation	Fire fighting		Fish ponds	HVAC	Toilet flushing
Food garden & lawn	Vehicle cleaning		Indoor surface & kitchen cleaning	Drinking	
	Outdoor hard surface cleaning		Laundry washing	Water features (contact e.g. splash parks)	
			Cooking & food prep	Swimming pools	
			Body washing (ablution)		
			Water features (no contact)		

3.1. Flushing toilets

There are no guideline values for flushing toilets, therefore the groundwater could be used for flushing toilets. There are some proviso's:

- The presence of manganese above the aesthetic threshold could result in staining of toilets.
- The elevated Ryznar index suggests potential for metal piping work or plumbing fixtures to be corroded, but if PVC piping or ceramic is used, this will not be an issue.

3.2. Swimming pools

According to COCT guidelines, swimming pool water should comply with the SANS 241 drinking water standards. This is based on Notice 1229 (2015) in the Government Gazette: *National Health Act, 2003 (Act No. 61 of 2003) - National Environmental Health Norms and Standards for Premises and Acceptable Monitoring Standards for Environmental Health Practitioners* which sets out specifications for management of public and semi-public swimming pools. However, according to WHO (2006), appropriate allowance can be made for the much lower quantities of water ingested and shorter exposure periods when screening swimming pool water against drinking water standards.

The variables that exceed the SANS 241 guidelines in the borehole water include EC/TDS, sulphate, chloride, sodium, manganese and turbidity. The sulphate content only marginally exceeds the

aesthetic drinking water guideline, potentially causing a slightly bitter taste. As the swimming pool water is not intended for drinking purposes, this is not of concern. Although the salt content is elevated, it is not higher than would be expected in a salt chlorinated pool, and the risks to health are minimal. Manganese may result in staining issues, and turbidity could lead to murky water.

Potential health risks related to use of groundwater for swimming pool top-up are:

- Risk of disease through microbial infection – microbes in groundwater have not been analysed. However, microbes in pools are managed through chlorination, and as long as chlorination levels remain within prescribed ranges, the pool water should be disinfected.
- Risk of formation of disinfection byproducts – chlorination of water containing dissolved organic carbon can lead to the formation of disinfection byproducts, such as trihalomethanes. Long term exposure to trihalomethanes increases the risk of developing cancer. The groundwater has not been tested for the presence of dissolved organic carbon, and it is recommended that this is done before utilising groundwater for swimming pools.

Corrosion of metal piping and fittings should again be considered.

3.3. Household use – laundry & dishwasher

Aesthetic aspects of the drinking water standard that affect the ability to use water for laundry and dish washing include:

- Hardness i.e. degree to which the water will form a lather with soap. The groundwater is very hard, indicating that it will not easily form a lather with soap, limiting it's usefulness for applications requiring soap, such as showering, laundry and dishwashing.
- LSI and RSI –the three groundwater samples indicate a tendency to corrosivity. Corrosion is most evident in copper pipes and mild steel, but can also affect stainless steel systems.
- Manganese – the presence of manganese in the groundwater can result in staining.

It is not recommended to use the groundwater for laundry and dishwasher use without treatment such as softening and reducing the corrosive potential of the water.

3.4. Household use – ablution (showering/bathing)

The requirements for ablution are similar to those for swimming pool water. However, the following should be noted:

- shower water will not be treated by chlorination as swimming pool water will be, therefore there is a greater risk of exposure to microbes. Microbial content should be assessed prior to utilising the water for showering.
- Ablution water will be run through pipes and other plumbing fixtures, and there is a risk of corrosion of these fixtures.
- The hard nature of the water will mean that soaps are unlikely to lather.
- The presence of manganese in the water may lead to staining.

4. Summary

The groundwater quality from the Croydon Vineyard Estate has been assessed for various water uses. The findings are as follows:

- Irrigation of vineyards – **not viable** as vine yields are likely to be affected. Potential for corrosion and clogging of irrigation equipment.

- Irrigation of lawns and gardens – **may be viable** if salt tolerant species are planted. Potential for corrosion and clogging of irrigation equipment.
- Flushing of toilets – **viable**, as long as non-metal plumbing is used. May be some staining due to manganese.
- Swimming pool top-up – **viable**, although would be advisable to test for dissolved organic carbon prior to making a decision.
- Laundry and dishwasher use – **not viable** with untreated water due to hardness, potential for corrosion, potential for staining.
- Ablutions – **not viable** with untreated water due to hardness, potential for corrosion, potential for staining, and potential for exposure to microbes. Not currently permitted by City of Cape Town.

5. References

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