Ellen Brook Catchment

Water Quality Monitoring

July – October 2012

Plate 1: Bingham Rd Creek (EBICG, 2012).

Prepared by the Ellen Brockman Integrated Catchment Group: March 2013.

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1. Acknowledgements

This report was prepared for the Ellen Brockman Integrated Catchment Group (EBICG) by Natural Resource Management Officer, Bonny Dunlop-Heague. Water samples were collected with the help of Megan O'Grady and various work experience students from Edith Cowen University. Samples were analysed by the National Measurement Institute (NMI), an accredited laboratory of the National Association of Testing Authorities (NATA).

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2. Executive Summary

The assessment of water quality within the Ellen Brook catchment was undertaken between July and October 2012 in compliance with the sampling and analysis plan (Appendix G). The objective of the 2012 snapshot is to provide baseline information on the water quality within the Ellen Brook catchment, and to identify high contaminant contributing sub-catchments, emergent and ongoing trends. Recommendations are then made for areas with nutrient and metal concentration levels outside the Australian and New Zealand Environment and Conservation Council water quality guidelines for aquatic ecosystems (2000) to improve or maintain water quality in the catchment, and mitigate detrimental environmental effects in the Swan–Canning estuary system. Intensive clearing, grazing and fertiliser use combined with poor sandy soils in the Ellen Brook catchment has historically contributed a large amount of nutrients entering the Swan-Canning system. The high nutrient levels contribute to algal blooms in the upper reaches of the Swan River.

It must be noted that this assessment was based on once-off grab sampling of water quality in July, August, September and October from 27 selected sites within the Ellen Brook catchment (Figure 2). Consequently, the results represent the condition of the water in the catchment at the time of sampling only. Twenty six of the sites were tested for physical parameters (pH, salinity, temperature and total suspended solids) and nutrients, including total nitrogen (TN), total oxidised nitrogen (TON), and filterable organic nitrogen (FON), total phosphorous (TP), total filterable phosphorous and soluble reactive phosphorous (SRP). Total metals and total water hardness were sampled from seven strategically identified sites.

Comparison to previous nutrient data collected by the Ellen Brockman Integrated Catchment Group indicates that nutrient concentrations have remained relatively static at most sampling sites since 2005; however they have increased slightly since 1996. Acidity has also remained relatively static at most of the sampling sites since 2005. However the increase in acidity since 1996 at a number of sampling sites (identified in Figure 8) is of great concern to the ecological health and function of the Ellen Brook and agricultural production. If left unmanaged this could become a major issue for landholders in terms of agricultural production with metal toxicity affecting livestock and soil condition. Continued monitoring will help identify potential trends and patterns as more data is collected over a greater period of time. All data is entered into the Department of Water's Water Information Network (WIN) database and available to the public.

3. Key Findings

- Total Nitrogen and Total Phosphorous were found in relatively high concentrations, above the guideline trigger values, across the catchment.
- The sub-catchments to the west of the Ellen Brook were the primary sources of total nitrogen in the catchment. Nitrogen was mostly in soluble form at sites with high TN concentrations.
- The sub-catchments to the west of the Ellen Brook were the primary sources of phosphorous. The phosphorous was mostly in soluble form at sites with high TP concentrations when compared to the ANZECC Guidelines.
- All western sub-catchment sampling sites had high total nitrogen, total phosphorous and filterable reactive phosphorous concentrations which were above the ANZECC trigger values. Muchea North (EBN11) was identified as the highest contributor of these nutrients to the Ellen Brook.
- All western sub-catchment sampling sites had total oxidised nitrogen(TON) concentrations above the trigger value.
- Lennard Brook (EBN1), Yal Yal Brook (EBN5) – sub catchments to the east of the Ellen Brook, and Egerton (EBN26) and Roxburgh Ave (EBN29) – sub catchments to the west of Ellen Brook were identified as the greatest contributors of TON to the Ellen Brook.
- Wandena North (EBN7) and Muchea East (EBN10) had low pH levels, which were outside the guidelines, and were identified as contributors of metals to the Ellen Brook.
- Results from Table 1 show that the majority of sites exceeded the lowland trigger value for conductivity on most sampling occasions. This is more evidence to show that salinisation of waterways is an issue in the Ellen Brook catchment. Marginal to brackish conductivity levels were recorded predominantly in the main channel of the Ellen Brook and the subcatchments to the east of Ellen Brook including Wandena North (EBN7) and Muchea East (EBN10), (Table 7).
- Acidity of surface water, potentially due to the effects of exposure of soils containing iron sulphide and acid groundwater seepage, in the Ellen Brook catchment is becoming an issue. These identified sites should continue to be investigated and include Wandena North (EBN7), Muchea East (EBN10) and Upper Yal Yal (EBN28).
- Aluminium and Iron concentrations were above the ANZECC guidelines at all metal sampling sites, on every sampling occasion.

Table 1: Number of sites (out of a total of 27) equal to or exceeding the ANZECC Water Quality Guidelines and trigger values.

*Note, metals out of a total of seven sampling sites. Cadmium, Chromium, Copper, Lead, Nickel and Zinc ANZECC water quality trigger values have been modified according to Water Hardness (Appendix) and must be equal to or exceed the Hardness-modified Trigger Value to be over the guideline.

Parameter	**Number of Sampling Sites**	**D.O.W Interim Guideline**	**ANZECC Trigger Value**	**Water Quality Trigger Value-lowland rivers**				**Total Suspended Solids-DOE Interim Guideline**			
				18th July	27th Aug	24th Sept	17th Oct	18th July	27th Aug	24th Sept	17th Oct
Physical											
pH	27		6.5-8	4	8	4	3				
Conductivity	27		0.12-0.3 mg/L	22	24	23	16				
Total Nitrogen	27		1.2 mg/L	17	19	17	10				
Total Oxidised Nitrogen	27		0.15 mg/L	7	4	4	4				
Nitrogen as Ammonia	27		0.08mg/L	5	3	4	2				
Total Phosphorous	27		0.065 mg/L	14	17	16	10				
Soluable Reactive Phosphorous	27		0.04 mg/L	13	17	16	9				
Total Suspended Solids	27	6mg/L						4	6	6	6

Metal	**Number of Sampling Sites**	**Hardness Modified Trigger Value (400)**	**ANZECC Trigger Value (mg/L)**	**21st July**	**17th Aug**	**15 th Sept**	**20th Oct**
Aluminium	7		0.055	7	7	7	5
Arsenic	7		0.024	0	0	0	0
Cadmium	7	0.002mg/L	0.0002	0	0	0	0
Chromium	7	0.0049/0.0084mg/L	0.001	0	0	0	0
Copper	7	0.00728/ 0.0126mg/L	0.0014	0	0	0	0
Iron	7		0.3	7	7	7	5
Lead	7	0.04/0.09mg/L	0.0034	0	0	0	0
Mercury	7		0.0006	0	0	0	0
Nickel	7	0.099/0.057mg/L	0.011	0	0	0	0
Zinc	7	0.072mg/L	0.008	0	0	0	0

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5. Background

The Ellen Brockman Integrated Catchment Group (EBICG) was formed in 1996 as part of the Swan Avon Regional Initiative. EBICG focuses on coordinating activities, improving communication between stakeholders, encouraging natural resource management (NRM) in the catchment, which varies from revegetation to improved agricultural practices and property planning to educate landholders on how to best manage their land no matter the size(Horwood & Worley, 1996). EBICG and has developed a catchment management plan for the Ellen Brook catchment and works with the Shires of Chittering and Gingin, as well as the City of Swan to improve the health of the Ellen Brook Catchment (SRT, 2009).

With support from Tronox and the Department of Water (DoW), the Ellen Brockman Integrated Catchment Group commenced an annual sampling program focusing on nutrients, physical parameters and total suspended solids at 20 sites within the Ellen Brook catchment, in 2005 and 2006. Water samples collected from seven strategically selected sampling sites in 2005, and six sites in 2006 were also analysed for heavy metals. In 2007 the number of sampling sites were increased to 27 and 'Muchea South' (EBN12) was removed. In 2008 sampling occurred once every three weeks over a three month period commencing with the first consistent winter flows in July. From 2009 to 2012 sampling occurred monthly over four months. The program was funded through the Ellen Brockman Integrated Catchment Group.

An assessment of the water quality within the Ellen Brook Catchment was undertaken on four occasions, between July and October 2012. The objectives of this snapshot are to provide annual data on the water quality within the catchment, to assess and monitor the outcomes of on ground works carried out to reduce nutrient transport, to monitor areas of high nutrient transport identified in the previous year's sampling, to determine other potential areas of high nutrient transport arising in the catchment as a result of altered land use, and to build on previous results to determine emerging trends in the subcatchments of the Ellen Brook catchment.

EBICG has been sampling the physical water quality parameters since 1999 as part of a large range of activities in monitoring and environmental repair, concentrated on reducing nutrient export from the region. 2012 water quality has been entered on to the Department of Water's (DoW) Water Information

Network (WIN) database.

5.1 Ellen Brook Catchment

The Ellen Brook Catchment is located to the north-east of the Perth metropolitan region and has a gauged area of 71, 500 hectares(Figure 1). The Ellen Brook headwaters start just south of Gingin and run for approximately 60km south through the townships of Muchea and Bullsbrook to its confluence with the Swan River near All Saints Church in Henley Brook. The catchment is situated in three local government authorities, including the Shire of Chittering, Shire of Gingin and the City of Swan(SRT, 2009)

The Ellen Brook and its tributaries (134 subcatchments) form a catchment area shown in Figure 1 as the western portion of the North-East sub region of the Perth Region NRM. These subcatchments include: eastwards flowing groundwater fed streams rising from the Gnangara Mound; westward flowing streams from catchments extending onto the Darling and Dandaragan Plateau; smaller streams and drains flowing into the Ellen Brook from the east and west, rising in the agricultural land on the Swan Coastal Plain (Russell, 2001).

The Ellen Brook, which is an ephemeral stream, discharges into the upper Swan River contributing an average of 8.3% of the total volume each year to this system. The catchment represents the largest coastal subcatchment of the Swan-Canning estuary system, (SRT, 2009).

Despite this relatively small portion of run-off compared to its geographical size, the Ellen Brook catchment is the single largest contributor of nutrients entering the Swan River estuary, on the Swan Coastal Plain (Micenko, 2005). The excessive input of nutrients, predominantly nitrogen and phosphorous, have been partially responsible for regular and potentially toxic algal blooms in the upper reaches of the estuary (DEBCMP, 2000). These algal blooms have caused major ecological disturbances including unsightly scums, foul odours and occasional fish deaths.

According to the Draft Ellen Brook Catchment Management Plan (PPK Environment and Infrastructure, 2000), landuses such as livestock grazing and clearing of vegetation has caused significant land degradation, including soil salinity, wind erosion, water erosion, waterlogging and flooding. These processes lead to phosphorous and nitrogen export. If these processes are left unmanaged it will continue to compromise the catchment's economic, environmental and social value.

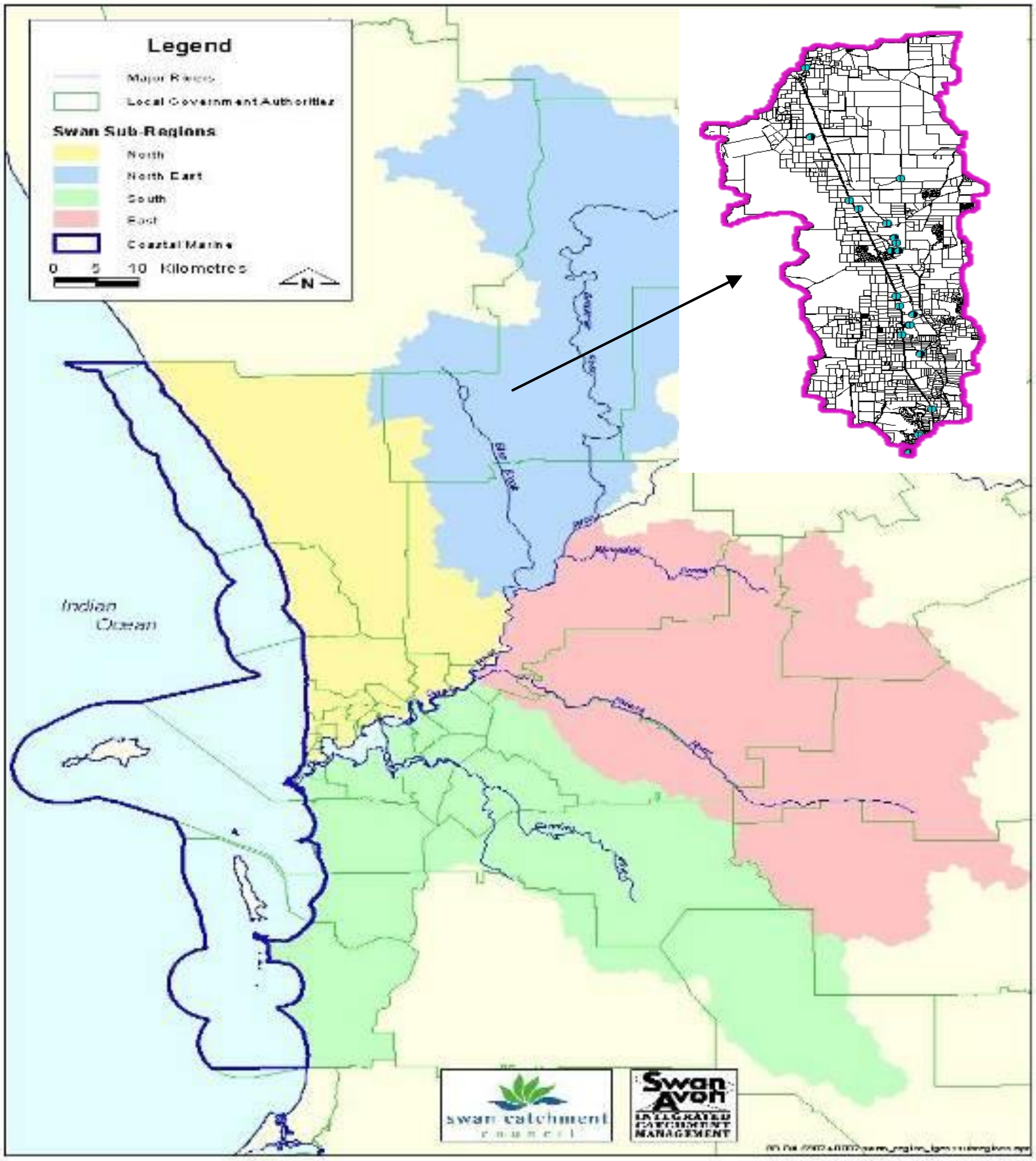


Figure 1: Ellen Brook Catchment Regional Location.

5.1.1 Climate

The Ellen Brook catchment experiences a Mediterranean climate of distinctly dry (and hot) summers and cool wet winters. Mean maximum temperatures range from 17.8ºCin winter and 33.5ºC in summer and mean minimum temperatures range from 8.1ºC in winter to 18ºC in summer. Average Annual rainfall for Pearce is 684.1mm. The break of season has changed from April or May to June or July, and 90% of the rainfall occurs between May and October. The growing season lasts several months. Total pan evaporation is 1934mm/yr, with an average daily evaporation of 10.8mm in January to 1.8mm in June (BOM, 2012).

5.1.2 Geology and Geomorphology

The Ellen Brook catchment can be divided into three major geomorphic regions (Figure 2); the Darling Plateau to the east; the Dandaragan Plateau which covers the north eastern part of the catchment and the Swan Coastal Plain which covers the western portion of the catchment (King & Wells, 1990). The geological setting of the Ellen Brook is strongly linked to nutrient transport, with a noticeable difference in nutrient levels in the east and west of the catchment.

The Darling Plateau is part of the Yilgarn Block in the eastern section of the catchment. The Yilgarn Block is an extensive area of Archaean crust typified by old granite rock outcrops with younger doleritic intrusions. It has been dissected by the Avon River system and includes the following geomorphic characteristics; lateritic uplands, dissected valleys, spurs and valleys below the scarp surface, minor valleys and drainage depressions. It is separated from the Dandaragan Plateau by the Darling Fault (DEBCMP, 2001).

The Dandaragan Plateau, in the north east part of the catchment, is less dissected than the neighbouring Darling Plateau and is covered by sands and laterite overlaying older sedimentary formations. It includes a gentle scarp, sandy (lateritic) uplands and relatively shallow incised valleys. The sand plain features dominate, and the western margin of the Dandaragan Plateau is formed by the Gingin Scarp, a moderately sloping topographical feature formed by shoreline erosion and rising approximately 90 metres above the Swan Coastal Plain (WRC 2002).

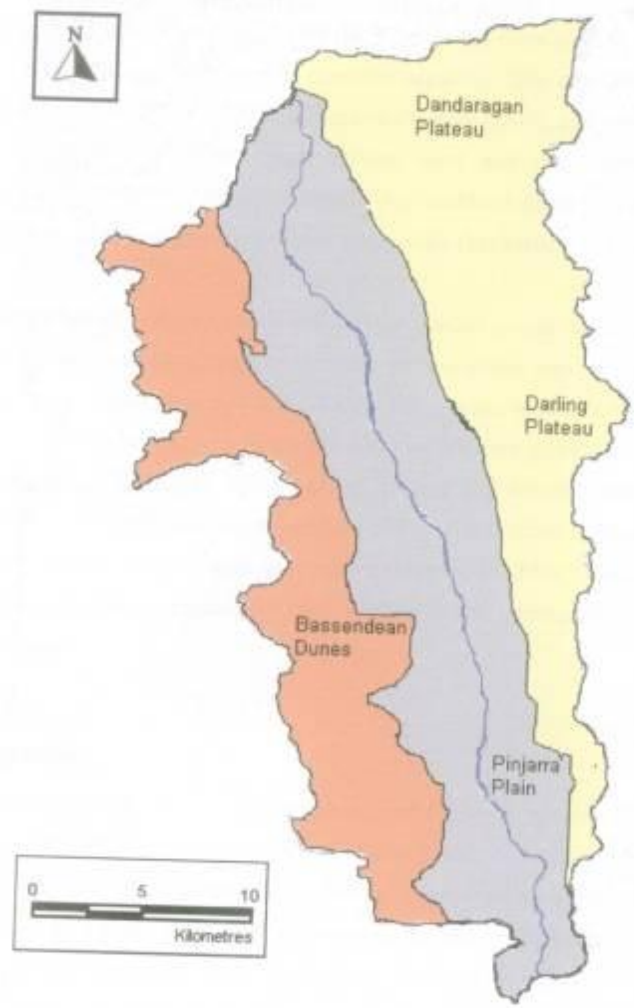


Figure 2: Major Landforms of the Ellen Brook Catchment.

5.1.3 Soil types

Soil types are grouped according to their geomorphic setting. Aeolian deposits on the Swan Coastal Plain are characterised by the Bassendean dune system (Figure 3). These are well drained porous soils with very poor phosphorous retention capacity. The alluvial deposits in the centre of the catchment are part of the Pinjarra Plain landform, and contain soils made up of coalescing alluvial fans with varying sand and clay content subject to water logging in low-lying areas. Soils of this landform often contain a duplex of impermeable clay layers overlain by deep sandy soils (Russell, 2001).

The Darling Plateau and Dandaragan landforms contain lateritic uplands characterised by gravely yellow earths and yellow duplex soils. Minor valleys and drainage depressions often contain soils in which the surface layer of the soil profile is often separated from lower finer textured materials by a layer of gravels or stone (Russell, 2001).

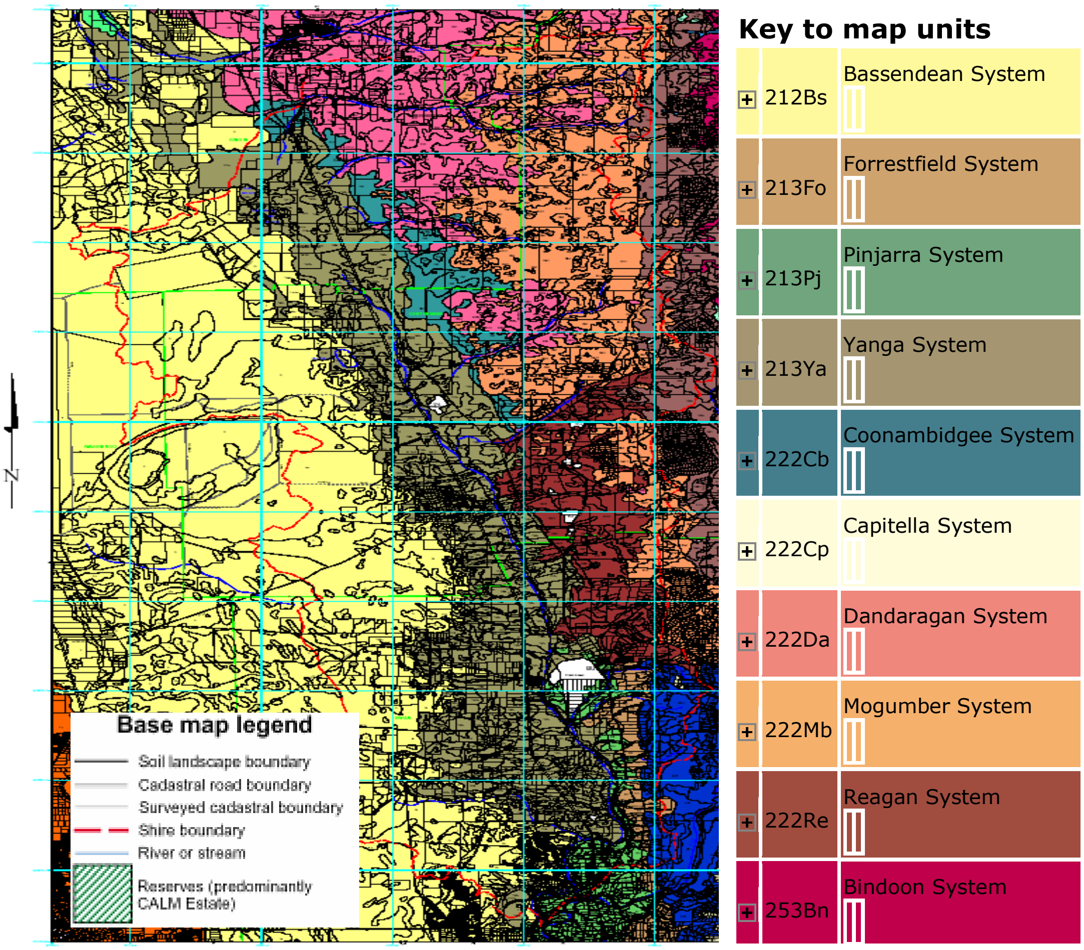


Figure 3: Major landform and soil-landscape of the Ellen Brook Catchment (LandSmart™, 2006)

5.1.4 Vegetation

Weeds in the Ellen Brook catchment are usually soft leaved, decaying quickly and releasing high levels of organic nutrients and carbon. Organic matter accumulated in the soil is released following clearing. Native vegetation contains and releases high levels of tannins and oils into the Ellen Brook catchment (DEBCMP, 2001).

A significant area of the catchment has been cleared. The majority of clearing has occurred in the western margin of the Darling Plateau, parts of the Dandaragan Plateau to the north, and much of the southern section of the Swan Coastal Plain. Remnant vegetation is found in state forests, in the sloping lands of the western edge of the Darling Scarp, in local streamlines and wetlands and in local areas of nature reserves and national parks, and in some isolated areas of privately owned land (DEBCMP, 2001).

5.1.5 Land Use

The majority of the Ellen Brook Catchment has been cleared for either urban use or agriculture. The main categories of agriculture are grazing, horticulture and fodder production. Specific land uses include vineyards and other intensive horticulture, cattle grazing, piggeries, abattoir, chicken farms, gravel extraction, mining, golf courses and residential developments (SRT, 2009).

Pasture and grazing are the largest land-uses in the region, covering over 31,000ha and representing over 85% of all recorded land uses (KBR, 2003). Land use generally changes from cattle grazing and horticulture in the northern parts of the catchment to more urban settlements and small scale light industry in the southern parts(SRT, 2009)

Cattle grazing contributes large amounts of nutrients to the Ellen Brook as the cattle tend to congregate in or around unprotected waterways causing soil compaction and erosion, and directly excreting nutrients into the waterway. The pasture needed to support the cattle is fertilised resulting in an application of over 20kg/ha/yr of phosphate (DECMP 2001). Although the pasture does fix a small amount of phosphorous, most of the nutrients associated with this land use are transported through the soil and into the waterways. The soil has a very poor ability to retain nutrients, which is exacerbated by over stocking and erosion. In comparison, although on a smaller scale with regards to area, horticulture has an even higher concentrated nutrient run off potential. For example, orchards in the north of the catchment are supplied with 65kg/ha/yr of phosphorus, although more established vineyards over ten years old were supplied with half of this amount (Gerritse 1996).

Urban expansion is an issue in the catchment, particularly in the southern part of the region where many large farms have been subdivided into small “lifestyle” sized blocks. It is difficult to predict whether this change in land use will be beneficial or detrimental to water quality in the Ellen Brook (Table 2). If managed appropriately during the planning phase, it may allow for conditions to be in place that will improve or at least maintain water quality. If not managed correctly, issues such as over stocking, increased fertiliser application and herbicide use, increased water use, erosion and more weeds would certainly be detrimental to the water quality in the catchment (CSIRO 1994).

The excessive nutrient load in the Ellen Brook is diffuse because of the nature of the erosion prone, sandy, draining soils with underlying clay layers and high water table which is ideal for the transport of nutrients. All land uses contribute to the nutrient run-off to the Ellen Brook, particularly phosphorus which does not bind in the soil as effectively as nitrogen (Horwood 1997). This nutrient load does not have as much effect on the local environment as it does to the Swan-Canning system.

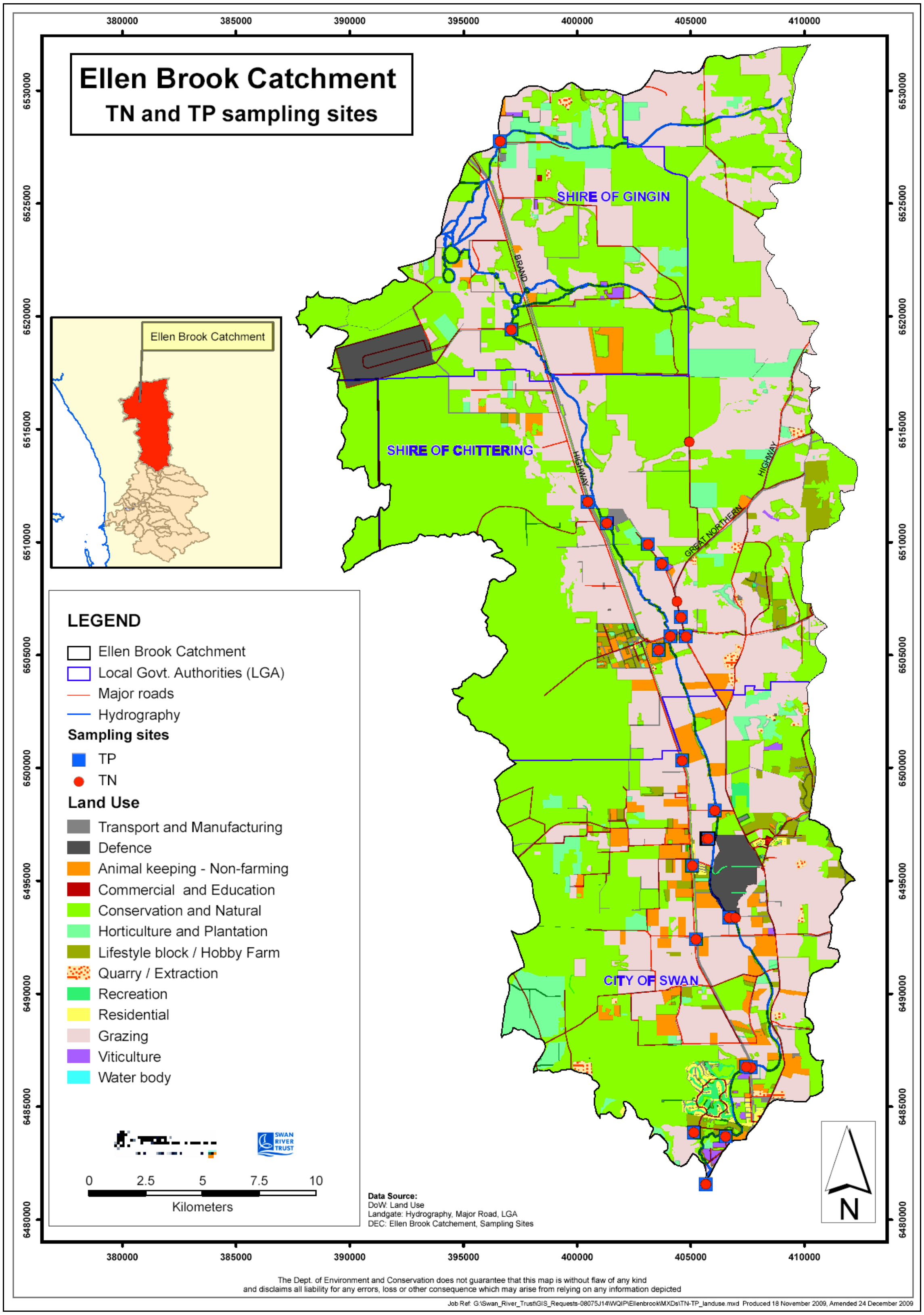


Figure 4: Ellen Brook catchment Land Use map (SRT, 2009).

Table 2: Land Use and Management Issues: Factors affecting Conservation or Protection of Natural Resources (Land Assessment Pty Ltd, 1999).

Water	Deteriorating Water Quality due to; Nutrient loss to drainage (eutrophication) Salinity Other pollutants
Soils	Loss of soil due to; Water erosion Wind erosion
Vegetation	Decrease in amount and quality of vegetation due to; Clearing Weed infestation
Agricultural Productivity	Soil salinity Waterlogging Soil acidity Soil structure decline Water repellence
Land Development	Flooding Waterlogging Ease of excavation/slope instability
Socio economic aspects of land use change	Loss of agricultural land Land use conflict Diversification Fire risk

6. Methodology

Water samples were taken from twenty seven sites within the Ellen Brook catchment (Figure 5). These sites were selected to be representative of a particular part of the catchment, to determine their relative nutrient and metal contribution to the Ellen Brook, and whether they were situated upstream or downstream of potentially high impact land uses or of likely contaminant sources. Table 3 lists the sampled sites by site number, site name and relative waterway component. Site location is also provided using street names, northings and eastings.

Table 3: Site information including site number, site name, waterway section/component, location, northings and eastings.

Site no.	Site Name	Waterway section/ Component	Location	Northing	Easting
EBN1	Lennard Brook	Lennard Brook	Lennard Brook Road	6527771	0396613
EBN2	Airfield Road	North Chandala/Ellen Brook (Bambun Lakes)	Airfield Road	6519428	0397101
EBN3	Chandala West	Chandala Brook West	Brand Hwy west loc # 853	6511801	0400463
EBN4	Chandala South	Chandala Brook South	Brand Hwy east / TIWest	6510846	0401302
EBN5	Yal Yal Brook	Yal Yal Brook	Reserve Road	6514458	0404923
EBN6	Rocky Gully Creek	Rocky Gully Creek	Old Gingin Rd	6509047	0403714
EBN7	Wandena North	Waterway to Ellen Brook	Wandena North - Great Northern Highway	6507384	0404384
EBN8	Wandena South	Waterway to Ellen Brook	Wandena South - Great Northern Highway	6506686	0404561
EBN9	Brand Hwy Bridge	Ellen Brook - Muchea Central	Bridge on Brand Hwy south	6505838	0404093
EBN10	Muchea East	Waterway to Ellen Brook Muchea East	Great Northern/Brand Highways	6505833	0404780
EBN11	Muchea North	Waterway to Ellen Brook -	Muchea south /Railway Rd 491 chit/swan sign	6500336	0404611
EBN13	Rutland Road	Ellen Brook (upper)	Rutland Road bridge	6498117	0406044
EBN14	Nutrient Inflow	Waterway – Nutrient stripping inflow	Bingham Road/ Department of Defence	6496871	0405690
EBN15	Nutrient Outflow	Waterway - Nutrient stripping Pond outflow	Bingham Road/ Department of Defence	6496885	0405757
EBN16	Bulls Brook	Bullsbrook	Sth past Strachan on Railway Rd	6495684	0405054
EBN17	Warren Road	Mid Ellen Brook	Warren Road	6493379	0406685
EBN18	Gauging Station	Ellen Brook - Almeria Gauging Station	Almeria Parade/Apple Street	6486743	0407638
EBN19	Belhus Reserve	Lower Ellen Brook	Belhus Reserve Millhouse Rd Bridge	6483685	0406519
EBN21	Lower Yal Yal	Yal Yal Brook South	Old Gingin Road	6509922	0403110
EBN22	Ki-it Brook	Ki-it Brook	Warren Road	6493382	0406959
EBN23	Peters Road	Waterway to Ellen Brook – Muchea town site	Peters Road	6505232	0403580
EBN24	Stock Road	Waterway to Ellen Brook West	Railway Parade	6492415	0405221
EBN25	Sawpit Gully	Waterway to Ellen Brook – The Vines north	Lot 4/285 Railway Parade, Upper Swan	6486777	0407430
EBN26	Egerton	Waterway from Egerton Estate to Ellen Brook	Corona Way	6483859	0405129
EBN27	Wandena Road	Waterway to Ellen Brook	Corner of Great Northern Hwy and Wandena Road	6502590	0406553
EBN28	Upper Yal Yal	Yal Yal Brook North	Great Northern Hwy	6516783	0409421
EBN29	Roxburgh Avenue	Drain leading to Ellen Brook from The Vines east	Roxburgh Avenue	6486603	0406975

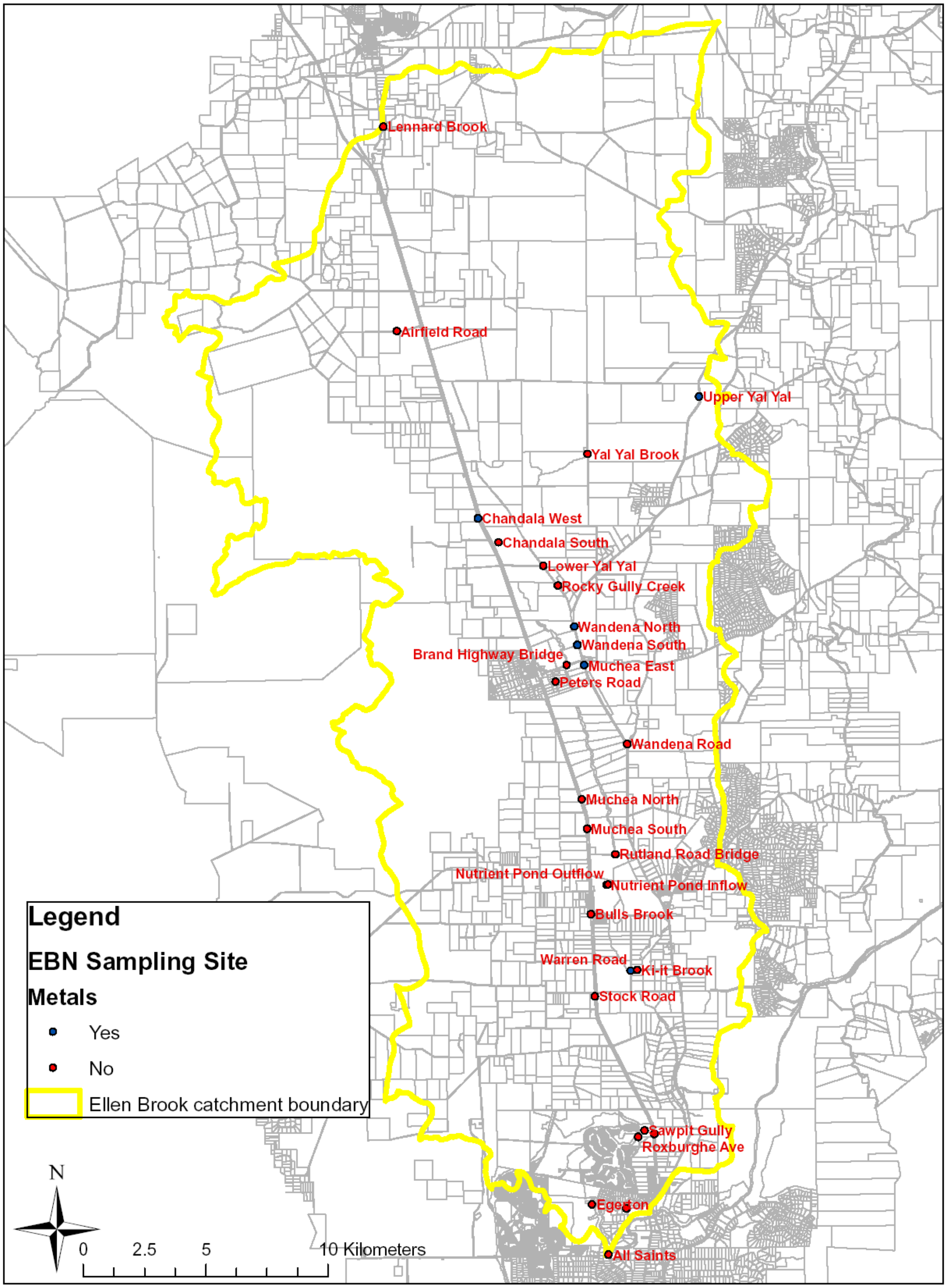


Figure 5: Ellen Brook water quality sampling site locations.

6.1 Water Sampling

Western Australia experienced a below average rainfall year in 2012. With the total annual rainfall for Perth recorded as 649.4mm. The average total annual rainfall for Perth is 732mm, and 684mm for Pearce RAAF Base (BOM, 2012). In 2007 the Pearce RAAF received a total of 626.2mm In 2008 Pearce received a total of 610.8mm. In 2009 Pearce received a total of 554.9mm. In 2010 Pearce received at total of 347.2mm. In 2011 pearce received a total of 638.6mm which is 93% of the average rainfall. In 2012 Pearce received 543.7mm which is approximately 80% of the average. Because of this one site did not flow at all in 2012 with several other sites drying up before the October sampling run. (Appendix F).

Sampling occurred on 18-19th July, 27–28th August, 24-25th September, and 17-18th October. The collection of the samples followed strict protocols to prevent contamination and ensure consistency in results. An outline of the sample collection technique is included in the Ellen Brook sampling and analysis plan 2012 (Appendix G). Field observation forms were filled out for each water sample. All samples were transported under 'chain of custody' to NMI and were analysed in accordance with the laboratory methods. All samples collected from the Ellen Brook catchment were analysed by NMI laboratory, which has been accredited by the National Association of Testing Authorities (NATA).

6.2 Water Analysis

Water at each of the sites was measured *in situ* for physical properties (pH, conductivity and temperature), using WTW pH and EC probes. Samples were also collected and analysed for a range of contaminants likely to be present in semi-rural, industrial and urban catchments. They were then sent to NMI laboratory to be analysed for nutrients including total nitrogen (TN), total phosphorus (TP), total filterable phosphorous (TFP), total oxidised nitrogen (TON), soluble reactive phosphorus (SRP), dissolved organic nitrogen (DOrgN), nitrogen as ammonia (NH4-N), and total suspended solids on each sampling occasion.

Samples from Chandala South (EBN4), Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10), Warren Road (EBN17), Brand Hwy (EBN9) and Upper Yal Yal (EBN28) were also collected and sent to NMI laboratory for analysis of metals on each sampling occasion. NMI analysed the samples for the following metals; cadmium (Cd), mercury (Hg), arsenic (As), copper (Cu), lead (Pb), zinc (Zn), aluminium (Al), chromium (Cr), iron (Fe) and nickel (Ni). Table 4 summarizes analysis techniques used for physical parameters, nutrients and heavy metals by NMI.

Table 4: Summary of chemical analysis techniques.

Parameters	**Limit of Reporting (LOR)**	**Variable Unit**	**Analysis Technique**
Cond (Comp25ºC)	1	uS/cm	direct read
pH	0.05		direct read
TSS	1	mg/L	grav
PO_4-P	0.003	mg/L	DA
NOx-N	0.005	mg/L	DA
TP	0.01	mg/L	DA
TN	0.05	mg/L	DA

Parameter	**Limit Of Reporting (LOR)**	**Variable Unit**	**Analysis Technique**
Inorganics			
Aluminium	0.005	mg/L	NT2.47
Arsenic	0.001	mg/L	NT2.47/2.51
Cadmium	0.0001	mg/L	NT2.47
Chromium	0.001	mg/L	NT2.47
Copper	0.001	mg/L	NT2.47
Iron	0.005	mg/L	NT2.47
Lead	0.001	mg/L	NT2.47
Mercury	0.0001	mg/L	NT2.47/2.44
Nickel	0.001	mg/L	NT2.47
Zinc	0.001	mg/L	NT2.47

7. Results and Discussion

The National Water Quality Management Strategy provides guidance on both ecosystem and human health protection. Water quality guidelines are provided for a range of environmental values including aquatic ecosystems, primary industries, recreation and aesthetics, drinking water, industrial water, cultural issues, and monitoring and assessment (ANZECC & ARMCANZ, 2000). This report will compare sample concentration results with aquatic ecosystem trigger values for lowland river systems and, when necessary, livestock drinking water trigger values. This is in accordance with the trigger values suggested in the Draft Ellen Brook Management Plan.

The guidelines recognise three levels of protection for aquatic ecosystems; those with high conservation value, slightly to moderately disturbed ecosystems and highly disturbed ecosystems. To assess the level of toxicant contamination in aquatic ecosystems, trigger values were developed from data using toxicity testing on a range of test species. The trigger values (99%, 95%, 90% and 80%) approximately correspond to the levels of protection described above. This report will use the 95% protection level for aquatic ecosystems due to the high conservation value of the receiving environment of the Swan River.

Six metals (cadmium, copper, chromium, lead, nickel, mercury and zinc) are known to have varying toxicity in different water hardness and so were compared to the ANZECC hardness-modified trigger values (HMTV). Refer to Appendix E for details on calculations.

It is important to note that exceedence of the trigger value does not indicate that “standards” are not being met, but is rather an indication that further consideration should be given to the situation. An exceedence of the trigger value indicates that there is the potential for an impact to occur and should therefore trigger a management response such as further investigation or adaptation of the guidelines according to local conditions (ANZECC & ARMCANZ 2000). No ecosystem is pristine, so when using guidelines the realistic and achievable water quality of the Ellen Brook should be considered.

7.1 Water Quality

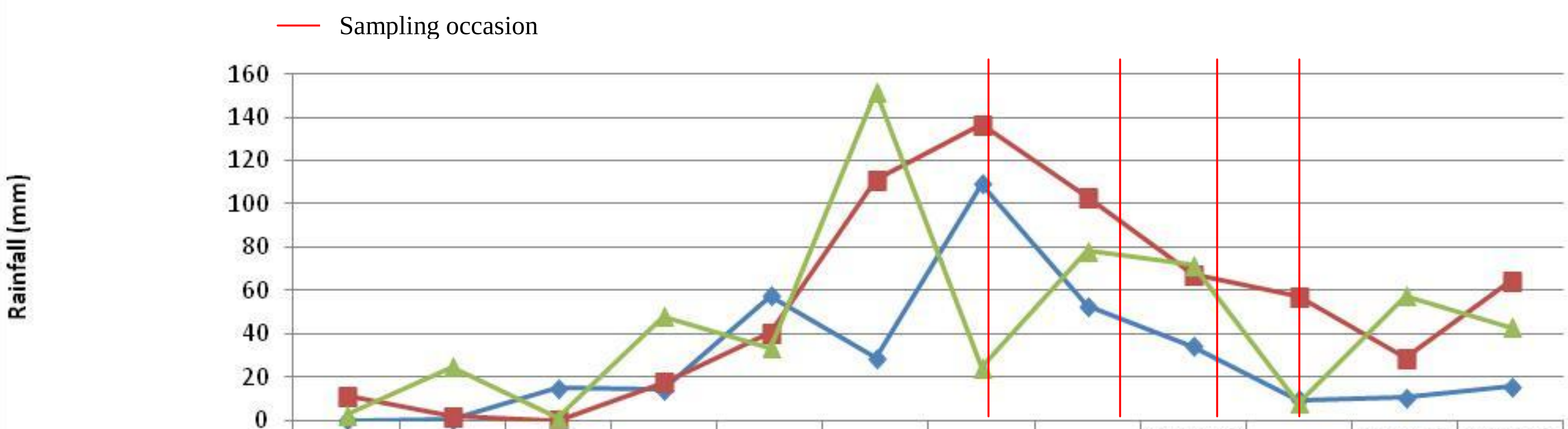
7.1.1 Flow and Rainfall

According to the DEBCMP (2000) runoff from the Ellen Brook catchment consists of approximately 60% surface and near-surface runoff, with 40% shallow groundwater flow. Additionally, it has been suggested that surface runoff from agricultural paddocks during the winter months is the primary cause of nutrient (nitrogen and phosphorous) discharge to streams within the catchment. The existing townships including Pearce, Bullsbrook and Muchea also contribute small amounts to the total load. Muchea and West Bullsbrook are unsewered townships.

Muchea and Bambun are situated on Palusplains which are seasonally waterlogged plains or flats. Groundwater levels vary seasonally and in relation to rates of recharge from rainfall, evapo-transpiration, changes in vegetation and land use, and groundwater extraction. The shallow depth to groundwater for the low lying portion of the Ellen Brook catchment and the risk of seasonal inundation places constraints on urban and industrial development, and facilitates the transport of readily soluble nutrients into the waterways.

Flow from the Ellen Brook into the Swan River occurs as a result of winter rainfall and groundwater seepage, and ceases over the summer months. The Lennard Brook and Yal Yal Brook are perennial streams which depend on groundwater discharge during the hotter months.

Figure 6 shows the total rainfall for Station 009053 – Pearce RAAF Base. In 2010, July had the highest monthly rainfall of 109.2mm. Overall the season was very dry which severely impacted on revegetation efforts in the catchment, particularly in the more sandy sites where water retention is at its lowest. In 2011 July had the highest monthly rainfall, however the season broke earlier with the 2nd highest monthly rainfall in June. There was however a continuous rainfall season which was beneficial for revegetation projects, but also caused significant growth of summer weeds. In 2012 the season broke in June with the highest monthly rainfall received in June but unfortunately July was very dry and no substantial rain was received until August.



	January	February	March	April	May	June	July	August	September	October	November	December
2010 Pearce RAAF	0	0.2	15	14.2	57.6	28.8	109.2	52.6	34.2	9.4	10.4	15.6
2011 Pearce RAAF	11	1.6	0	17.4	40.2	111	136.6	103	67.4	57.2	28.8	64.4
2012 Pearce RAAF	2.4	24.6	0.8	48	33.6	151.8	24.4	78.1	71.6	7.8	57.6	43

Month

Figure 6: Total monthly rainfall for 2012, 2011 and 2010 within the Ellen Brook Catchment at 009053 – Pearce RAAF Base.

All samples taken were from sites with flowing water at a depth ranging from 10-20cm below the surface and not in contact with the sediment at any time. Water temperatures ranged from 2.2ºC to 26.6ºC (Figure 7). Temperatures recorded during the July sampling run ranged between 2.2ºC and 16.8ºC. Temperatures recorded during the August sampling run ranged between 12ºC and 17.6ºC. Temperatures recorded during the September sampling run ranged between 15.6ºC and 24.4ºC. Temperatures recorded during the October sampling run ranged between 15.6ºC and 26.6ºC.

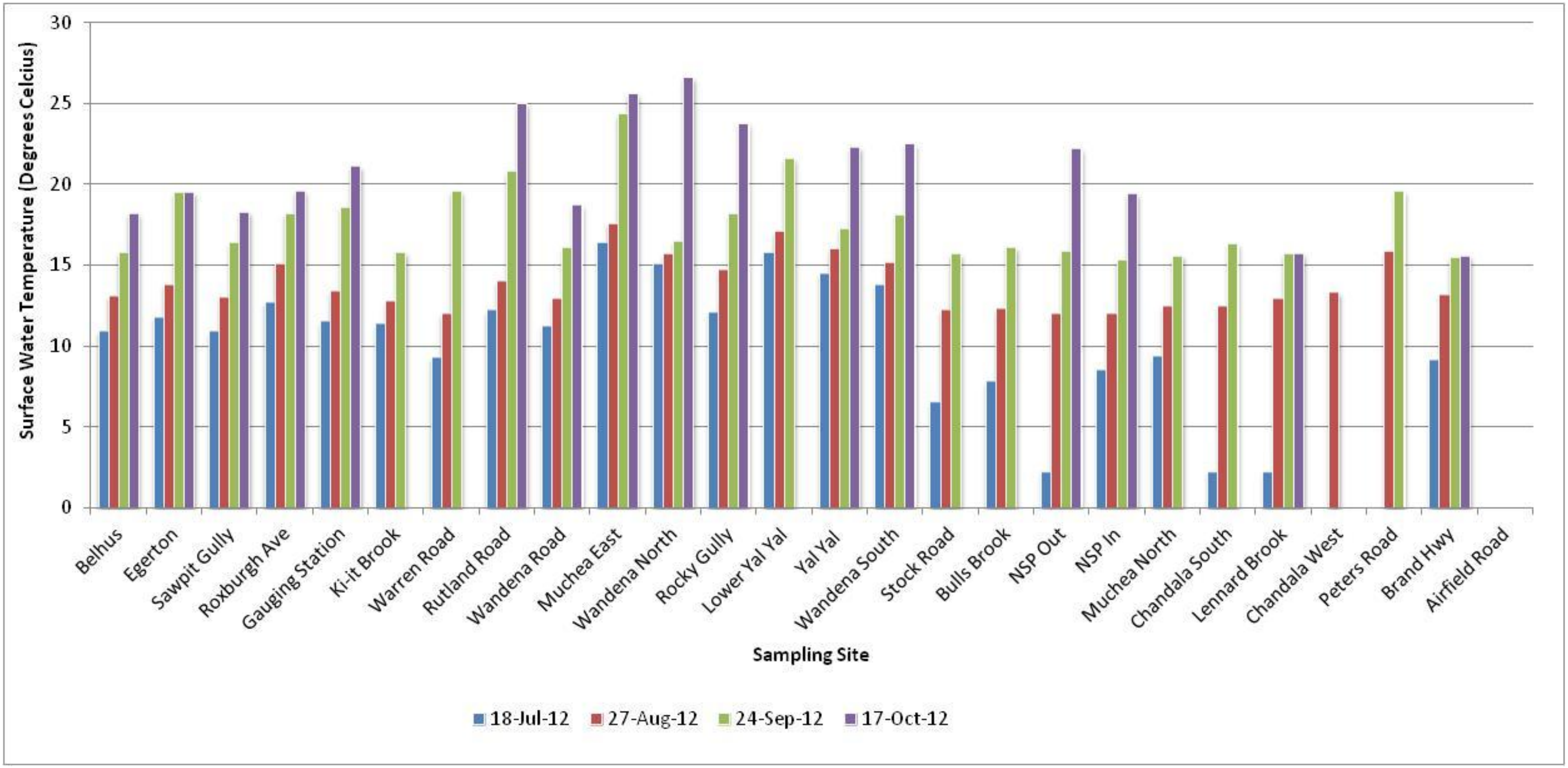


Figure 7: Temperature of surface waters sampled between July and October within the Ellen Brook catchment in 2012.
* Note, blanks represent no sample.

7.2 Physical Properties

7.2.1 pH

pH is a measure of acidity and alkalinity. It is measured on a logarithmic scale with a pH of 7.0 being neutral, a pH of less than 7 being acidic and a pH of greater than 7 being alkaline or basic. The importance of pH lies mainly in its effect on other water quality parameters, chemical reactions and aquatic organisms. For example, pH can affect the solubility and toxicity of a wide range of metal contaminants (IEA 2003). No pH data was collected at Upper Yal Yal (EBN28) as it is known to have extremely acidic pH values and would have possibly damaged the monitoring equipment.

The majority of pH levels recorded within the Ellen Brook catchment were within the ANZECC water quality guidelines of 6.5-8 for lowland rivers (Figure 8). There was little variation in pH among most sites or between most sampling occasions.

Wandena South (EBN8), Wandena North (EBN7) and Muchea East (EBN10) recorded pH levels below the ANZECC Guidelines on each sampling occasion (Figure 8). These three sites have consistently recorded pH levels lower than the ANZECC guideline since the 2005 water quality sampling program. There has been a significant drop in pH at Muchea East (EBN10) since the 2005 water quality monitoring program. In 2005 pH ranged between 6.3 and 6.95. In 2011 pH ranged between 3.4 and 6.2 This is potentially due to clay extraction pits located upstream of the tributary. Dewatering clay pits located higher up in the catchment may have contributed to pulses of increased acidity being released from those sites. An acidic dam, with a recorded pH as low as 2.8 is on a neighbouring property. Therefore, sites situated downstream of existing clay pits require regular monitoring. Interactions with groundwater could also impact the level of pH, and warrants further investigation.

According to Parsons Brinckerhoff et al. (2006), the overlying gravely sands found at the Wandena and Muchea East subcatchments are slightly acidic with pH values ranging between 5 and 6. pH was found to decrease with increasing depth to the clay horizon. At a depth of 2m pH values were recorded around 5. At a depth of 10m pH was recorded as low as 3.63. The likely source of actual acidity identified by Parsons Brinckerhoff included;

- Historic precipitation of iron sulphides under anoxic marine conditions and subsequent oxidation of sulphides forming sulphuric acid as sea levels declined.
- Some of the acidity would have been leached by rainfall infiltration.
- Some of the acidity may have been lost by displacement of cations (e.g. Al3+, Mg2+) on cation exchange sites of clay minerals.
- Potential acidity was only encountered beneath the watertable at a 15m depth as expected because of the relatively permanent anoxic condition.

Therefore, these soils are naturally acidic, however disturbance and excavation works carried out at these sites has altered the groundwater table and the relationship between anoxic and aerobic conditions. This has resulted in sulphides in the soil forming sulphuric acid that mobilises metals in the soil profile. Refer to Table 5 for pH value of Wandena North (EBN7), Wandena South (EBN8) and Muchea East (EBN10).

Sawpit Gully (EBN25) and Warren Rd (EBN17) recorded pH values below the ANZECC Guideline on 1 out of 4 sampling occasions. This was during the first sampling occasion at both sites. All other sampling occasion recoded pH values within the guidelines, these results at this stage will be considered an anomaly however these site will be closely monitored in 2012 to ensure that they do not measure outside the ANZECC Guideline.

Lennard Brook (EBN1) and Yal Yal Brook (EBN5) have been identified in previous Ellen Brook Snapshot Reports as a potential cause for concern due to low pH values being recorded, below the ANZECC guidelines, in November 2006. Their respective values were 4.36 and 5.65. Since 2007 pH levels have remained within the guidelines on nearly all sampling occasions. In 2012 both Lennard Brook and Yal Yal Brook remained within the ANZECC guidelines on each sampling occasion.

Peters Rd (EBN 23) recorded pH levels above the ANZECC guidelines on two out of two sampling occasions (Figure 8) This sites have been sampled since 2007 and prior to 2011 had never previously exceeded ANZECC guidelines on more than one occasion. Increased pH can be caused by a combination of factors including reduced flow and an increase in temperature resulting in algal growth. Increased algal growth can result in an increase in pH. This is likely due to the reduced flow that was experienced at this site throughout the sampling period however investigations will be made to any land use changes that could have attributed to the increase in pH. This site will be closely monitored in the 2013 sampling run to ensure these results are an anomaly rather than a decline in water quality.

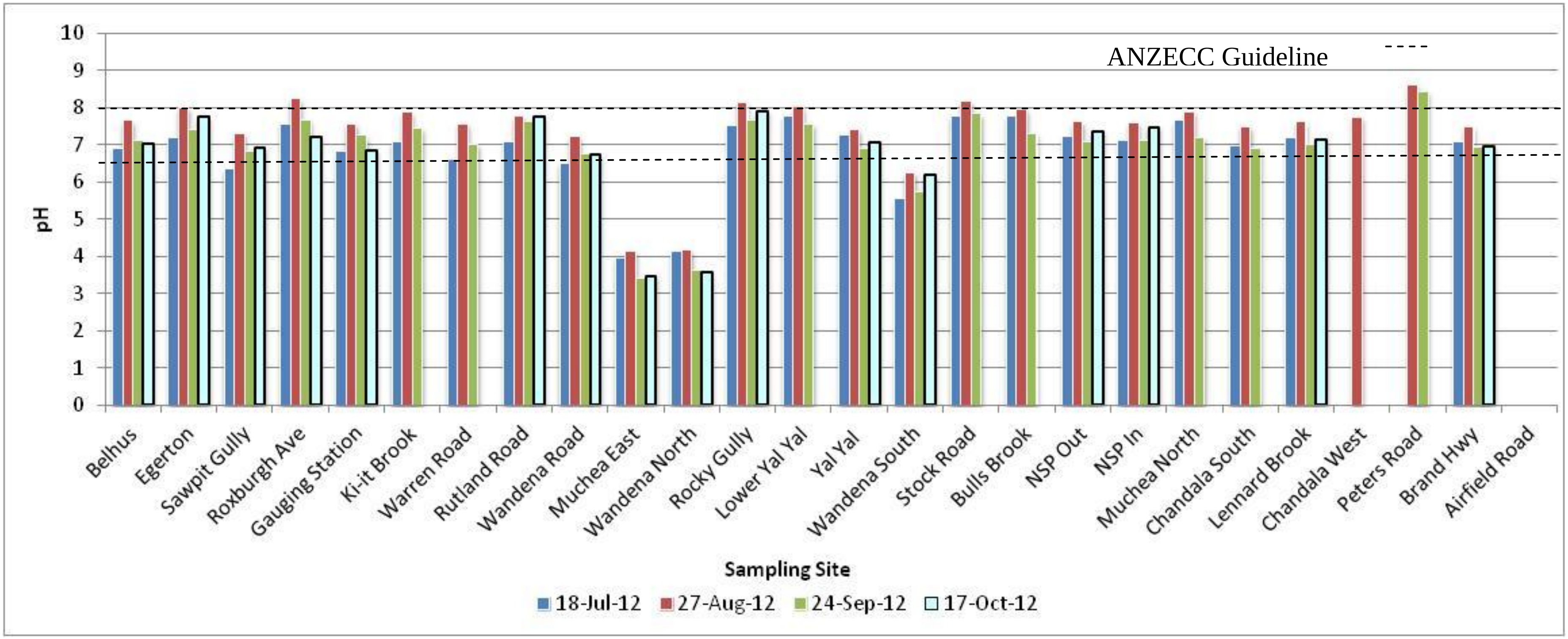


Figure 8: pH of surface water sampled within the Ellen Brook catchment between July and October 2012. *Note: blanks represent no sample

Table 5: pH levels of Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10) between July and October 2012.

Date	EBN 7	EBN 8	EBN 10
18/07/12	4.12	5.54	3.96
27/08/12	4.17	6.25	4.13
24/09/12	3.62	5.72	3.39
17/10/12	3.56	6.17	3.47

7.2.2 Electrical Conductivity

Electrical conductivity (EC) measures the total concentration of inorganic ions (particularly sodium, chlorides, carbonates, magnesium, calcium, potassium and sulfates). Conductivity is often used as a measure of salinity. The conductivity level can directly affect the use of the water. For example, different types of plants have varying tolerance levels to salinity, as does livestock.

Electrical conductivity ranged from 0.274mS/cm at Ki-It Brook to 10.91mS/cm at Wandena North. All but one site exceeded ANZECC guidelines for freshwater lowland rivers of 0.12mS/cm to 0.3mS/cm (Figure 9). Ki-it Brook was the only site below the ANZECC guideline on all sampling occasions.. Although the sites exceeded the guidelines for ecosystem value, the majority of them were within the marginal zone (marginal water is between 0.9mS/cm to 2.7mS/cm), anything above 2.7mS/cm is considered brackish and would be detrimental for irrigation of stone fruit and citrus orchards (Appendix D). Therefore, the conductivity is acceptable for current land uses (grazing) but consideration for long term effects on ecological value should also be considered and continued monitoring is essential. The exceptions to this included Wandena North (EBN7), Wandena South (EBN 8), Muchea East (EBN10) and Rocky Gully (EBN6) which exceeded the Marginal Zone on all four sampling occasions. Wandena Rd (EBN 27) exceeded on three sampling occasions, Rutland Rd (EBN13), Lower Yal Yal (EBN21) and Chandala West (EBN3) exceeded on one sampling occasion. Conductivity at these eight sites was brackish on at least one of the sampling occasions, and ranged between 2.80mS/cm (EBN27) and 10.91mS/cm (EBN7). High conductivity readings were concentrated to the central-east of the Ellen Brook catchment, at the Muchea East and Wandena sub-catchments (Appendix A).

The results showed that nine out of twenty sites were brackish in 2006. In 2007, five out of twenty-seven sites were brackish. In 2008, eight of the twenty eight sites were brackish. In 2009, ten of the twenty seven sites were brackish. In 2010 seven of the 27 sites were brackish. In 2011, seven out of the 27 sites were brackish. In 2012 eight out of the 27 sites were brackish. The Ellen Brook itself had relatively marginal conductivity readings. No site on any sampling occasion of the Ellen brook recorded a brackish conductivity reading.

Some individual samples taken from Muchea East, Wandena North and Wandena South were unacceptable for milk cows, poultry, irrigation of olives and figs, grapes, tomatoes and lettuce

(Appendix D). This is unlikely to effect surrounding landholders as the cattle are for beef production which have a much higher tolerance level, and the nearby chicken farm uses bore water. New urban developments have occurred throughout the catchment in the past few years and particularly in these areas of concern, However the land is generally used for small hobby farms, with most landholders using bore water and rain water tanks.

It is of great concern for environmental value that most sites consistently exceeded ANZECC water quality guidelines for lowland river systems and certainly warrants further monitoring. Over the four sampling occasions the conductivity reading for the southern most sampling site of the catchment, (Belhus Reserve, EBN19), averaged 1.9mS/cm. This shows that the higher concentrations of salts in the major tributaries are diluted as they flow into the Ellen Brook and through the catchment. However, this concentration is above the guideline, deemed to be marginal and unacceptable for stone fruit, citrus, peas, carrot, onion and hot water systems (Appendix D). The most brackish sites were in the mid-eastern part of the catchment (Horwood, 1997). This trend has been noted in previous water quality programs.

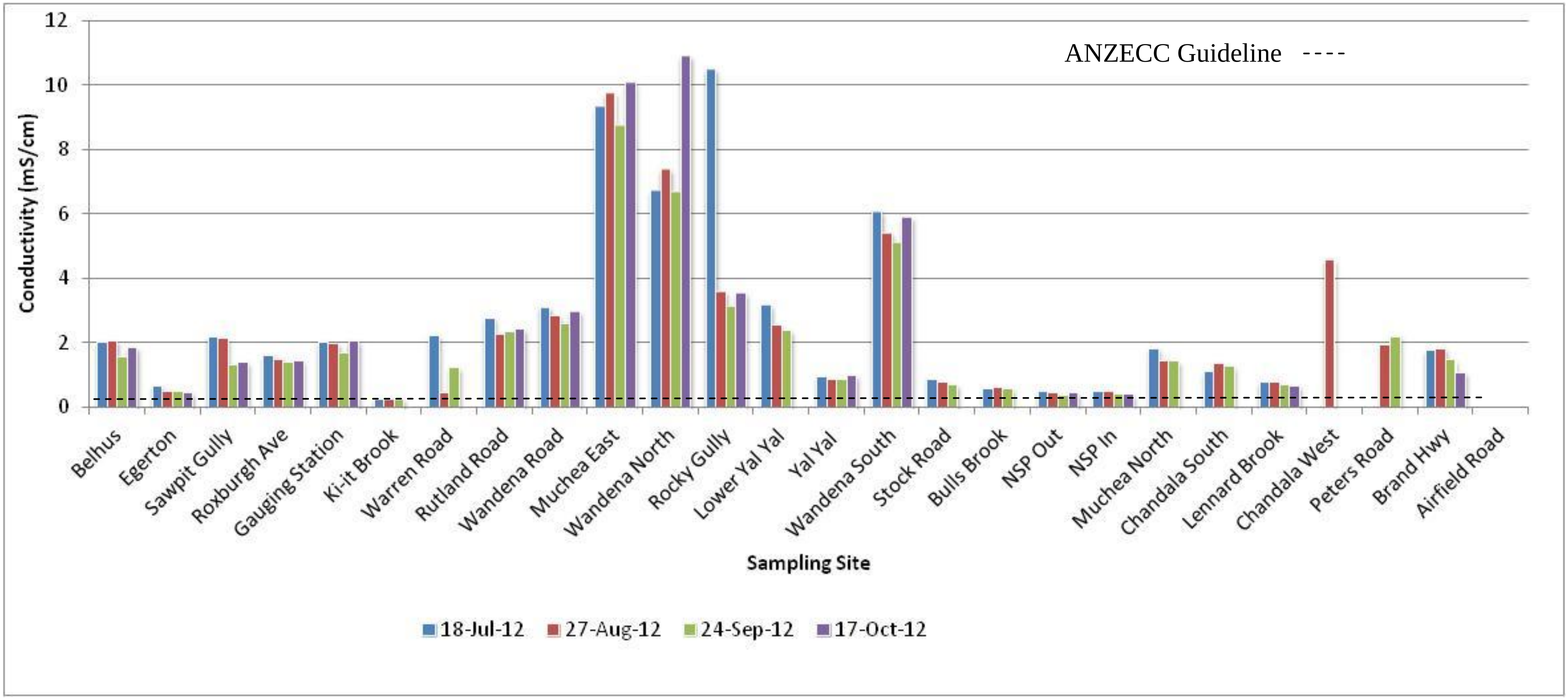


Figure 9: Electrical Conductivity of surface water within the Ellen Brook Catchment between July and October 2012.*Note blanks represent no sample

7.2.3 Total Suspended Solids

Total Suspended Solids (TSS) refers to naturally occurring suspended particles including; silt, phytoplankton and organic matter within a water body. Natural sources of TSS include water turbulence from storms, phytoplankton blooms and wind/wave action. However, TSS may also indicate detrimental environmental conditions such as erosion. This makes levels higher than normal in the water body and can result in increased deposition of material to the substrate that may smother faunal communities (McTaggart, 2002).

There are large variations in TSS throughout water bodies and guidelines should be determined by including information on natural levels in the area. As no ANZECC guideline currently exists for TSS, this report will use the interim guideline of 6mg/L adopted by the Department of Water and originally developed by the Waters and Rivers commission for the Wilson Inlet report to community (October 2000).

TSS in the Ellen Brook catchment ranged between less then 1 and 44mg/L at Wandena South (EBN8), (Figure 10). There was great variation in the TSS recorded at most of the sites. No specific sampling occasion recorded consistently high TSS concentrations across the sampling sites. However eleven sites exceeded the interim guideline on at least one of the sampling occasions, these included, Sawpit Gully (EBN25), Gauging station (EBN18) Warren Rd (EBN17), Rutland Rd (EBN13), Lower Yal Yal (EBN21), Yal Yal (EBN5) Wandena South (EBN8), Bulls Brook (EBN16), Chandala South (EBN4), Chandala West(EBN3) and Lennard Brook (EBN1), (Figure 10). Concentrations at these sites ranged between 7 and 44mg/L. The outliers in these results is Wandena South(EBN8) and Lower Yalyal(EBN21), this result is likely due to a combination of stock on the water way increased development and Rainfall Events. The other less extreme events were experienced at most subcatchments on various sampling occasions. They do not appear to be localized, but are probably due to a combination of influencing factors including peak rainfall events, earthworks and development, stocking rates and stock access to waterways, clearing of vegetation and increased erosion.

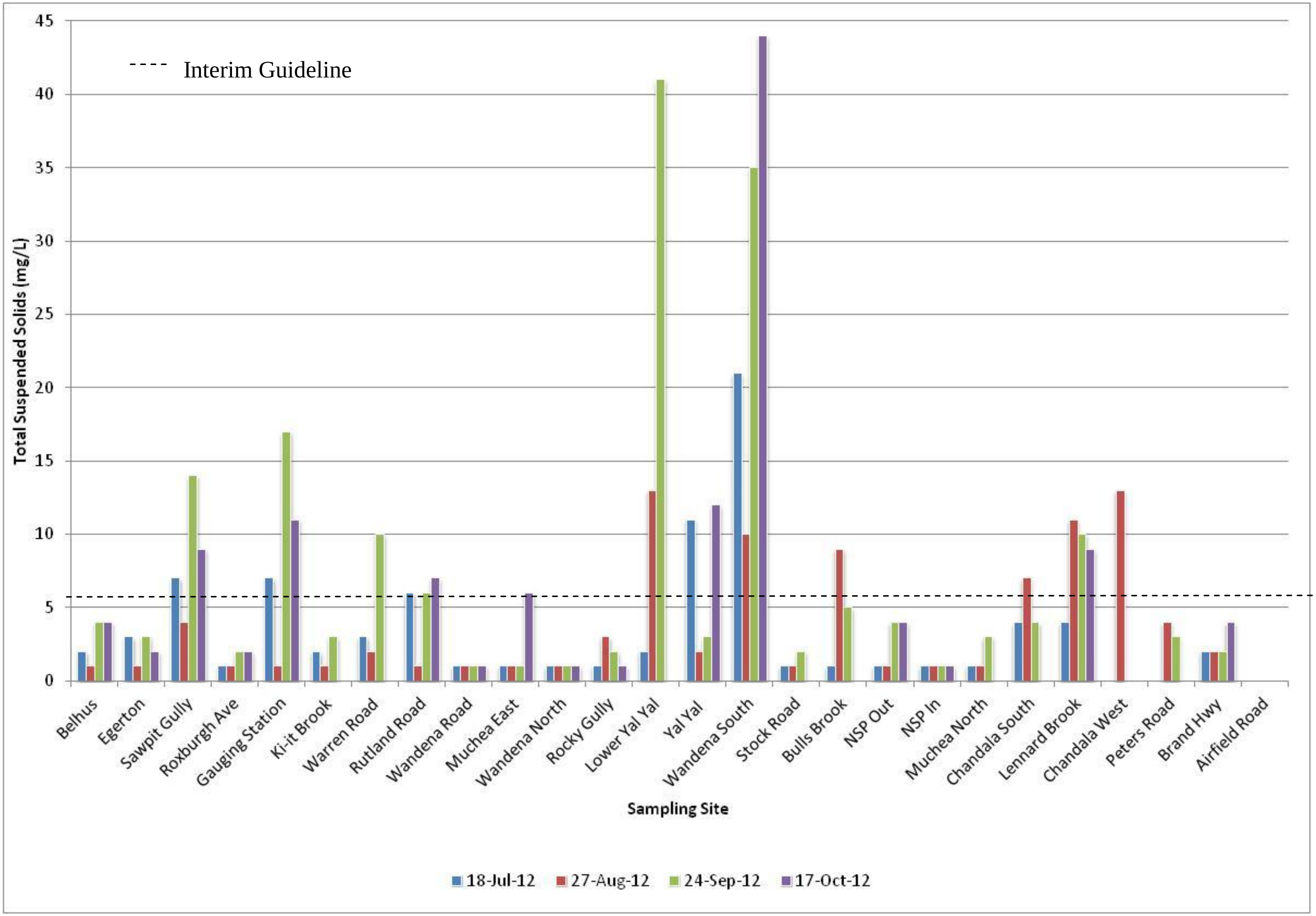


Figure 10: Total Suspended Solid concentrations in surface water within the Ellen Brook Catchment between July and October 2012. *Note blanks represent not sampled

7.3 Nutrient concentrations in water

Most nutrients present in the catchment are stored in the soils and are transported to the Ellen Brook via surface water (tributaries, drains and general run-off). The original sources of nutrients include; weathering, leaching from soils particularly in eroded areas, fertiliser run-off, detergents, sewerage, fixation by some plants, and decomposition of plant matter, animal wastes and other organic wastes (IEA 2003). Nitrogen and phosphorus are the two major essential elements to plants. Excessive amounts of nutrients in waterways can result in eutrophication with plant and algae growth, increases in nuisance insect numbers and unbalanced aquatic ecosystems. Nutrients include nitrogen in the form of ammonia, nitrate and nitrite, and phosphorus in the form of phosphate either dissolved (soluble reactive phosphate) or particulate (suspended).

7.3.1 Total Nitrogen

Total nitrogen (TN) refers to all forms of nitrogen present including organic (e.g. plant decay matter) and inorganic in the forms of ammonia, nitrate and nitrite (McTaggart 2002). Sources of nitrogen include fertilisers, industrial cleaning operations, feed lots, animal droppings, combustion of fossil fuels and plant debris.

Most sites except Rutland Rd(EBN13), Brand Hwy (EBN9), Yal Yal (EBN5) Wandena North (EBN7), Muchea East (EBN10), Wandena South (EBN8), Ki-it Brook (EBN22), Rocky Creek (EBN6) and Wandena Road (EBN27) were consistently above the ANZECC water quality guideline values of 1.2mg/L for lowland river systems and ecosystem health on most sampling occasions (Figure 11). These results were consistent with those from 2011. Generally, TN concentrations at all sites were lowest during the July sampling occasion which could be accounted for due to the below average rainfall received that month.

Muchea North (EBN11) consistently recorded the highest TN values between 6.4 and 6.9mg/L on all sampling occaisions. Belhus (EBN19), Gauging Station (EBN18) Lower Yal Yal (EBN21), Stock Road (EBN24), Bulls Brook (EBN16), NSP Out (EBN15) and NSP In (EBN14), Chandala South (EBN4) Chandala West (EBN3) and Lennard Brook (EBN 1) all recorded relatively high TN concentrations and should continue to be monitored. Belhus and the Gauging station receive runoff from agricultural land uses to the north of The Vines development. Stock Road (EBN24), Bulls Brook (EBN 16), NSP In (EBN14) and NSP Out (EBN 15) are located downstream of agricultural and horticultural land located on sandy soils which accounts for increased nutrients from runoff. Lower Yal Yal (EBN21), Chandala West (EBN3), Chandala South (EBN4) and Lennard Brook (EBN1) are also located down stream of agricultural areas where runoff of nutrients is common due to poor soils. Most of these sites are situated on the western half of the catchment and contribute a significant amount of TN to the Ellen Brook.

As shown in previous Snapshot Reports for the Ellen Brook catchment, there appears to be a general trend in the data showing that western parts of the catchment have higher levels of nutrients in the run off than eastern sites, most likely due to a change in soil type. Duplex soils of sand over clay with higher nutrient retention capabilities and lateritic uplands dominate on the Darling and Dandaragan Plateaus to the east of the Ellen Brook. These soils are able to retain nutrients in the soil for a longer period of time than the well drained, porous, sandy soils of the Bassendean sands complex located to the west (DEBCMP, 2001).

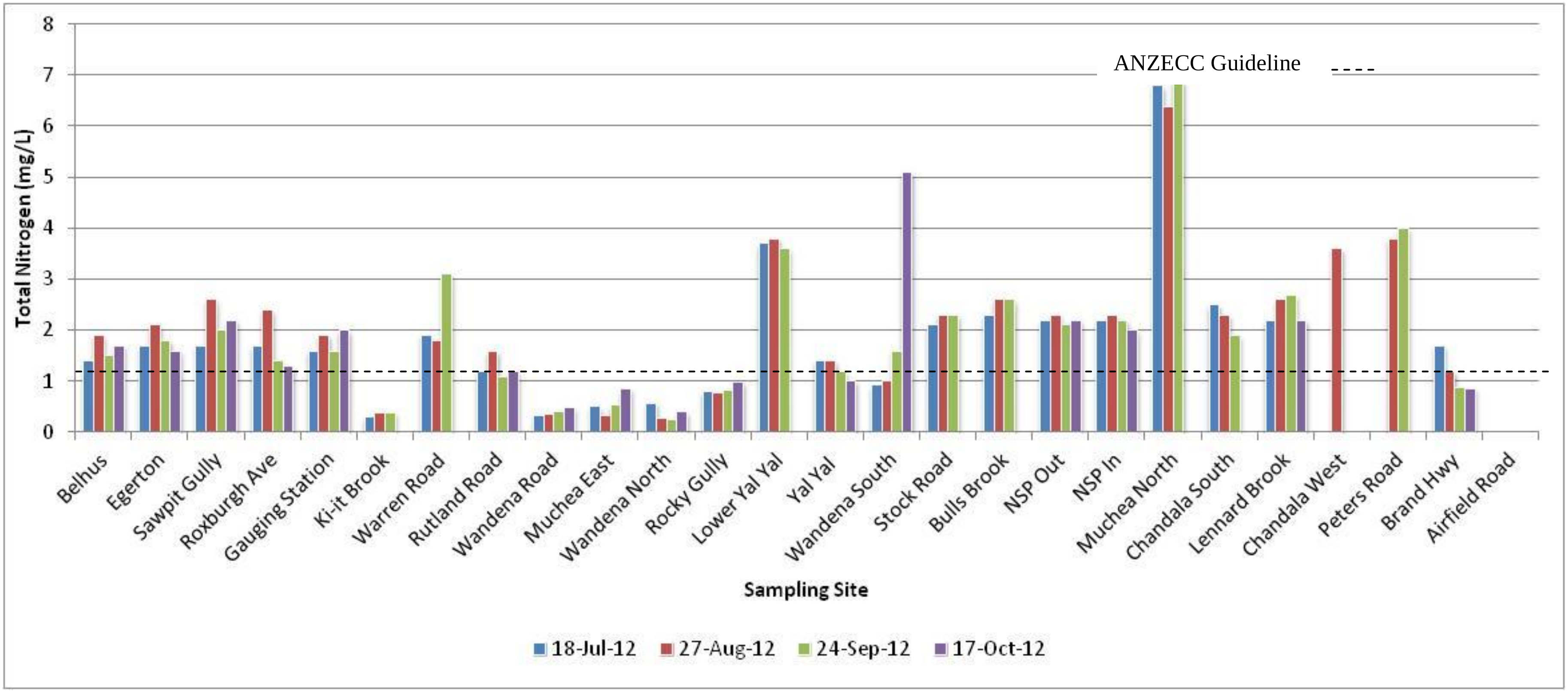


Figure 11: Total Nitrogen concentration in surface water within the Ellen Brook catchment sampled between July and October 2012.
* Note, blanks represent no sample.

7.3.2 Total Oxidised Nitrogen

Total oxidised nitrogen (TON/NOx) is the sum of the oxidised forms of nitrogen, which includes nitrite (NO_2) and nitrate (NO_3), and is often referred to as NOx. Nitrite can be converted to nitrogen gas by denitrifying bacteria and ammonium (NH_4) in the form of nitrate; hence plants can easily absorb this form of nitrogen in a continuous cycle as it is readily soluble in water and is rapidly transported through the catchment via surface run-off, sub-surface and groundwater flows (Horwood, 1997).

The majority of sites were within the ANZECC water quality guidelines for TON (0.15mg/L) for lowland river systems and ecosystem health on most sampling occasions, (Figure 12).

Lennard Brook (EBN1), Yal Yal Brook (EBN5), Roxburghe (EBN29) and Egerton (EBN26) recorded TON concentrations above the guideline on every sampling occasion. This is consistent with results from 2011. Lennard Brook TON concentrations ranged between 1.8mg/L and 2.3mg/L. Yal Yal Brook TON concentrations ranged between 0.73mg/L and 1.3mg/L. Roxburghe TON concentrations ranged between 0.23mg/L and 1.4 mg/L. Egerton TON concentrations ranged between 0.57mg/L and 0.82mg/L. Muchea North (EBN11), Muchea East (EBN10) and Rocky Gully (EBN6) recorded TON concentrations above guidelines on 1 out of 4 occasions sampled and ranged between 0.01mg/L and 0.24Mg/L, which is only slightly above the guideline. Some of these results are high in comparison to other sampling sites within the Ellen Brook catchment as TON is directly available to plants and therefore has a direct correlation with algal blooms. These exceedences are potentially a result of the surrounding intensive land uses (golf course and urban development and agriculture), (Horwood, 1997).

Lennard Brook (EBN1) recorded TON concentrations over fifteen times greater than the guideline value, and Yal Yal Brook (EBN5) recorded concentrations over eight times greater then the guideline. These sites are perennial tributaries in the northern half of the catchment (Figure 5). Lennard Brook is a proclaimed waterway, an important source of water for nearby horticulture, so monitoring of this site should continue. Potential sources of the elevated TON concentrations are linked to land use including an abattoir on Lennard Brook, and intensive horticulture further upstream on both waterways which use high levels of fertiliser.

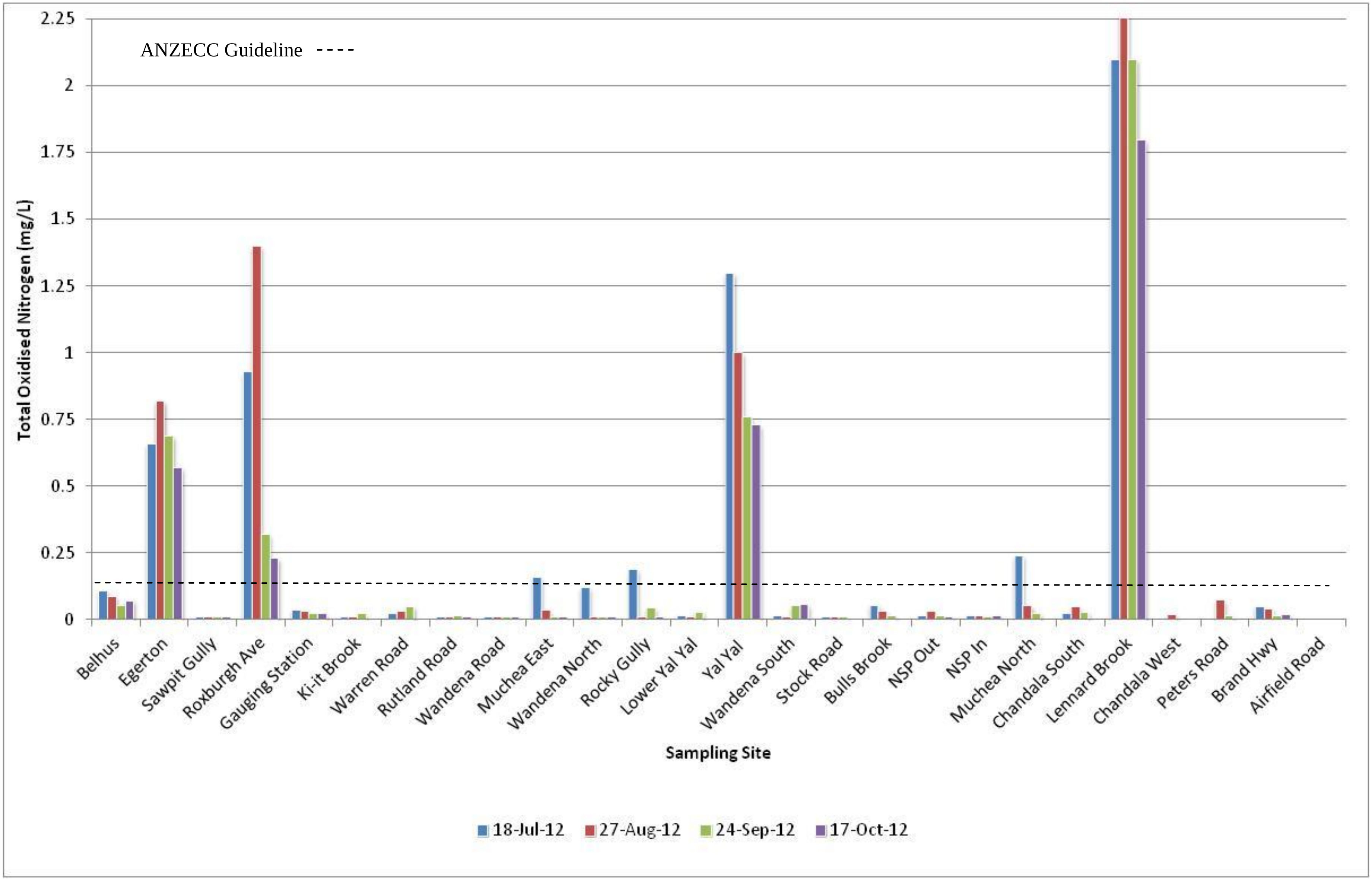


Figure 12: Total Oxidised Nitrogen (TON) sampled within the Ellen Brook catchment between July and October 2012. *Note blanks represent no sample.

7.3.3. Ammonia as NH3N

Most sites were within the ANZECC guideline of 0.08mg/L on at least 1 sampling occasion(Figure 13). Warren Road (EBN17), Muchea East (EBN10), Belhus (EBN19) and Muchea North (EBN11) exceeded the guidelines on more than one occasion. In general levels were significantly lower than in 2011. Possible causes to the reduction at some sites could be reduced stocking rates on the surrounding areas or reduction in the use of highly soluble fertilisers. Muchea East did record levels significantly higher then in previous years. Possible causes could be a breakdown in the treatment system for animal manure at the WAMIA saleyards. Monitoring in 2013 will provide further information on the results to see if the increased NH3 was a one off or an emerging trend. Other Sources of this Ammonia could include agricultural fertilisers, and the decomposition of organic wastes. Most of these sites are situated adjacent to or near to agricultural land-uses such as cattle grazing, cropping, fertiliser storage, stock yards and horticulture.

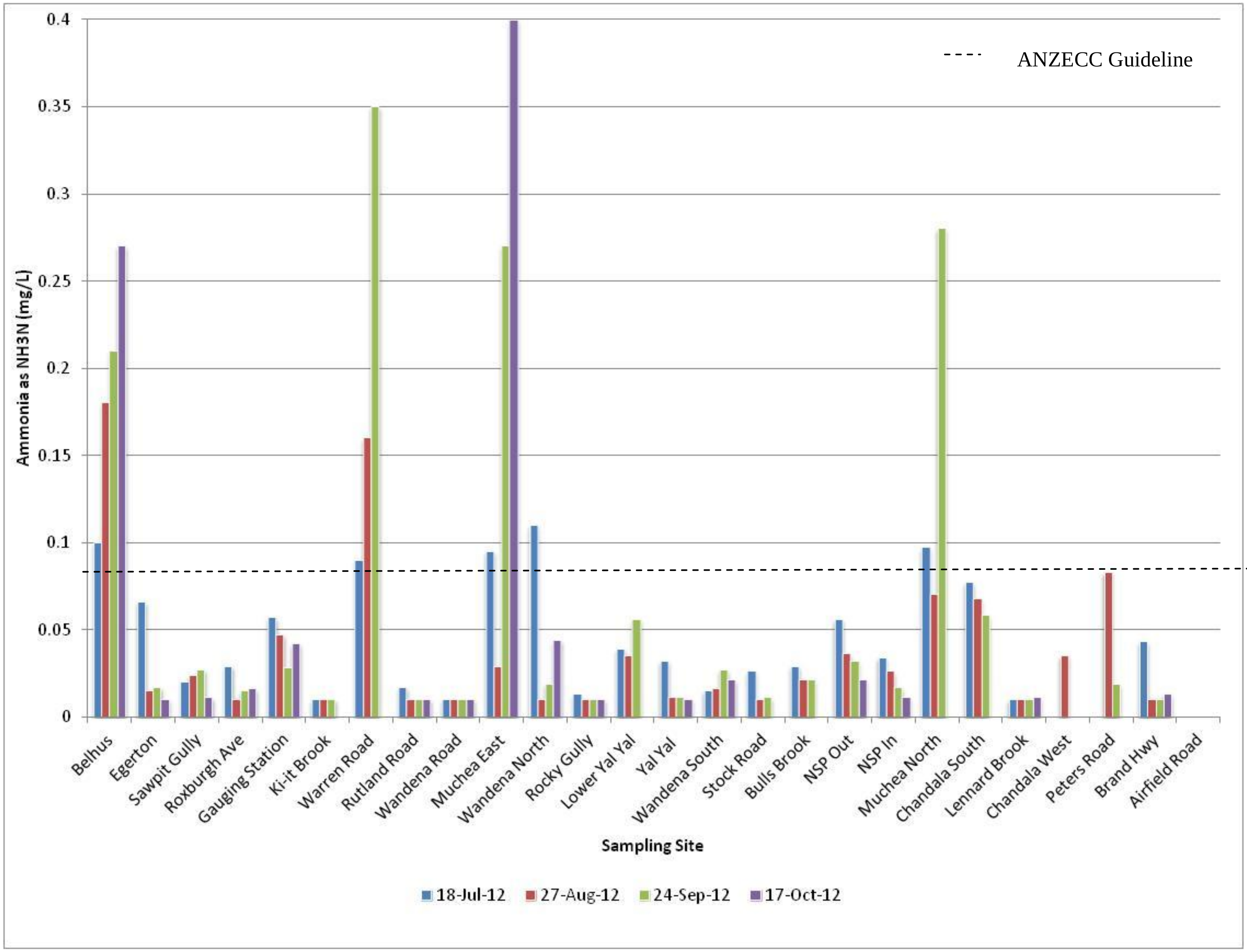


Figure 13: Ammonia as Nitrogen (NH3N) sampled within the Ellen Brook catchment between July and October 2012. ***Note blanks represent no sample

7.3.4. Dissolved Organic Nitrogen

Dissolved Organic Nitrogen (Dissolved Organic Nitrogen) is comprised of the organic forms of nitrogen including amino acids, proteins, urea and humic acid. All sampling sites exceeded the ANZECC guideline of 0.04mg/L on all sampling occasions. The DON results show a direct correlation with the Total Nitrogen (TN). Additionally, DON concentrations when compared with total nitrogen, ammonia and total oxidised nitrogen concentrations showed that nitrogen exists primarily in its soluble form in the Ellen Brook catchment.

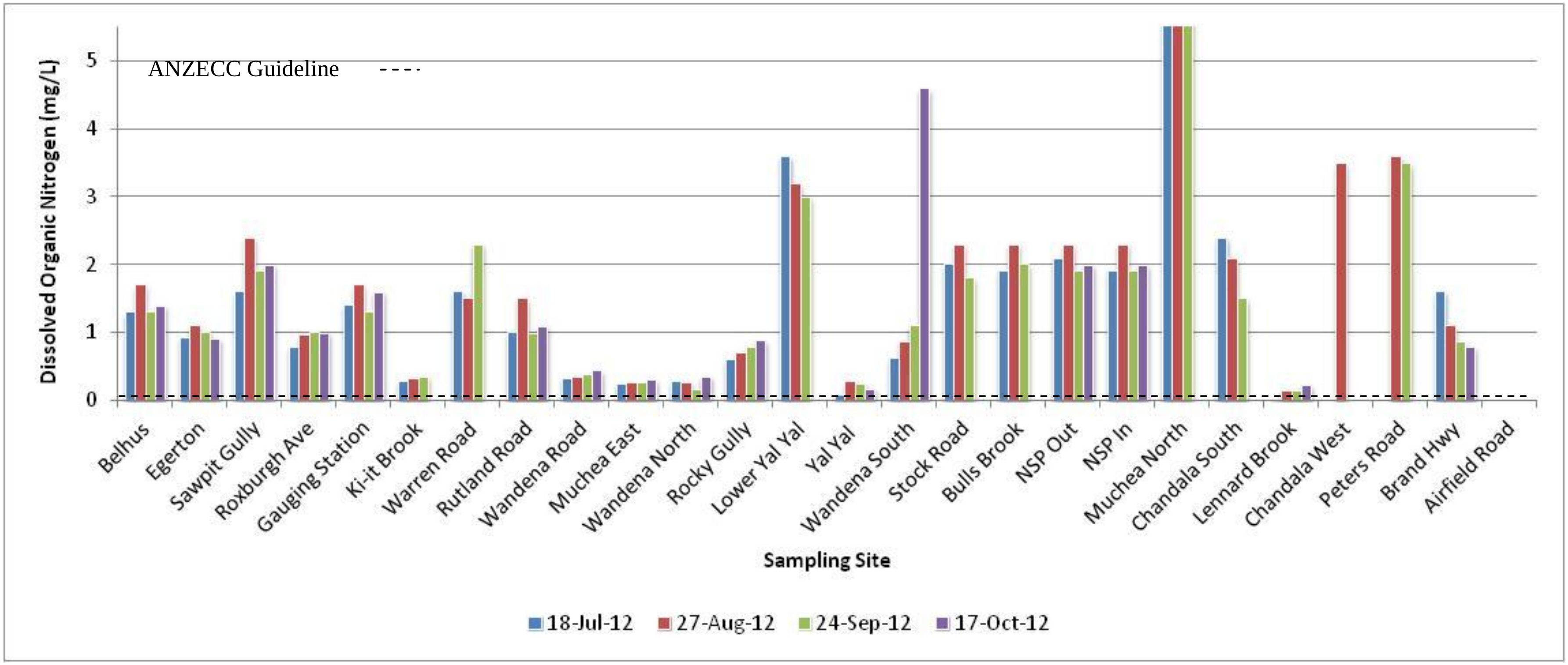


Figure 14: Dissolved Organic Nitrogen (DON) sampled within the Ellen Brook catchment between July and October 2012. *Note blanks represent no sample

7.3.3 Total Phosphorous

Total phosphorus (TP) is a measure of all phosphorus in the water including the available and unavailable (or potentially available) forms of phosphorus including orthophosphates (fertilisers), organic phosphate (plants & animals) and condensed phosphates (inorganic cleaning agents). Sources of phosphorus include fertilisers, plant debris, detergents, industrial wastes and lubricants (McTaggart 2002). Phosphorus is naturally occurring in the environment and is usually the limiting factor for plant growth. The concentration of phosphorous is generally lower than nitrogen in most waterways. However, an increase in the total P level in freshwater bodies stimulates the production of *Chlorophyll a* in phytoplankton and results in an algal bloom (Russell, 2001).

As plants and animals excrete waste or die then decay, the organic phosphate sinks to the bottom where bacteria convert it back to inorganic phosphate. Inorganic phosphate returns to the water column when sediments are disturbed, making it available again for uptake by the plants and the cycle continues. Inorganic phosphate is not as mobile as soluble forms of nutrients and tends to be absorbed by most soils and particulate material. This results in a steady accumulation of phosphorus that slowly moves through the soil profile. Holding time of phosphorus in the catchment depends on the recharge rate to groundwater, rate of adsorption to soil particles and the extent of soil saturation (Gerritse, 1996).

There was no relationship between the time of sampling and the level of TP as concentrations varied at each sampling site, each month (Figure 15). The majority of sites were consistently higher than the guideline value of 0.065mg/L on all four sampling occaisions, except for Roxburgh Avenue (EBN27), Kit-it Brook (EBN22), Wandena Road (ENB27), Muchea East (EBN10), Rocky Gully (EBN6), Yal Yal Brook (EBN5) and Wandena North (EBN7). Which were below the guideline on all sampling occasions. Wandena South (EBN8) only exceeded the guidline on the September and October sampling occaision. Muchea North (EBN11) however recorded TP concentrations of approximately seventy times higher than the guideline value of 0.065mg/L. This is consistant with the levels recorded in 2011 and significantly less then what was recorded in 2009.

These results are certainly cause for further investigation. Similar to total nitrogen, there appears to be a general trend in the data showing that sub catchments to the west of the Ellen Brook have higher levels of nutrients in the runoff than those to the east. This is due to changes in soil type (Figure 3). Duplex soils of sand over clay with high phosphorous retention capabilities dominate on the Darling and

Dandaragan Plateaus to the east of the Ellen Brook. These soils have a higher nutrient trapping capability and are able to retain nutrients in the soil for a longer period of time than the well drained, porous, sandy soils of the Bassendean sands complex located to the west (DEBCMP, 2001).

Muchea North (EBN11) was identified as the highest contributor of TP to the Ellen Brook. This emerging trend has been identified in every Snapshot report since 2005. As a result of monitoring by the Ellen Brockman Integrated Catchment Group, Muchea North was identified in the Swan River Trust’s Drainage Nutrient Intervention Program (DNIP) as a site requiring nutrient removal/intervention in the Lower Ellen Brook catchment. On-ground works formed a treatment train approach to nutrient removal and was implemented during 2009 and 2010. The treatment train involved the installation of a drain diversion to slow the flow before passing through a nutrient filter and into the Ellen Brook. Continued monitoring is required to determine the effectiveness of this treatment train approach in this catchment however our initial snapshot results look positive.

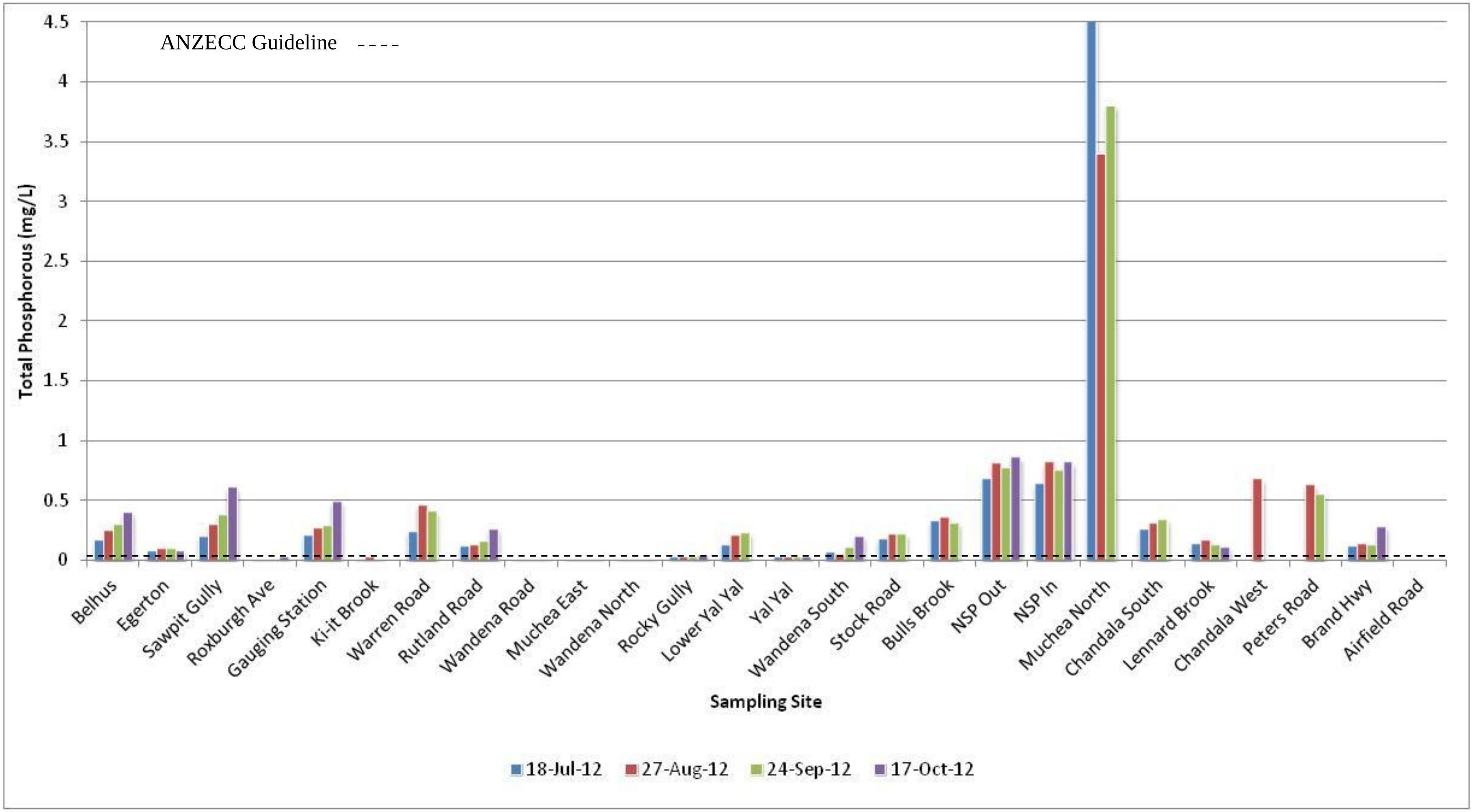


Figure 15: Total Phosphorous concentration sampled within the Ellen Brook catchment between July and October 2012.
NB: Roxburgh Ave, Ki-it Brook, Wandena Road, Muchea East, Wandena North, Rocky Gully and Yal Yal recorded very low concentrations of TP.
*Note blanks represent no sample

7.3.4 Soluble Reactive Phosphorous

Soluble reactive phosphorus (SRP) measures only the dissolved phosphorus in water and provides a measure of the immediately available phosphate in the system at the time of sampling; it is also referred to as PO_4. As this form of phosphorus is readily available it is more likely to stimulate algal blooms. This can lead to more decaying vegetation which alters river characteristics including elevated temperature, reduced oxygen and fish kills. This nutrient enrichment process is known as eutrophication (McTaggart, 2002).

Most of the sites were significantly above the lowland river system guideline value of 0.04mg/L on one or more occasions, with the exception of Yal Yal Brook (EBN5), Rocky Gully (EBN6), Wandena north (EBN7), Muchea East (EBN10), Ki-it Brook (EBN22), Wandena Road (EBN27), and Roxburgh Ave (EBN29), (Figure 16).

Muchea North (EBN11) recorded the highest concentrations of SRP with values over one hundred and five times greater than the guideline. SRP concentrations have been recorded up to one hundred and thirty two times greater than the ANZECC guideline in 2009 sampling program and one hundred and seven times greater in 2010. Even considering that the guideline value may be unrealistic for the Ellen Brook, the magnitude of the concentration at this site compared to others is alarming and requires further monitoring.

The source of the spikes in SRP at Muchea North was most likely diffuse; the land uses at this site involve high stocking rates of cattle grazing on flat, deep draining, sandy soils. This area is prone to being seasonally waterlogged (palusplain), transporting significant amounts of dissolved nutrients to the Ellen Brook. Again, most of the sites on the western side of the catchment have higher concentrations than those to the east.

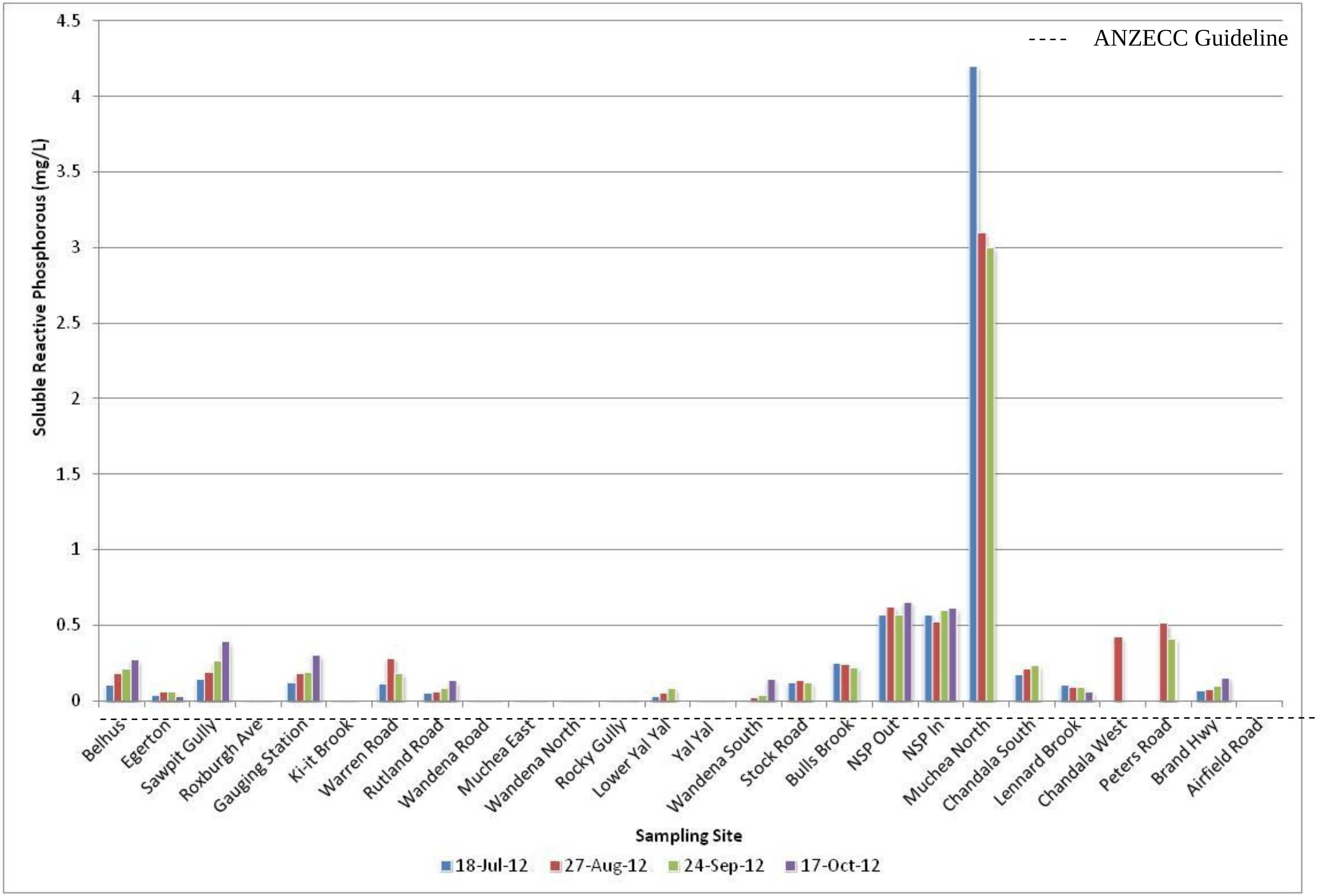


Figure 16: Soluble Reactive Phosphorous concentrations sampled within the Ellen Brook catchment between July and October 2012

*Note blanks represent no sample

7.3.5. Total Filterable Phosphorous

Total Filterable Phosphorous (Figure 17) was analysed to allow the Swan River Trust to determine the Filterable Unreactive Phosphorous, also known as Soluble Organic Phosphorous. Total Filterable Phosphorous minus Soluble Reactive Phosphorous equals Soluble Organic Phosphorous. TFP compared to Soluable Reactive Phosphorous (Figure 16) shows that TFP is comprised primarily of soluble reactive phosphorous. Figures 18, 19, 20 & 21 shows each sampling occasion and highlights the percentage of Soluble Reactive Phosphorous and soluble Organic Phosphorous as part of the Total Filterable Phosphorous.

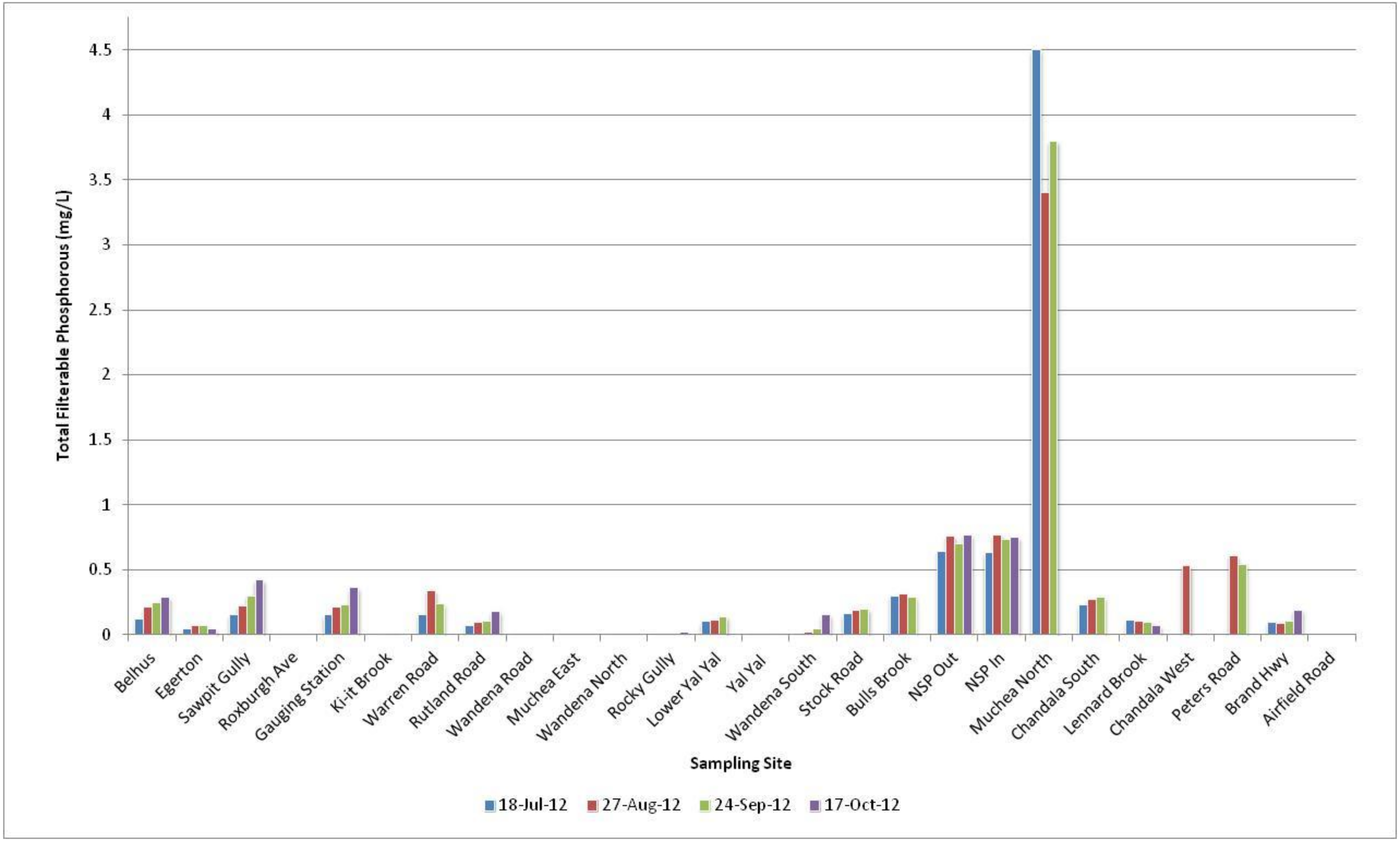


Figure 17: Total Filterable Phosphorous (TFP) concentrations sampled within the Ellen Brook catchment between July and October 2012.
*Note blanks represent no sample or very low values

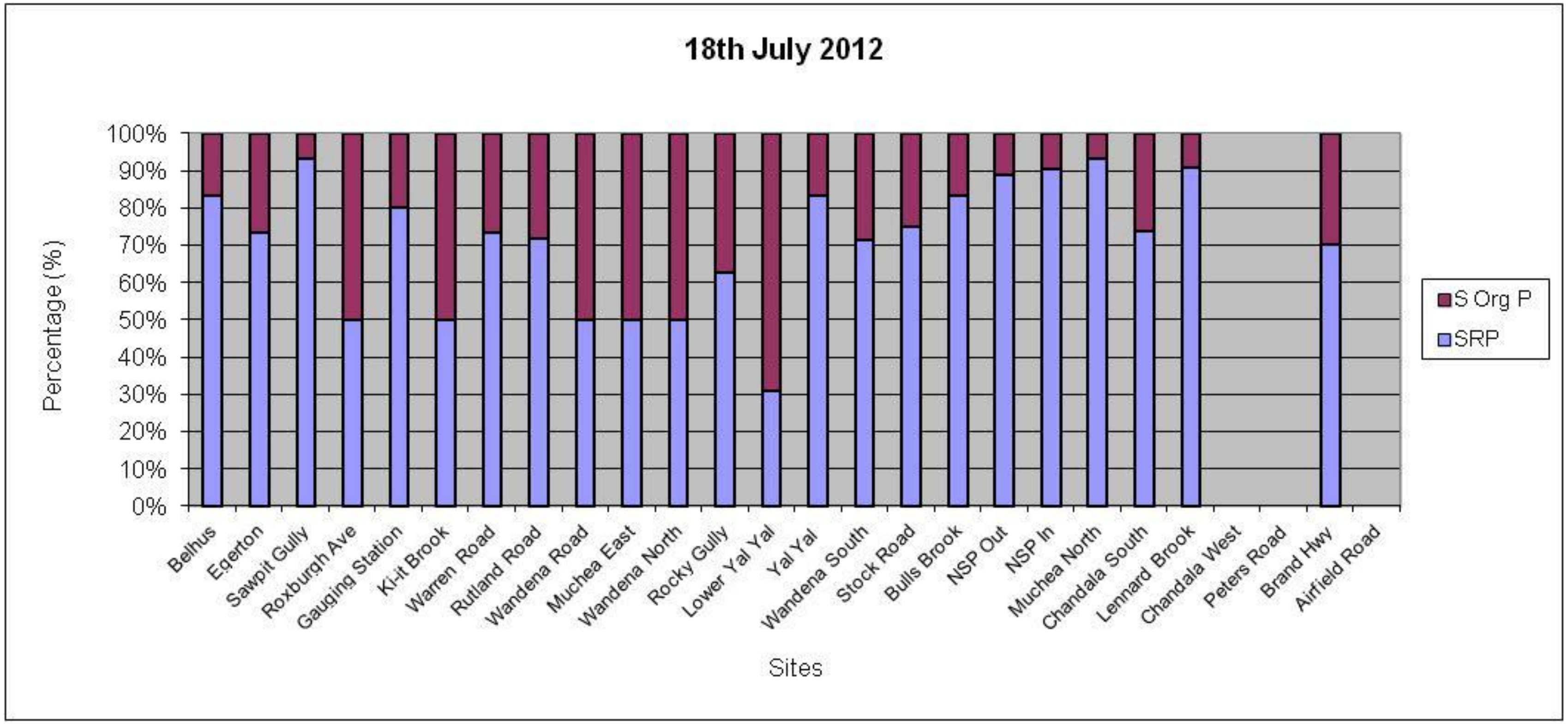


Figure 18: Composition of Total Filterable phosphorous in percentages of Soluble Organic P and SRP in July Sampling run 2012. *note that blanks represent no sample or TFP below LOR

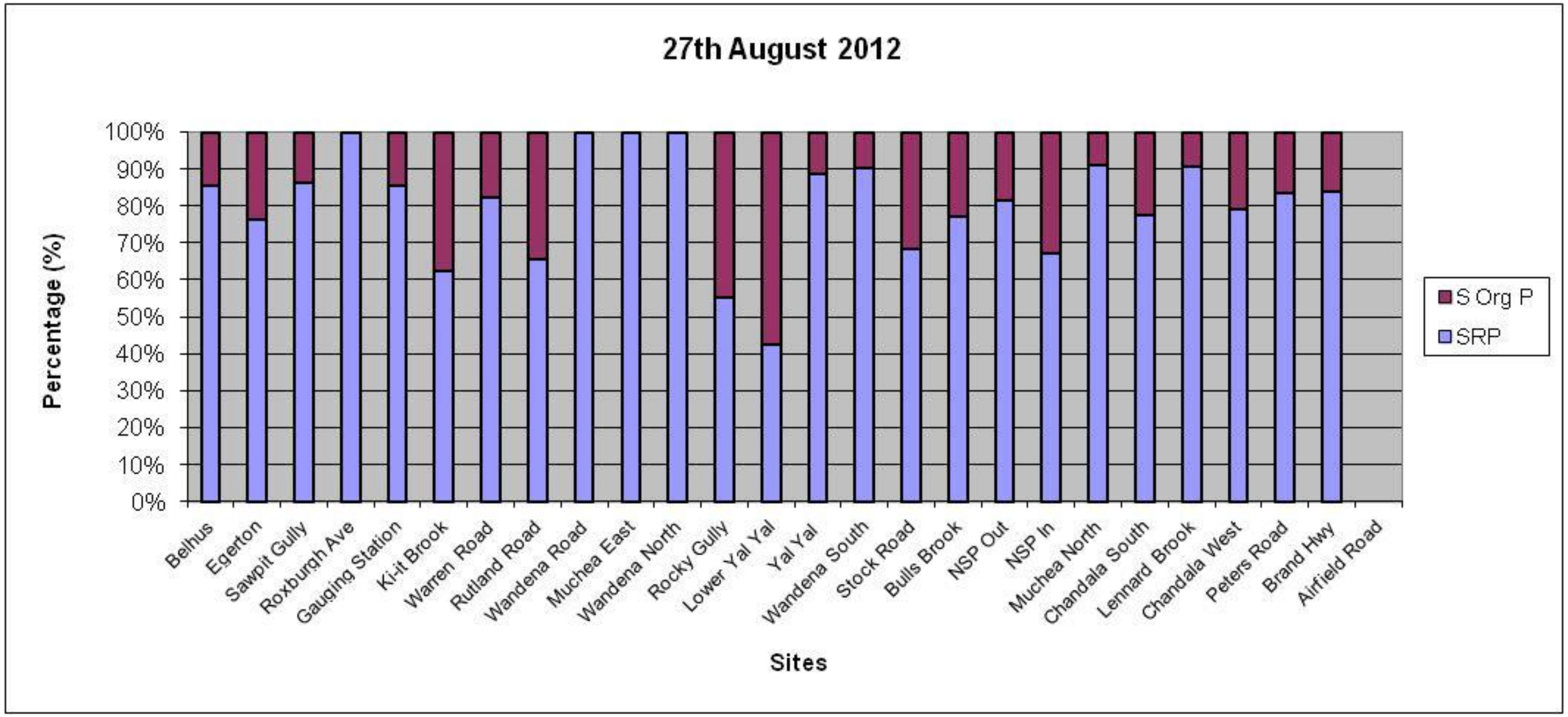


Figure 19: Composition of Total Filterable phosphorous in percentages of Soluble Organic P and SRP in August Sampling run 2012. *note that blanks represent no sample

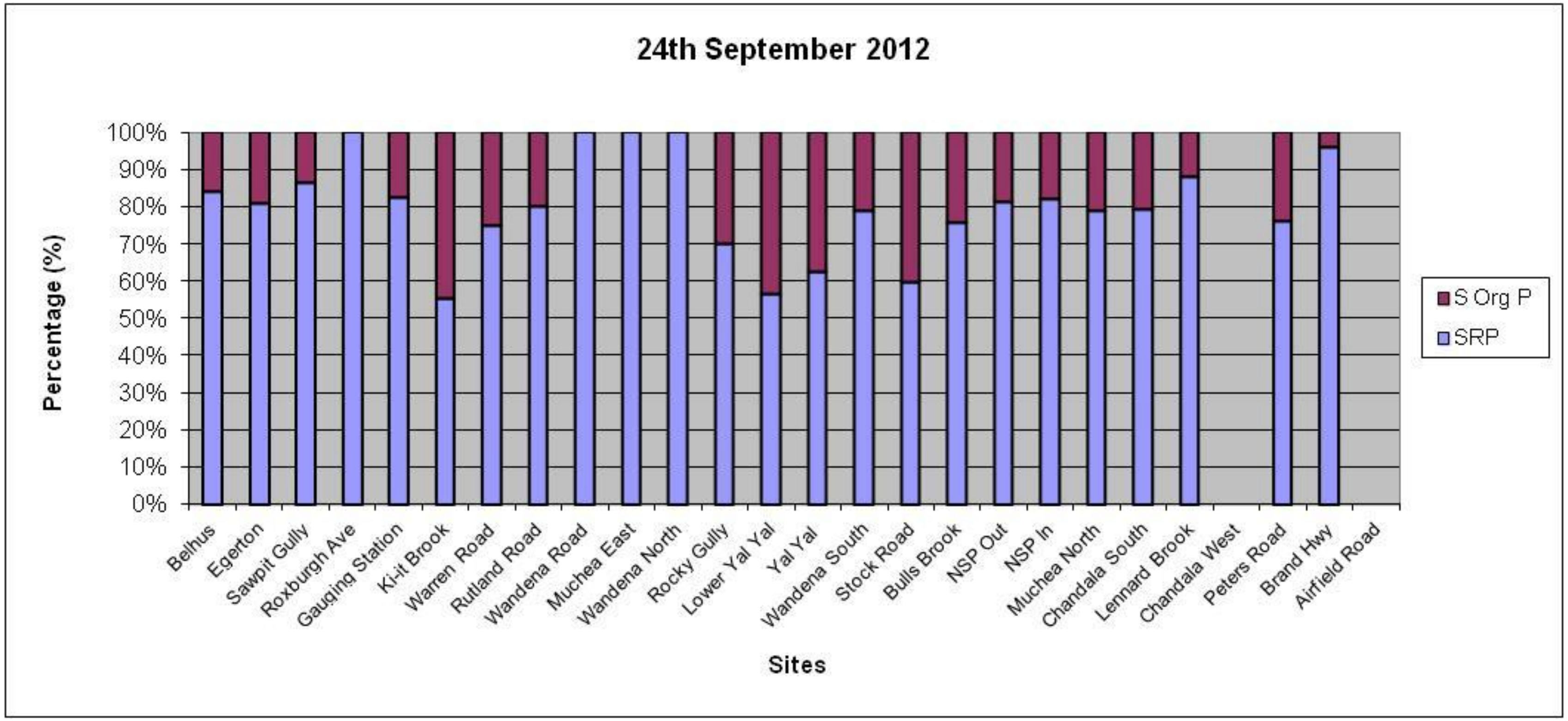


Figure 20: Composition of Total Filterable phosphorous in percentages of Soluble Organic P and SRP in September Sampling run 2012. *note that blanks represent no sample or TFP below LOR

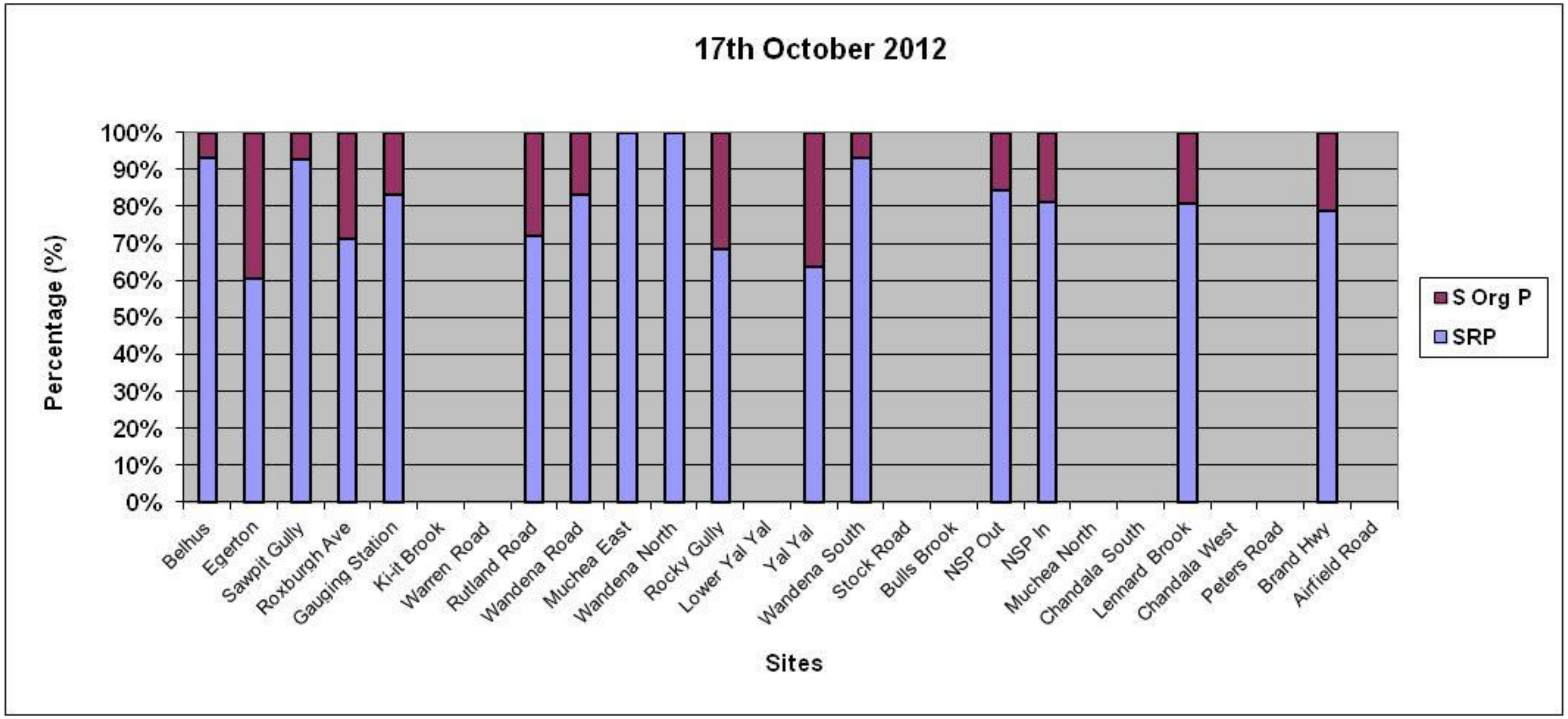


Figure 21: Composition of Total Filterable phosphorous in percentages of Soluble Organic P and SRP in October Sampling run 2012. *note that blanks represent no sample or TFP below LOR

7.4 Metals in surface water

Metals are found naturally in aquatic ecosystems. However, in excessive amounts they are toxic and associated with pollution. They are derived from a variety of sources such as industrial waste, refuse leachate, and corrosion of pipes and roofs (McTaggart, 2002). The most common sources of metal contaminants in the Ellen Brook are pesticides and fertiliser application. Copper, zinc and cadmium are often found in fertilisers. In the Ellen Brook most metals would enter via stormwater run-off or groundwater contamination. Other metals such as aluminium and iron can also reach toxic levels when mobilised from the soil by acidic groundwater.

Aquatic organisms have varying tolerance levels to different metals. Metals that are essential for growth can become toxic to aquatic organisms at levels beyond their tolerance which may only be slightly higher than normal concentrations. Metals may also accumulate in fatty tissues of animals and in the human body, so repeated exposure to metals can cause toxic levels to build up, this is known as "bioaccumulation" (IEA 2003).

Metals accumulate through the food chain in a process called "biomagnification" which can result in animals at the top end of the food chain receiving a high concentration of metals even if the organisms consumed at lower levels of the food chain have acceptable levels of metals. Tolerance levels of aquatic organisms to metals and their ability to absorb those metals can be influenced by many factors including their interaction with other metals, the chemical form of the metal, dissolved oxygen levels, salinity levels, temperature and hardness of the water.

Samples were taken at seven strategically identified sites and analysed for metals. The sites included Upper Yal Yal (EBN28) – an acidic dam, Warren Road (EBN17 – Ellen Brook main stem), Muchea East (EBN10), Wandena South (EBN8), Wandena North (EBN7) Chandala South (EBN3) and Brand Hwy (EBN9) on all four sampling occasions.

Metal concentrations in the waters of the Ellen Brook catchment were generally high based on the ANZECC water quality trigger values for freshwater ecosystems. However, concentrations for cadmium, nickel, and zinc were below the hardness-modified trigger values (HMTV) (Table 6), Chromium and Copper was above the HMTV value at one or more sites (Figure 26). Lead was above the limit of reporting but below the relative HMTV value at one or more sites (Figure 29). Arsenic was above the limit of reporting but below the relative ANZECC trigger value at one or more sites (Figure 24). Aluminium (Figure 23) and Iron (Figure 28) were well above the ANZECC trigger values for freshwater ecosystems at one or more sites.

7.4.1 Metals at Upper Yal Yal (EBN28)

Upper Yal Yal (EBN28) is an unregistered contaminated site in the Ellen Brook catchment (Figure 5). This site was included in the Ellen Brook Water Quality Monitoring Program to provide some baseline data for remediation works undertaken by the Ellen Brockman Integrated Catchment Group in cooperation with the Department of Agriculture and Food (Albany Office) and the ARWA Centre for Eco-hydrology UWA.

This site has not been sampled for pH since 2009 due to the possibility of damaging equipment. However, it has been tested in the past and recorded pH levels of less than 3. Furthermore, total water hardness at this site was recorded as extremely hard (Figure 18). Increased mobilisation of metals as a result of low pH levels could be the cause of elevated concentrations recorded. Results show that metals at this site exceeded the ANZECC water quality trigger values on more than one sampling occasion. The ANZECC water quality trigger values for cadmium, chromium, copper, lead, nickel and zinc were modified to take into account the effect of water hardness on metal toxicity (Figure 22). As a result copper exceeded the hardness-modified trigger values (HMTV) on more than one sampling occasion.

EBN28 is a dam which is located on private property and fenced off from stock. There are major acid-saline scalds situated in the adjacent paddock. The sampling point is situated down slope from a clay extraction operation and surrounded by agricultural enterprises. Natural occurrences, farming practices, major earthworks and altered hydrology could be the cause of elevated heavy metal concentrations recorded at this site. The water table was cut at a point above the dam allowing groundwater to flow into the retention dam. This groundwater flows through ancient marine deposits resulting in increased acidity. Furthermore, cadmium, copper and zinc are often found in fertilizer which would have been applied to the paddocks higher in the sub catchment.

Results show cause for concern to the immediate landholder and those who have access to this water source in this sub catchment. It is also of concern that this water could potentially contaminate the Yal Yal Brook (EBN5) which is one of two remaining freshwater perennial streams in the Ellen Brook catchment. To date monitoring of the Yalyal has not produced any evidence that the Upper Yalyal site is having any effect on the catchment however ground water movent is extremely slow so there is still risk of contamination in the future.

7.4.2. Surface Water Hardness

Water described as ‘hard’ is high in dissolved minerals. Hard water is not a health risk, but a nuisance because of mineral build up on plumbing fixtures, and causes poor soap and detergent performance (DOW, 2006). Total hardness, expressed as calcium carbonate ($CaC0_3$), is the combined concentration of earth-alkali metals, predominantly magnesium (Mg^{2+}) and calcium (Ca^{2+}), and some strontium (Sr^{2+}). The source of this hardness is limestone dissolved by water that is rich in carbon dioxide. Hardness levels range from <60mg/L (soft) to >400 mg/L (extremely hard).

Water hardness can have an effect on the acceptable trigger values for particular heavy metal concentrations (cadmium, copper, zinc, lead, nickel and chromium). Water samples with higher water hardness need to have the trigger values for these metals adjusted by hardness-dependent algorithm or the approximate factors applied to soft water trigger values of varying water hardness provided in ANZECC and ARMCANZ (2000), (Appendix E).

Four sites sampled recorded ‘Extremely High’ water hardness concentrations on each sampling occasion which ranged between 500mg/L at Wandena South (EBN8) and 11000mg/L at Wandena North (EBN7) over the four month sampling period (Figure 22). Two sites sampled Very Hard which ranged between 73mg/L at Warren Rd (EBN17) and 340mg/L at Wandena South(EBN8).

Water hardness at six sites remained relatively the same as those recorded in 2011 in regard to the hardness category, except for Wandena North which recorded hardness values 11000mg/L more then 2011. Hardness Values were highly variable in 2012 sampling occasions. Wandena North recorded a hardness value of 11000mg/L which is over 10 times more then 2011. This result could just be an outlier so further sampling in 2013 will indicate whethere it is such or a decline in water quality. Refer to Table 6 for the calculated hardness-modified trigger values (HMTV) for cadmium, copper, chromium, lead, nickel and zinc.

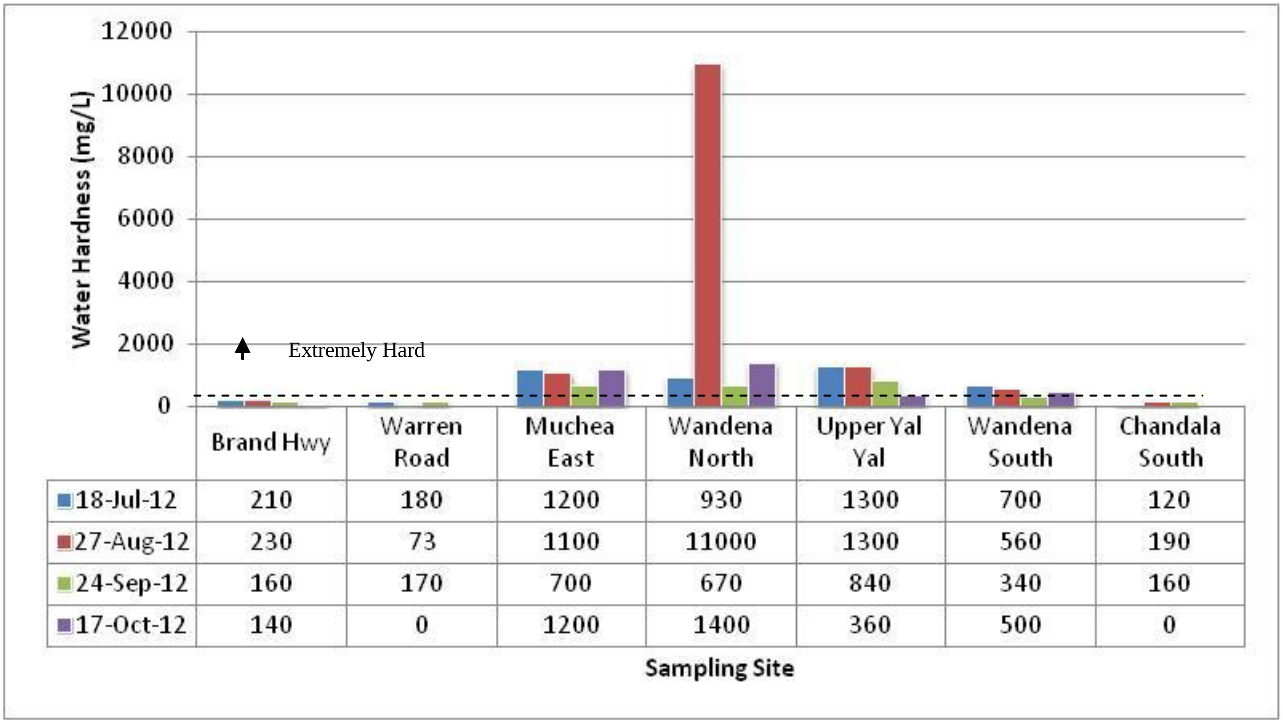


Figure 22: Water hardness of surface water within the Ellen Brook Catchment at sites sampled for metal contamination, between July and October 2012.*Blanks represent no sample

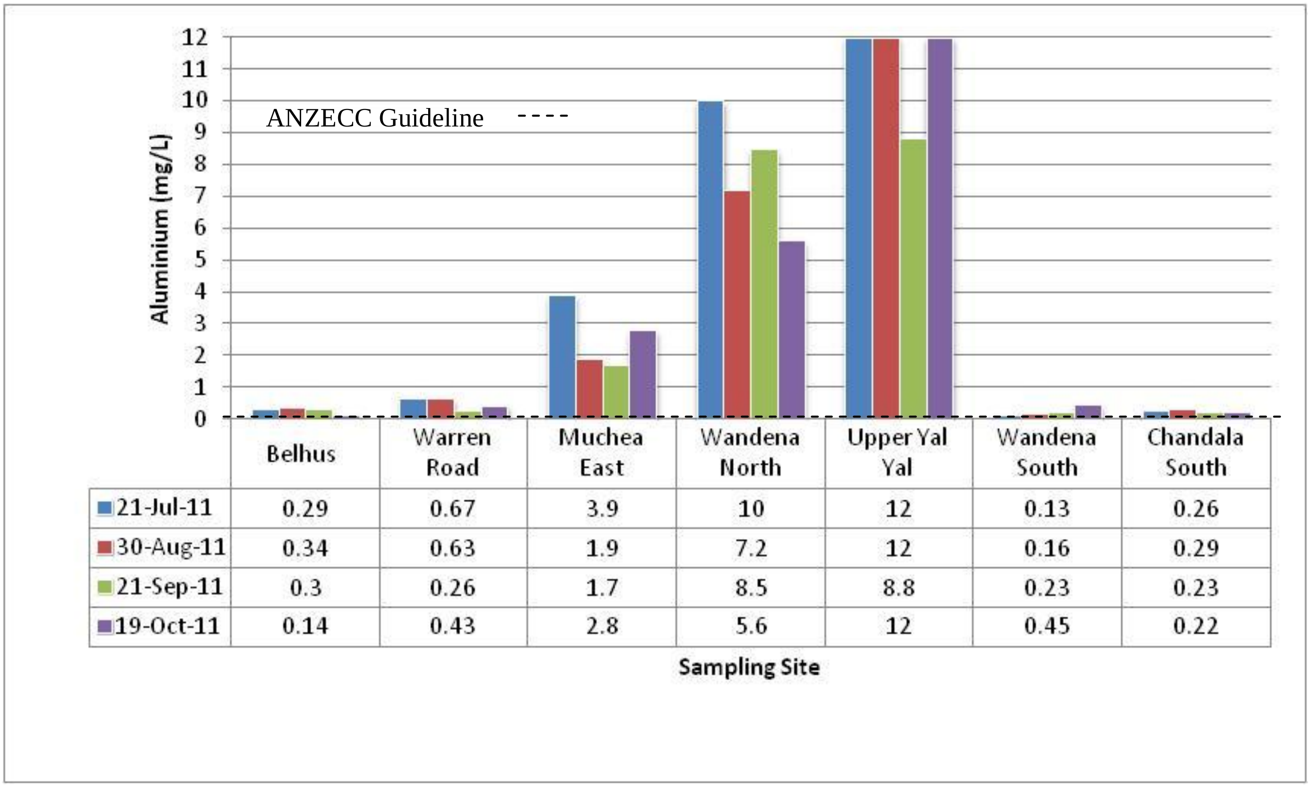
Table 6: Hardness-Modified Trigger Values (HMTV) for Cadmium, Copper, Chromium, Lead, Nickel and Zinc based on Figure 22 and Appendix E calculations.

Metal	ANZECC Trigger Value	HMTV for extremely hard water (250 - >400mg/L)	HMTV for very hard water (180 – 240).
Cadmium	0.0002	0.002	0.0011
Copper	0.0014	0.0126	0.0072
Chromium	0.001	0.0084	0.005
Nickel	0.011	0.099	0.057
Lead	0.0034	0.09	0.04
Zinc	0.008	0.07	0.04

7.4.2 Aluminium

All sites tested consistently exceeded the 0.055mg/L ANZECC water quality guideline for freshwater ecosystems (Figure 23). Upper Yal Yal (EBN21) and Wandena North (EBN7) recorded the highest aluminium concentrations. It is interesting to note that pH levels at Muchea East (EBN10) were very similar to those at Wandena North (EBN7) yet the aluminium concentrations at Wandena North were significantly higher(Figure 8). Wandena North (EBN7), Wandena South (EBN8) and Muchea East (EBN10) are situated below old clay pits and consistently record low pH levels between 3 and 7. This is potentially due to run off from old clay extraction pits up stream of the tributary where altered hydrology has resulted in ferrolysis (acid sulphate soil created by the alternating oxidation and reduction of iron/clays), which has subsequently increased the mobility of aluminium in the soil and enabled it to be transported downstream. The other contributing factor could be that these streams are partly groundwater fed. This groundwater flows through ancient marine deposits resulting in increased acidity which mobilizes the metals within the soil.

Brand Hwy was the only site that recorded concentrations close to the guidline.Concentrations reached as high as 16mg/L on the July and September sampling occasion at Upper Yalyal (EBN28). This is higher then the 2011 sampling for that site however the increase in Aluminium could be attributed to the reducd winter rainfall received in 2011.. It is of concern that all the sites recorded levels above the guidline however levels are not so high that they would be detrimental to the livestock or fauna using the water for drinking. What this also means is that the Ellen Brook is a contributor of aluminium to the Swan River (Figure 5).



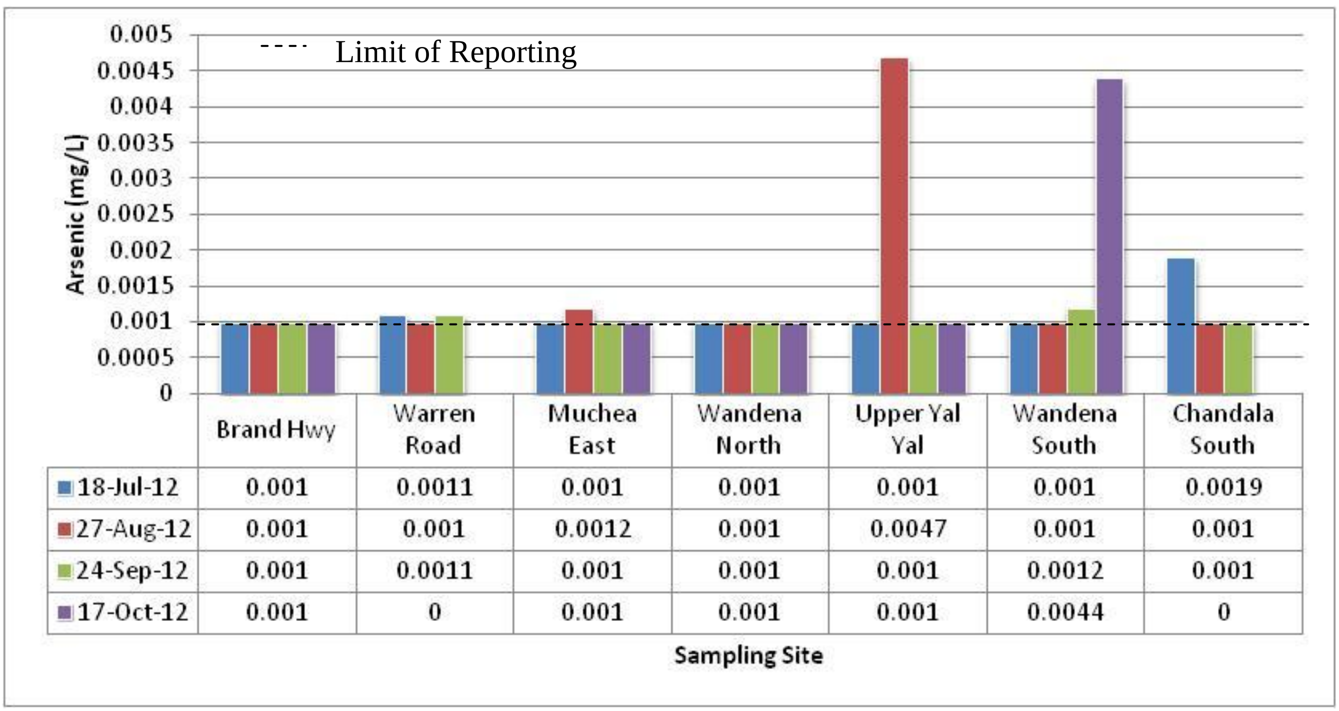
	Belhus	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
21-Jul-11	0.29	0.67	3.9	10	12	0.13	0.26
30-Aug-11	0.34	0.63	1.9	7.2	12	0.16	0.29
21-Sep-11	0.3	0.26	1.7	8.5	8.8	0.23	0.23
19-Oct-11	0.14	0.43	2.8	5.6	12	0.45	0.22

Figure 23: Aluminium concentrations in surface water within the Ellen Brook catchment between July and October 2012. *please note blanks represent no sample

7.4.3 Arsenic

All tested sites were recorded with concentration levels of arsenic below the ANZECC water quality trigger value for freshwater ecosystems of 0.024mg/L (Figure 24). Chandala South (EBN4), Wandena South (EBN8), Upper Yal Yal (EBN28) Warren Road (EBN17) and Muchea East (EBN10) were the only sites to record arsenic concentrations above the limit of reporting.

Arsenic is found in pesticides, insecticides, herbicides, fertilisers and various alloys, and occurs naturally in the environment. The recorded concentrations could be a result of excess fertilisers and chemicals transported to the waterways via surface water run-off and subsurface flow.



	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	0.001	0.0011	0.001	0.001	0.001	0.001	0.0019
27-Aug-12	0.001	0.001	0.0012	0.001	0.0047	0.001	0.001
24-Sep-12	0.001	0.0011	0.001	0.001	0.001	0.0012	0.001
17-Oct-12	0.001	0	0.001	0.001	0.001	0.0044	0

Figure 24: Arsenic concentrations in surface water within the Ellen Brook catchment between July and October 2012. *please note blanks represent no sample

7.4.4 Cadmium

All sites recorded cadmium levels below the Hardness Modified Trigger Values (HMTV) of 0.002mg/L in very hard water, 0.0011 in extremely hard water.(Figure 21) Brand Hwy (EBN9), Chandala South (EBN4) and Warren Rd (EBN17) were well below the HMTV for very hard water (180-240mg/L) and the remaining sites were well below their HMTV for extremely hard water (>400mg/L). Upper Yal Yal (EBN28) Muchea East (EBN10) and Wandena North (EBN7) were the only sites with cadmium levels above the limit of reporting. All other sites are below the limit of reporting on all occasions.

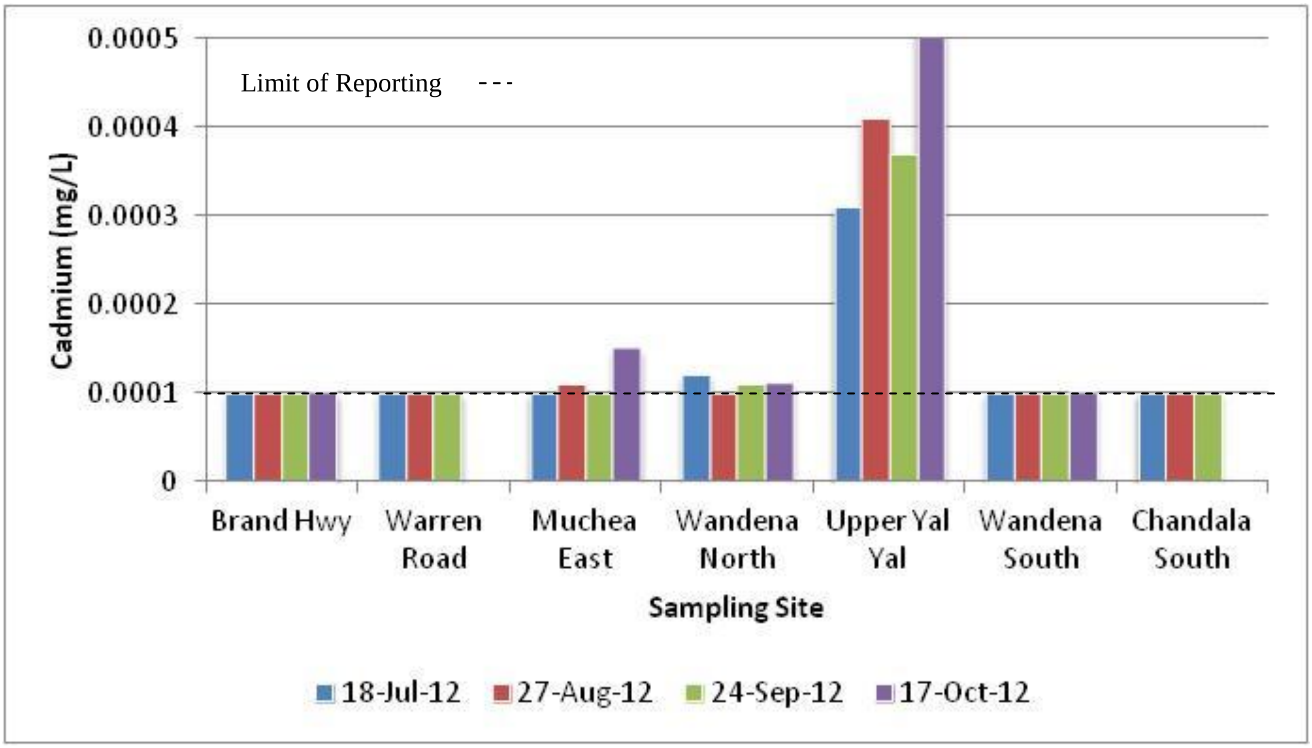


Figure 25: Cadmium concentrations in surface water within the Ellen Brook catchment between July and October 2012. *please note that blanks represent no sample

7.4.5 Chromium

All tested sites were well below the hardness-modified trigger values. Brand Hwy (EBN9), Chandala South (EBN4) and Warren Road (EBN17) were listed as very hard (Figure 17) and were below their HMTV of 0.005mg/L. Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10) and Upper Yal Yal (EBN28) were listed as extremely hard (Figure 17) and were below their HMTV of 0.0084mg/L, (Figure 26). Upper Yal Yal did come quite close to exceeding the guidline in comparison to previous years so further monitoring will need to continue.

Chromium is used in dyes and paints, and is also a naturally occurring and essential trace element in soil (Wikipedia, 2007).

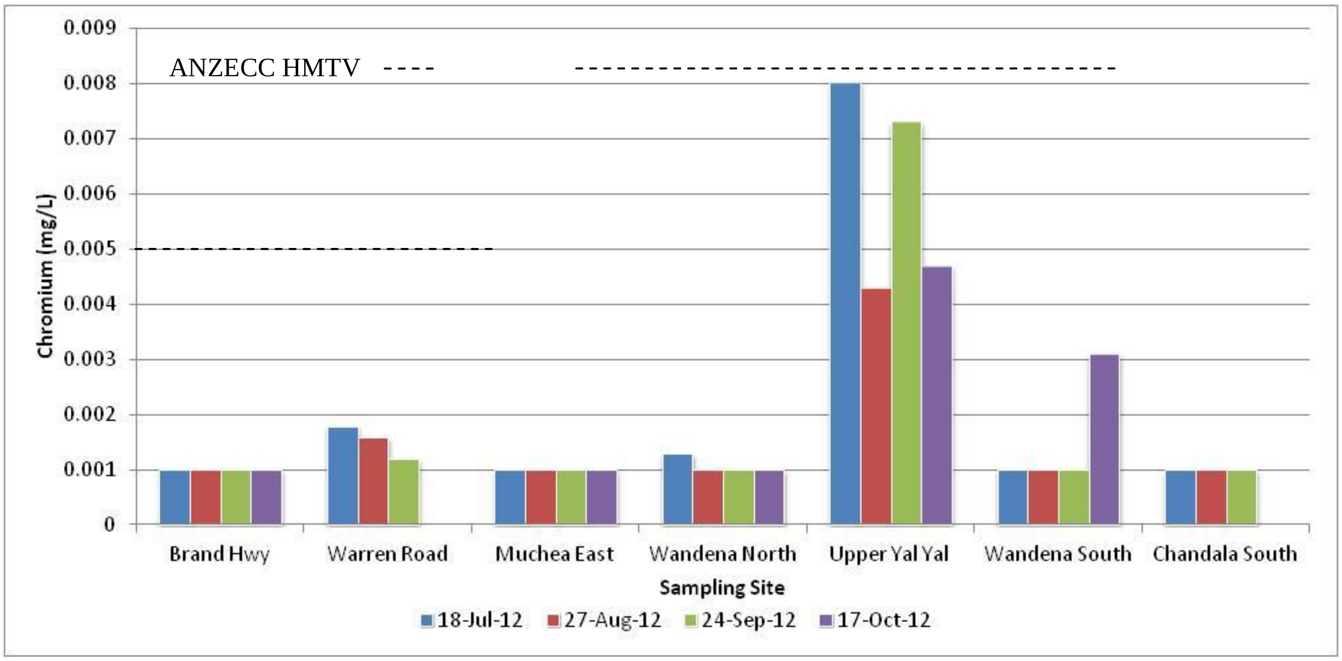


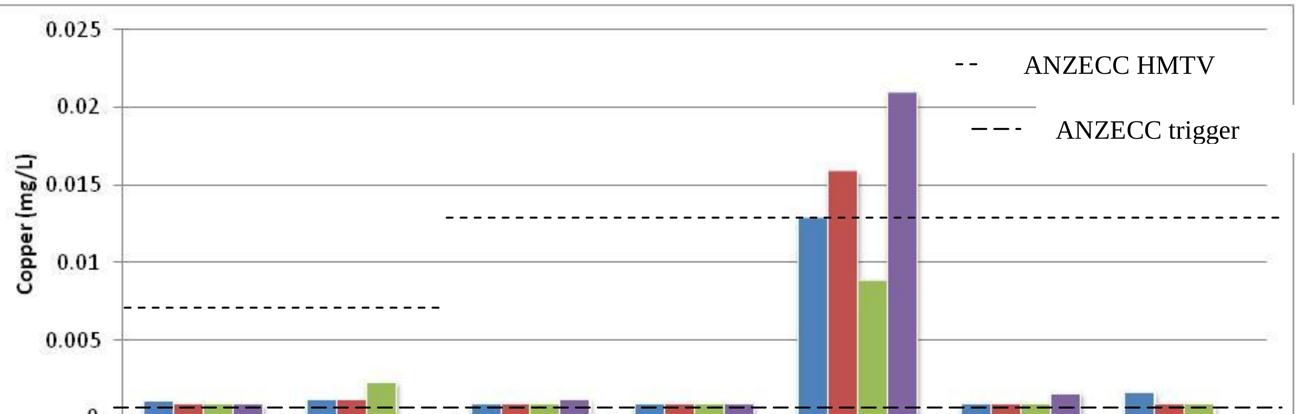
Figure 26: Chromium concentrations in surface water within the Ellen Brook catchment between July and October 2012. *Note blanks represent no sample.

7.4.6 Copper

Most sites were well below the hardness-modified trigger value (HMTV) of 0.0126mg/L for extremely hard water and 0.0072mg/L for very hard water. The Upper Yal Yal (EBN28) was the only site to exceed its HMTV on any sampling occasions (Figure 27).

Four of the sites were above the recommended ANZECC trigger value of 0.0014mg/L. Warren Rd (EBN17), Upper Yal Yal (EBN28) Wandena South (EBN8) and Chandala South (EBN4) exceeded the ANZECC trigger value on one or more sampling occasions. The sites are well below the ANZECC values for livestock watering, being 0.5 mg/L for sheep, 5 mg/L for pigs and poultry and 1mg/L for cattle. (ANZECC and ARMCANZ, 2000)

Copper is used in building material, electrical and heat conductors, and in household products. It is also an essential trace element; however in sufficient amounts it can be toxic. The proximity of these sites to the tip site, old clay extraction pits, Pearce RAAF Base, and urban development, accompanied by low pH levels and extremely/very hard water could have increased the mobilisation of the metal through the soil and resulted in increased concentrations in the waterways.



	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	0.0012	0.0013	0.001	0.001	0.013	0.001	0.0018
27-Aug-12	0.001	0.0013	0.001	0.001	0.016	0.001	0.001
24-Sep-12	0.001	0.0024	0.001	0.001	0.009	0.001	0.001
17-Oct-12	0.001	0	0.0013	0.001	0.021	0.0017	0

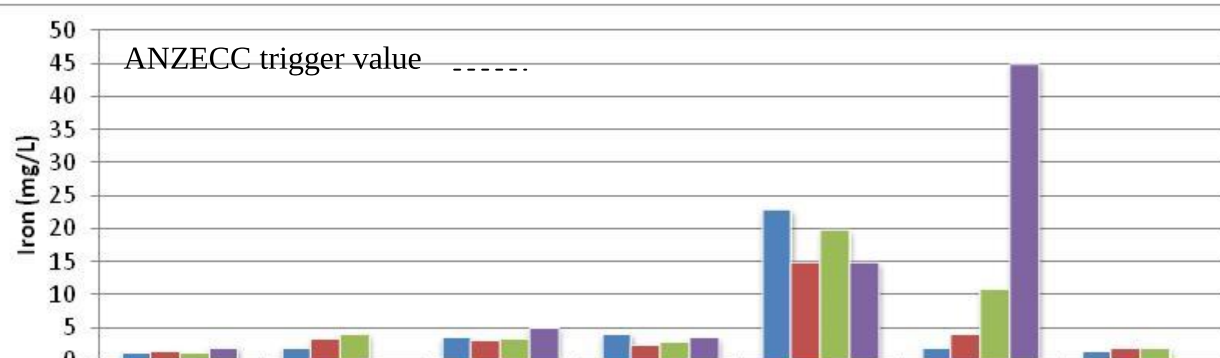
Sampling Site

Figure 27: Copper concentrations in surface water within the Ellen Brook catchment between July and October 2012.*note that blanks represent no sample.

7.4.7 Iron

All sites consistently exceeded the ANZECC guideline trigger value of 0.3mg/L (Figure 28). There is limited data on the effects of high iron levels for stock drinking purposes; however these sites were above the agricultural watering guideline of 1mg/L on all occasions (ANZECC and ARMCANZ, 2000).

Iron concentrations have been well above the guideline of 0.3mg/L on all sampling occasions since 2005. Since 2005, iron concentrations appear to have increased at each of the sites. Potential causes of high iron concentrations in surface waters at Chandala South (EBN4), Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10) and Warren Rd (EBN17) include the geology and soil type, the time of sampling and rainfall experienced on the day of sampling, and high acidity enabling the mobilisation of metal ions into solution. These metal ions are generally trapped in the sediments. The sites with higher concentrations than the guideline would more likely have a slight odour and cause an iron stain after irrigating.



	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	1.5	2.2	3.7	4.2	23	2.2	1.6
27-Aug-12	1.6	3.6	3.2	2.6	15	4.3	2.2
24-Sep-12	1.4	4.3	3.5	3	20	11	2.2
17-Oct-12	2.2	0	5.2	3.7	15	45	0

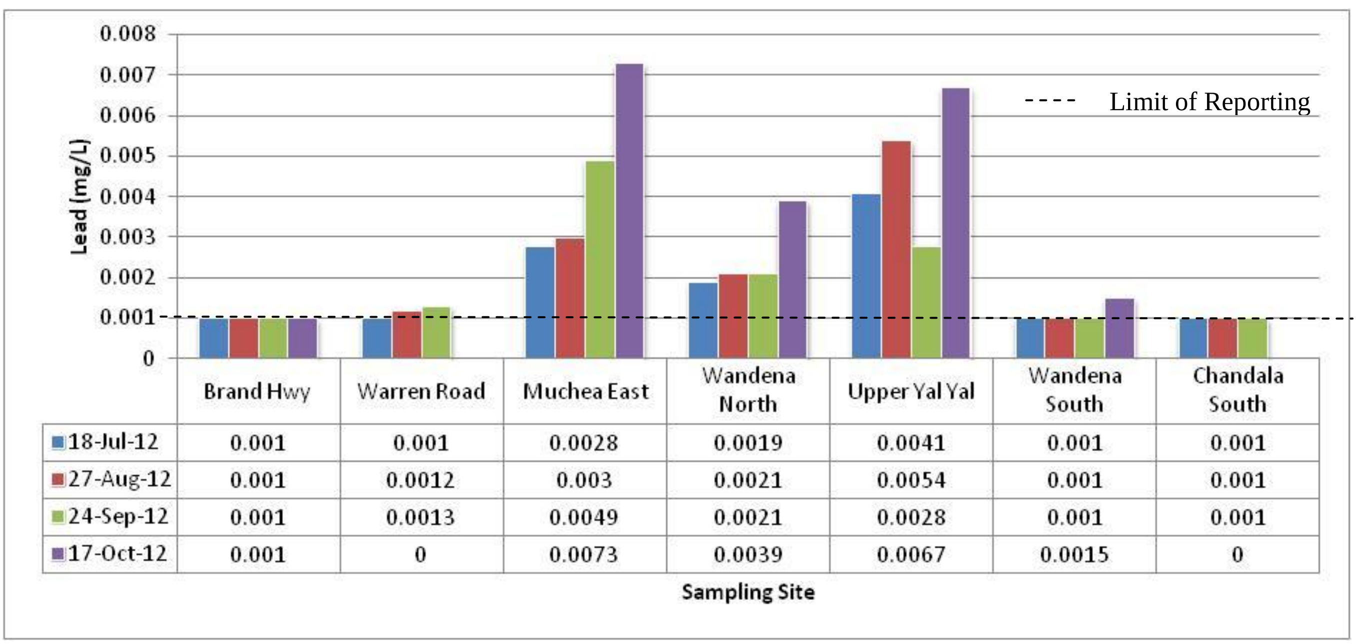
Sampling Site

Figure 28: Iron concentrations in surface water within the Ellen Brook Catchment between July and October 2012.*please note blanks represent no sample

7.4.8 Lead

Samples were well below the hardness-modified trigger values of 0.04mg/L at Brand Hwy (EBN9), Chandala South (EBN4) and Warren Road (EBN17), and 0.09mg/L at Chandala West (EBN3), Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10) and Upper Yal Yal (EBN28) (Figure 29). Lead was found to be at or below the limit of reporting at all sites except for Wandena North (EBN7), Upper Yal Yal (EBN28), Wandena South (EBN8) and Muchea East on one or more sampling occasions. However, lead concentrations remained below the HMTV and are therefore not of concern at this time.

Lead is used in building construction, lead-acid batteries, and bullets. It is also a neurotoxin that accumulates in soft tissues and bone over time. Lead is a soil contaminant, present in natural deposits and may enter the soil through petrol leaks or from grindings from particular industrial operations (DOW, NA).



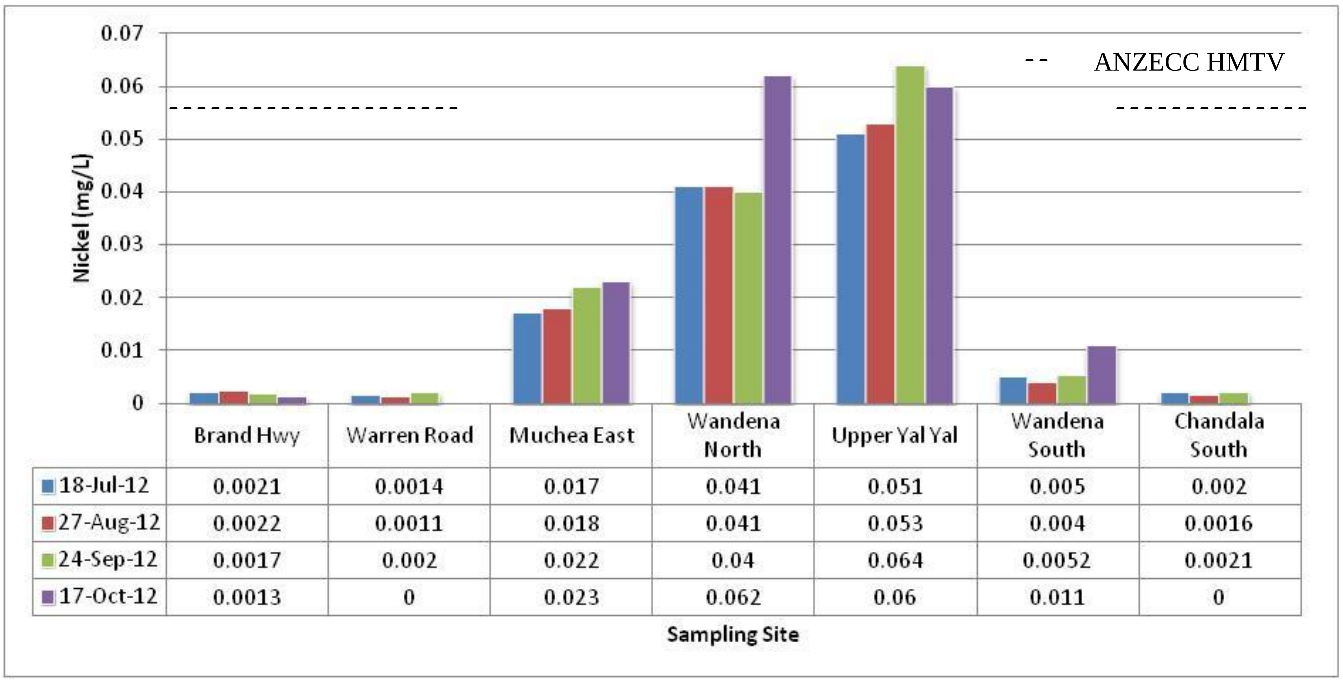
	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	0.001	0.001	0.0028	0.0019	0.0041	0.001	0.001
27-Aug-12	0.001	0.0012	0.003	0.0021	0.0054	0.001	0.001
24-Sep-12	0.001	0.0013	0.0049	0.0021	0.0028	0.001	0.001
17-Oct-12	0.001	0	0.0073	0.0039	0.0067	0.0015	0

Figure 29**:** Lead concentrations in surface water within the Ellen Brook catchment between July and October 2012. *Note blanks represent no sample

7.4.9 Nickel

All tested sites were well below the hardness-modified trigger values of 0.057mg/L at Brand Hwy (EBN9), Chandala South (EBN4) and Warren Road (EBN17), and 0.099mg/L at, Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10) and Upper Yal Yal (EBN28) (Figure 30). All sites were also well below the trigger value of 1mg/L for metals in livestock drinking water.

Nickel is used in many industrial and consumer products, plating and glass tinting.



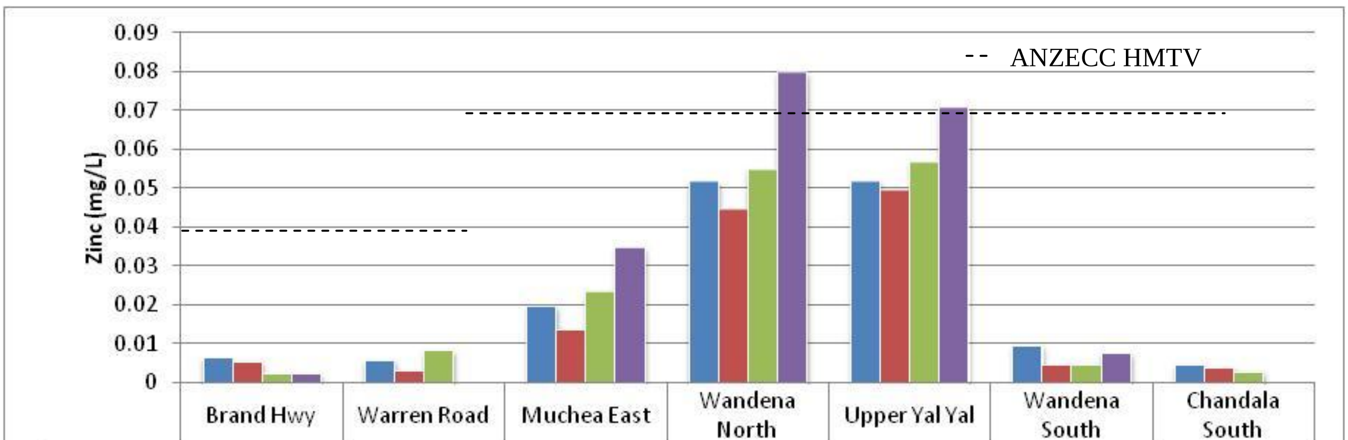
	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	0.0021	0.0014	0.017	0.041	0.051	0.005	0.002
27-Aug-12	0.0022	0.0011	0.018	0.041	0.053	0.004	0.0016
24-Sep-12	0.0017	0.002	0.022	0.04	0.064	0.0052	0.0021
17-Oct-12	0.0013	0	0.023	0.062	0.06	0.011	0

Figure 30: Nickel concentrations in surface water within the Ellen Brook catchment between July and October 2012. *Note blanks represent no sample

7.4.10 Zinc

No tested site exceeded the hardness-modified trigger values (HMTV) of 0.04mg/L at Brand Hwy (EBN9), Chandala South (EBN4) and Warren Road (EBN17). However Wandena North (EBN7) and Upper Yal Yal (EBN28) did exceed the extremely hard HMTV of 0.07mg/L on one sampling occasion. The remaining sites were below the HMTV (Figure 31). It is important to note that total zinc concentrations of less then 20mg/L in livestock drinking water is highly unlikely to be a threat to the health of livestock (ANZECC and ARMCANZ, 2000).

Concentrations of Zinc rarely exceed 0.01mg/L in natural water. Higher concentrations can be associated with pollution from industrial wastes or corrosion of zinc coated plumbing or galvanized water tanks, particularly in areas of low pH (ANZECC and ARMCANZ, 2000).



	Brand Hwy	Warren Road	Muchea East	Wandena North	Upper Yal Yal	Wandena South	Chandala South
18-Jul-12	0.0067	0.0062	0.02	0.052	0.052	0.01	0.0049
27-Aug-12	0.0058	0.0036	0.014	0.045	0.05	0.005	0.0043
24-Sep-12	0.0028	0.0086	0.024	0.055	0.057	0.0051	0.0032
17-Oct-12	0.0026	0	0.035	0.08	0.071	0.008	0

Figure 31: Zinc concentrations in surface water within the Ellen Brook catchment between July and October 2012. *Note that blanks represent no sample

8. Comparison with previous results

The Ellen Brook catchment water quality monitoring program has been undertaken on an annual basis for eight years, with four or five sampling runs conducted each year, commencing in 2005. Enough data has been collated across the catchment to provide some indication of water quality and emerging trends. It is imperative that this monitoring program be continued to add to the data collected to date and identify emerging trends more clearly.

The sampling results are dependent upon the ‘flushing’ of the system and therefore, the amount of rainfall during that season. Nutrient concentrations in the Ellen Brook originate from sediments on the river bed and tributaries that result from erosion and surface runoff from the eastern part of the catchment, and nutrients carried in suspension through surface runoff and sub-surface flow from the western sub catchments. Therefore, nutrient concentrations represent the amount transported into the Ellen Brook via sedimentation and surface water runoff.

Nutrient concentrations entering the Ellen Brook will vary each sampling year. Additionally, a consequence of snapshot sampling is that it only produces data for four to five individual sampling occasions within the three to four month sampling period, over the seven years (2005, 2006, 2007, 2008, 2009, 2010, 2011 & 2012). It does not take into account daily fluxes or extremes. Therefore, it is imperative that annual monitoring continues in order to determine the significance of change in concentrations and emerging trends.

8.1 pH

Throughout the duration of the 2005-2012 sampling program, pH generally remained within the ANZECC water quality guidelines for freshwater ecosystems between 6.5 and 8 at the majority of sites (Appendix I). However, there are some exceptions.

Subcatchments to the east of the Ellen Brook have been identified as contributors of metals with low pH values. Wandena North, Wandena South and Muchea East sampling sites are located downstream of old, current and proposed clay extraction pits which we infer to have resulted in the exposure of acid clay soils. Parsons Brinckerhoff (2006) found that the overlying gravely sands are slightly acidic with pH values ranging between 5 and 6. pH was found to decrease with increasing depth to the clay horizon. At a depth of 2m pH values were recorded around 5. At a depth of 10m pH was recorded as low as 3.63, therefore, these soils are naturally acidic. Disturbance and excavation works carried out at these sites has altered the groundwater table and potentially the severity of the acid soils contribution to acidic water (refer to 7.2 for more details).

Wandena North has recorded pH values between 3.17 and 8.24. Wandena South recorded pH values between 3.85 and 7.16. Muchea East recorded pH values between 3.15 and 6.95. It is interesting to note that in 2005 at Muchea East pH values were all above 6.3; however 2006 to 2012 averages being considerable lower. In 2012 the average pH was 3.74 which is relatively consistant with the years since 2005. There has definitely been a been a drastic fall in pH at Muchea East. The following graph has been included to illustrate the average pH trends from 2005 through to 2012 for each site(Figure 32). It is evident that the majority of sites have remained within the guideline. The few sites that have acidity issues are quite different from the other sites.

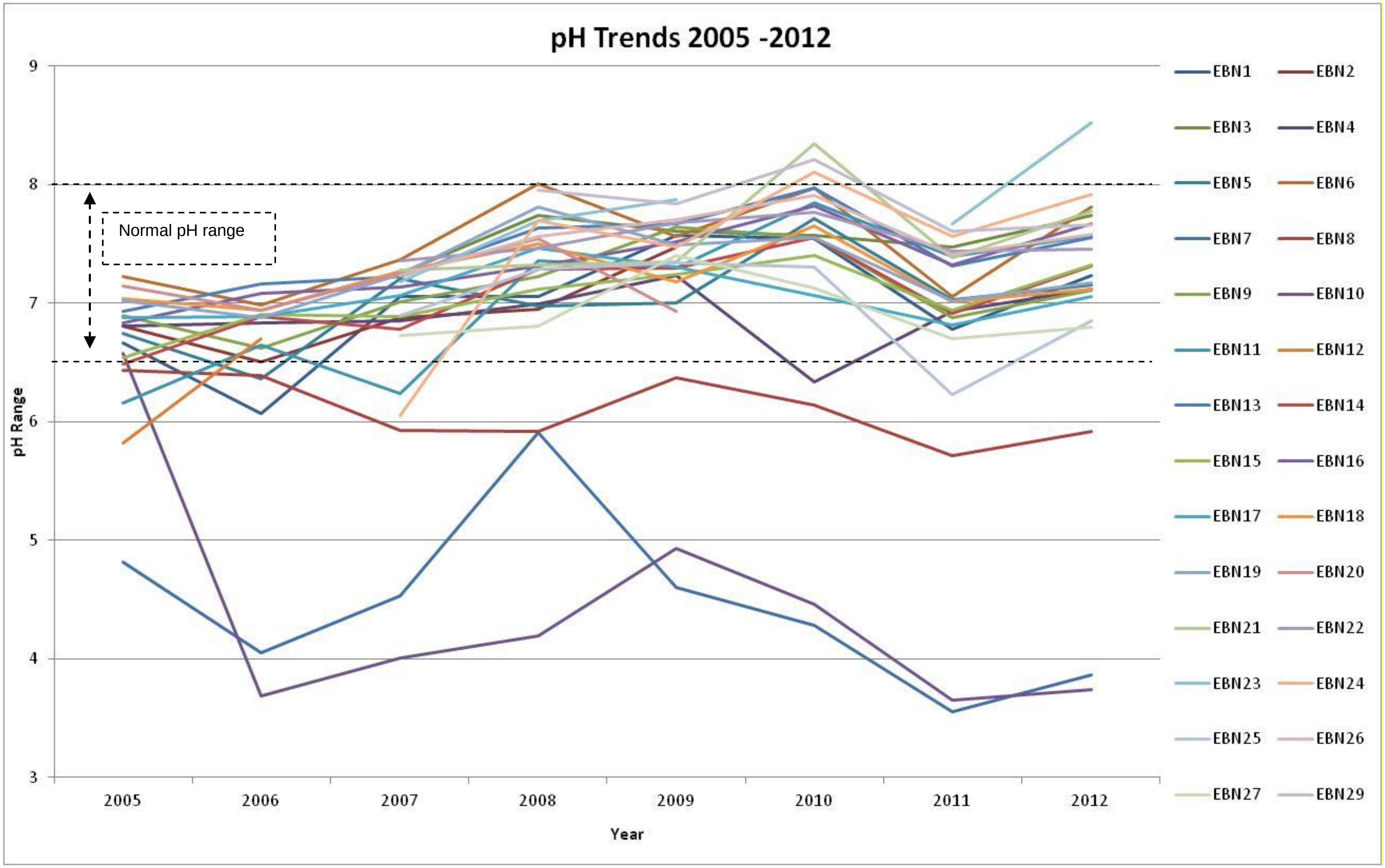


Figure 32: Average pH levels in surface water within the Ellen Brook catchment between 2005 and 2012.

8.2 Conductivity

Throughout the duration of the 2005-2012 sampling program, conductivity (EC) remained above the ANZECC water quality guidelines for freshwater ecosystems of 0.12-0.3mS/cm at most sites (Appendix I). Table 8 depicts the subcatchments sampled in the Ellen Brook catchment as fresh, marginal, brackish or saline based on the seven years of monitoring data.

Table 7: Sub catchment salinity measure based on the average of years of consistent data (2005-2012). *Please note that italicised salinity measurements represent 2-5years of sampling data ONLY.*

Sampling Site	**Salinity Measurement**
EBN1 Lennard Brook	Fresh to marginal
EBN2 Airfield Road	Fresh
EBN3 Chandala West	Marginal
EBN4 Chandala South	Marginal
EBN5 Yal Yal Brook	Fresh to Marginal
EBN6 Rocky Creek	Marginal to Brackish
EBN7 Wandena North	Brackish
EBN8 Wandena South	Brackish
EBN9 Brand Highway	Marginal to Brackish
EBN10 Muchea East	Brackish
EBN11 Muchea North	Fresh to Marginal
EBN12 Muchea South	*Fresh to Marginal*
EBN13 Rutland Road	Marginal
EBN14 Nutrient Inflow (Bingham)	Fresh
EBN15a Nutrient Outflow (Bingham)	Fresh
EBN16 Bulls Brook	Fresh
EBN17 Warren Road	Marginal
EBN18 Gauging Station	Marginal
EBN19 Belhus Reserve	Marginal
EBN20 All Saints	*Marginal*
EBN21 Lower Yal Yal	*Marginal*
EBN22 Ki-it Brook	*Marginal to Fresh*
EBN23 Peters Road	*Marginal*
EBN24 Stock Road	*Fresh*
EBN25 Sawpit Gully	*Fresh to Marginal*
EBN26 Egerton	*Fresh*
EBN27 Wandena Road	*Marginal to Brackish*
EBN28 Upper Yal Yal	NA
EBN29 Roxburgh Ave	*Marginal*

8.3 Total Nitrogen

Throughout the duration of the 2005-2012 sampling program, total nitrogen (TN) remained above the ANZECC water quality guidelines for freshwater ecosystems of 1.2mg/L at the majority of sites (Appendix I). Most sites across the catchment contribute a relatively significant amount of total nitrogen to the Ellen Brook; however Chandala West (EBN3), Muchea North (EBN11), Lower Yal Yal (EBN21), Bulls Brook (EBN16) Warren Rd (EBN17) and Lennard Brook (EBN1) were identified as high contributors with TN concentrations reaching as high as 7.8mg/L at Warren Rd.

A number of sites recorded TN concentrations below the ANZECC guideline for the majority of sampling occasions over the seven years of sampling and included Muchea East (EBN10), Ki-it Brook (EBN21), and Wandena Road (EBN27). It is also worth mentioning that Wandena North (EBN7) has recorded TN Concentrations below the ANZECC Guideline on six of the eight sampling years, of which includes the 2012 samples.

8.4 Total Phosphorous

Throughout the duration of the 2005-2012 sampling program, total phosphorous (TP) remained above the ANZECC water quality guidelines for freshwater ecosystems of 0.065mg/L at the majority of sites (Appendix I). Muchea North (EBN11) and Muchea South (EBN12) (no longer sampled) were identified as relatively significant contributors of total phosphorous to the Ellen Brook with concentrations ranging between 1.2 and 7.1mg/L, which is over one hundred times greater than the guideline value.

A number of sites recorded TP concentrations below the ANZECC guideline for the majority of sampling occasions over the six years of sampling and included Yal Yal Brook (EBN5), Rocky Gully (EBN6), Wandena North (EBN7), Wandena South (EBN8), Muchea East (EBN10), Ki-it Brook (EBN21), Wandena Road (EBN27) Egerton (EBN26) and Roxburgh Ave (EBN29).

TP in the Ellen Brook catchment is composed primarily of the soluble forms of phosphorous which are bioavailable. This ‘dissolved’ fraction (SRP) measures the immediately available phosphate in the system at the time of sampling. It is the dissolved (soluble) forms of phosphorous which are readily available for biological uptake, which is more likely to stimulate algal blooms.

9. Recommendations

- Continue the sampling and analysis monitoring program within the Ellen Brook catchment.

- Nutrient reduction strategies need to be continued in the catchment. Management actions for nutrient reduction may include the following;
    - Construction of nutrient stripping wetlands
    - Construction of nutrient intervention structures
    - Promotion of the use of fertiliser alternatives
    - Promotion of fertiliser wise in the Vines estate
    - Best management practice for fertiliser application through soil and leaf testing
    - Best Management practices for deep rooted pasture establishment
    - Revegetation and the fencing off of riparian zones along the Ellen Brook and major tributaries to prevent stock access
    - Revegetation and rehabilitation of remnant vegetation

- Continue to evaluate the effectiveness of the Bingham road subcatchment, Brand Highway and Muchea North Drain since the addition of new nutrient intervention technologies by the Swan River Trust in 2009/2010 under the Drainage Nutrient Intervention Program (DNIP).

- Identify areas of future rehabilitation, revegetation and waterway protection based on the results of the sampling program.

- Develop Ellen Brook priority sub catchment scale reports to determine emerging trends in water quality over the time of sampling (2005 – 2012). These progress reports could be complemented with an assessment of land use, existing and recommended landcare works in the area.

10. References

ANZECC and ARMCANZ (2000). *National Water Quality Management Strategy: Australia and New Zealand water quality guidelines for freshwater and marine.* Australian and New Zealand Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand.

Bureau of metorology (2012) *Climate statistics for Australian Locations, Pearce RAAF,* Western Australia. http://www.bom.gov.au/climate/averages/tables/cw_009053_All.shtml

Banfield, K. (2001). *Sustainable Land Management in the Ellen Brook catchment.* Department of Agriculture.

Connell, S (2003). *Ellen Brook catchment Vegetation Survey* unpublished

CSIRO (1994). *Managing nutrient discharge from the Ellen Brook Catchment, Western Australia – Discussion Paper* CSIRO Division of Water Resources, Western Australia.

Deeley DM, Donohue R & Parsons G (1993). *Nutrient loads in surface drainage from Ellen Brook from 1987-1992 – Swan River Trust Report No. 13*. Swan River Trust, Perth.

Department of Water. (2006). *Water Resources Data – Bureau of Meteorology Rainfall Sites; HYSITREP – Site Report 009018 – Gingin –Gingin, 009029 – Muchea Tree Farm, 009053 Pearce RAAF Base. Retrieved on the 28th January 2011 from* portal.water.wa.gov.au/portal/page/portal/WaterManagement/MonitoringAndData/WaterLevelMonitoring

Department of Water. (2006a). *Water Resources Data – Streamflow Sites; HYSITREP – Site Report 616189 – Ellen Brook Railway Parade. Retrieved on the 10th January 2007 from* portal.water.wa.gov.au/portal/page/portal/WaterManagement/MonitoringAndData/WaterLevelMonitoring

Department of Water. (NA). *Swan Region Water Quality Monitoring and Evaluation: Background information for measured parameters. Retrieved on the 22nd February 2011* from www.water.wa.gov.au/idelve/srwqm/measured.htm

Donohue, R (1994) *Phosphorus and Nitrogen in Ellen Brook 1987-1993* Swan River Trust, Perth WA.

Ellen Brockman Integrated Catchment Group (EBICG). (2006). *Sampling and Analysis Plan.* Unpublished report.

Environmental Protection Authority (2002). *Revised Environmental Quality Criteria Reference Document (Cockburn Sound) – a supporting document to the draft Environmental Protection (Cockburn Sound) Policy 2002*.

Environmental Protection Authority (2002). *Revised Draft Environmental Protection (Cockburn Sound) Policy 2002 – report to the minister for the environment as required under section 28 of the Environmental Protection Act, 1986*.

Gerritse, R (1996). *Leaching of nutrients and pesticides from the Scott River Catchment: A critical overview of existing data and a comparison with the Harvey River, Ellen Brook and Gingin Brook Catchments.* CSIRO Division of Water Resources Report No. 96-37

Horwood W, Swan River Trust (SRT) (1997). *A Walk Through the Ellen Brook Catchment.* Swan River Trust, Perth WA.

http://hermes.erin.gov.au/pls/crg_public/!CRGPPUBLIC.PSTART?strAction=SearchByChemical 2006 *National Chemical Reference Guide* internet site March 2006

IEA (Institute of Engineers Australia) (2003). *Australian Runoff Quality Guidelines (Draft).* Institute of Engineers Australia, Australia.

Kellogg, Brown & Root Pty Ltd (2003). *Water Study for the Shire of Chittering* Perth, Western Australia.

McTaggart A, 2002. A Community Guideline to Surface Water Quality Investigations – Version 1.0. Water and Rivers Commission Aquatic Science Branch.

Micenko, A, 2005. *Sourcing contributing areas to river flow in Ellen Brook, Western Australia, using environmental indicators and mixing models.* Centre for water research: University of Western Australia

NHMRC & ARMCANZ (1996). *Australian Drinking Water Quality Guidelines*. National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand.

Parsons Brinckerhoff. (2006). *Acid Sulphate Soil Investigation and Management Plan: Lot 6 Wandena Road, Muchea WA.* Midland Brick Company, Perth WA.

PPK Environment and Infrastructure (Australia) Pty Ltd. (2001). *Draft Ellen Brook Catchment Management Plan*. Acacia Springs Environmental, Australia.

Russell, J. (2001). *Contribution of the particulate fraction to the phosphorous load exported from the Ellen Brook Catchment.* Unpublished bachelor dissertation, University of Western Australia.

Schoknecht, N. (2004). *Acidity in the environment of South Western Australia.* Department of Agriculture, Western Australia.

Smith , RA & Shams R (WRC) (2002). *Hydrogeological Information for management planning in the Ellen Brook Catchment.* Water & Rivers Commission, Perth WA.

Sharma, ML & Craig, AB (1988). *Comparative recharge rates beneath Banksia woodland and two pine plantations on the Gnangara Mound Western Australia.* Balkema Publishing, Boston.

SRT (Swan River Trust) (1999). *Swan Canning Cleanup Program Action Plan: An Action Plan to Clean up the Swan-Canning Rivers and Estuary*. Swan River Trust. Perth, WA.

Swan River Trust (2009). *Local Water Quality Improvement Plan: Ellen Brook*. Swan River Trust. Perth, WA.

Van Looij, E. (2007). *Developing Salt Load Targets for Ellen Brook, Wooroloo Brook and the Brockman River. Department of Water, Perth WA.*

Waters and Rivers Commission (2000) *Wilson Inlet report to the community. Summary of the Wilson Inlet catchment monitoring program*. Waters and Rivers Commission and Wilson Inlet Management Authority, WA.

Water and Rivers Commission (WRC) (2002). *Hydrogeological Information for management planning in the Ellen Brook catchment.* Water & Rivers Commission, Perth WA.

Wikipedia. (2007). *Copper, Chromium, Cadmium, Iron, Lead, Arsenic, Nickel*. Retrieved on the 7th February 2008 from www.wikipedia.org

Appendix A – Water Quality Results (raw)

Physical Parameters

Site Ref No.	Site Name	Date Collected	pH	Conductivity	Temperature	Total Suspended Solids
ANZECC			6.5 - 8	(mS/cm)		7mg/L
EBN19	Belhus	18-Jul-12	6.91	2.03	10.9	2
		27-Aug-12	7.64	2.09	13.1	<1
		24-Sep-12	7.11	1.589	15.8	4
		17-Oct-12	7.03	1.889	18.2	4
EBN26	Egerton	18-Jul-12	7.18	0.677	11.8	3
		27-Aug-12	7.98	0.536	13.8	<1
		24-Sep-12	7.41	0.528	19.5	3
		17-Oct-12	7.73	0.491	19.5	2
EBN25	Sawpit Gully	18-Jul-12	6.34	2.22	10.9	7
		27-Aug-12	7.31	2.17	13	4
		24-Sep-12	6.83	1.344	16.4	14
		17-Oct-12	6.92	1.422	18.3	9
EBN29	Roxburgh Ave	18-Jul-12	7.55	1.619	12.7	<1
		27-Aug-12	8.24	1.533	15.1	1
		24-Sep-12	7.65	1.426	18.2	2
		17-Oct-12	7.19	1.456	19.6	2
EBN18	Gauging Station	18-Jul-12	6.82	2.06	11.5	7
		27-Aug-12	7.56	2.01	13.4	<1
		24-Sep-12	7.24	1.722	18.6	17
		17-Oct-12	6.85	2.1	21.1	11
EBN22	Ki-it Brook	18-Jul-12	7.07	0.274	11.4	2
		27-Aug-12	7.86	0.298	12.8	<1
		24-Sep-12	7.45	0.276	15.8	3
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN17	Warren Road	18-Jul-12	6.6	2.26	9.3	3
		27-Aug-12	7.56	0.478	12	2
		24-Sep-12	7.01	1.261	19.6	10
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN13	Rutland Road	18-Jul-12	7.08	2.8	12.2	6

Site Ref No.	Site Name	Date Collected	pH	Conductivity	Temperature	Total Suspended Solids
		27-Aug-12	7.75	2.29	14	<1
		24-Sep-12	7.61	2.38	20.8	6
		17-Oct-12	7.74	2.45	25	7
EBN27	Wandena Road	18-Jul-12	6.51	3.14	11.2	<1
		27-Aug-12	7.23	2.86	12.9	1
		24-Sep-12	6.75	2.62	16.1	1
		17-Oct-12	6.72	2.99	18.7	<1
EBN10	Muchea East	18-Jul-12	3.96	9.36	16.4	1
		27-Aug-12	4.13	9.76	17.6	<1
		24-Sep-12	3.39	8.76	24.4	<1
		17-Oct-12	3.47	10.1	25.6	6
EBN7	Wandena North	18-Jul-12	4.12	6.74	15.1	<1
		27-Aug-12	4.17	7.41	15.7	<1
		24-Sep-12	3.62	6.7	16.5	<1
		17-Oct-12	3.56	10.91	26.6	<1
EBN6	Rocky Gully	18-Jul-12	7.52	10.5	12.1	1
		27-Aug-12	8.14	3.63	14.7	3
		24-Sep-12	7.67	3.17	18.2	2
		17-Oct-12	7.89	3.56	23.8	1
EBN21	Lower Yal Yal	18-Jul-12	7.78	3.19	15.8	2
		27-Aug-12	8.01	2.58	17.1	13
		24-Sep-12	7.55	2.41	21.6	41
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN5	Yal Yal	18-Jul-12	7.24	0.959	14.5	11
		27-Aug-12	7.4	0.89	16	2
		24-Sep-12	6.9	0.897	17.3	3
		17-Oct-12	7.07	1.009	22.3	12
EBN28	Upper Yal Yal	18-Jul-12	NA	NA	NA	NA
		27-Aug-12	NA	NA	NA	NA
		24-Sep-12	NA	NA	NA	NA
		17-Oct-12	NA	NA	NA	NA
EBN8	Wandena South	18-Jul-12	5.54	6.1	13.8	21
		27-Aug-12	6.25	5.42	15.2	10

Site Ref No.	Site Name	Date Collected	pH	Conductivity	Temperature	Total Suspended Solids
		24-Sep-12	5.72	5.12	18.1	35
		17-Oct-12	6.17	5.92	22.5	44
EBN24	Stock Road	18-Jul-12	7.75	0.904	6.5	<1
		27-Aug-12	8.18	0.83	12.2	<1
		24-Sep-12	7.82	0.731	15.7	2
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN16	Bulls Brook	18-Jul-12	7.75	0.606	7.8	<1
		27-Aug-12	7.95	0.649	12.3	9
		24-Sep-12	7.3	0.607	16.1	5
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN15a	NSP Out	18-Jul-12	7.21	0.53	2.2	1
		27-Aug-12	7.61	0.492	12	1
		24-Sep-12	7.09	0.401	15.9	4
		17-Oct-12	7.35	0.481	22.2	4
EBN14a	NSP In	18-Jul-12	7.1	0.535	8.5	1
		27-Aug-12	7.58	0.508	12	1
		24-Sep-12	7.1	0.426	15.3	1
		17-Oct-12	7.47	0.442	19.4	1
EBN11	Muchea North	18-Jul-12	7.64	1.86	9.4	<1
		27-Aug-12	7.89	1.464	12.5	1
		24-Sep-12	7.19	1.453	15.6	3
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN4	Chandala South	18-Jul-12	6.98	1.126	2.2	4
		27-Aug-12	7.48	1.395	12.5	7
		24-Sep-12	6.91	1.293	16.3	4
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN1	Lennard Brook	18-Jul-12	7.18	0.823	2.2	4
		27-Aug-12	7.61	0.82	12.9	11
		24-Sep-12	6.99	0.725	15.7	10
		17-Oct-12	7.12	0.697	15.7	9
EBN3	Chandala West	18-Jul-12	NS-D	NS-D	NS-D	NS-D
		27-Aug-12	7.74	4.61	13.3	13
		24-Sep-12	NS-D	NS-D	NS-D	NS-D
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN23	Peters	18-Jul-12	NS-D	NS-D	NS-D	NS-D

Site Ref No.	Site Name	Date Collected	pH	Conductivity	Temperature	Total Suspended Solids
	Road					
		27-Aug-12	8.6	1.951	15.9	4
		24-Sep-12	8.43	2.23	19.6	3
		17-Oct-12	NS-D	NS-D	NS-D	NS-D
EBN9	Brand Hwy	18-Jul-12	7.08	1.795	9.1	2
		27-Aug-12	7.48	1.86	13.2	2
		24-Sep-12	6.93	1.498	15.5	2
_		17-Oct-12	6.96	1.106	15.6	4
EBN2	Airfield Road	18-Jul-12	NS-D	NS-D	NS-D	NS-D
		27-Aug-12	NS-D	NS-D	NS-D	NS-D
		24-Sep-12	NS-D	NS-D	NS-D	NS-D
		17-Oct-12	NS-D	NS-D	NS-D	NS-D

NB: 'NS' represents 'no sample taken at this time due to no flow'; 'NF' represents 'no flow'; 'NA' represents 'not applicable'.

Nutrients

Site Ref No.	Site Name	Date Collected	Ammonia as NH3-N	DOC	SRP as P	Organic Nitrogen - Filterable	TOC	Total Kjeldahl Nitrogen (Calc)	Total Nitrogen	Total Oxidised Nitrogen (TON)	Total Phosphorus	Total Phosphorus - Filterable
LOR			<0.010	<1	<0.005	<0.025	<1	<0.025	<0.025	<0.010	<0.005	<0.005
Unit			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC			0.08		0.04				1.2	0.15	0.065	
EBN19	Belhus	18-Jul-12	0.04	31	0.1	1.3	34	1.3	1.4	0.11	0.16	0.12
		27-Aug-12	0.028	41	0.18	1.7	44	1.8	1.9	0.087	0.24	0.21
		24-Sep-12	0.035	37	0.21	1.3	38	1.4	1.5	0.054	0.29	0.25
		17-Oct-12	0.067	37	0.27	1.4	39	1.6	1.7	0.073	0.39	0.29
EBN26	Egerton	18-Jul-12	0.066		0.033	0.93		1	1.7	0.66	0.064	0.045
		27-Aug-12	0.015		0.055	1.1		1.3	2.1	0.82	0.093	0.072
		24-Sep-12	0.017		0.055	1		1.2	1.8	0.69	0.087	0.068
		17-Oct-12	<0.010		0.026	0.91		1.1	1.6	0.57	0.065	0.043
EBN25	Sawpit Gully	18-Jul-12	0.02		0.14	1.6		1.7	1.7	<0.010	0.19	0.15
		27-Aug-12	0.024		0.19	2.4		2.6	2.6	<0.010	0.29	0.22
		24-Sep-12	0.027		0.26	1.9		2	2	<0.010	0.37	0.3
		17-Oct-12	0.011		0.39	2		2.2	2.2	0.01	0.6	0.42
EBN29	Roxburgh Ave	18-Jul-12	0.029		<0.005	0.78		0.81	1.7	0.93	<0.005	<0.005
		27-Aug-12	<0.010		<0.005	0.96		1	2.4	1.4	0.007	0.005
		24-Sep-12	0.015		<0.005	1		1.1	1.4	0.32	<0.005	<0.005
		17-Oct-12	0.016		<0.005	0.99		1	1.3	0.23	0.015	0.007
EBN18	Gauging Station	18-Jul-12	0.057		0.12	1.4		1.5	1.6	0.036	0.2	0.15
		27-Aug-12	0.047		0.18	1.7		1.8	1.9	0.033	0.26	0.21
		24-Sep-12	0.028		0.19	1.3		1.6	1.6	0.025	0.28	0.23
		17-Oct-12	0.042		0.3	1.6		2	2	0.023	0.48	0.36
EBN22	Ki-it Brook	18-Jul-12	<0.010		<0.005	0.28		0.29	0.3	<0.010	0.009	<0.005
		27-Aug-12	<0.010		<0.005	0.33		0.37	0.38	<0.010	0.017	0.008
		24-Sep-12	<0.010		0.005	0.35		0.37	0.39	0.024	0.01	0.009

Site Ref No.	Site Name	Date Collected	Ammonia as NH3-N	DOC	SRP as P	Organic Nitrogen - Filterable	TOC	Total Kjeldahl Nitrogen (Calc)	Total Nitrogen	Total Oxidised Nitrogen (TON)	Total Phosphorus	Total Phosphorus - Filterable
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN17	Warren Road	18-Jul-12	0.09		0.11	1.6		1.8	1.9	0.023	0.23	0.15
		27-Aug-12	0.16		0.28	1.5		1.8	1.8	0.033	0.45	0.34
		24-Sep-12	0.35		0.18	2.3		3.1	3.1	0.051	0.4	0.24
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN13	Rutland Road	18-Jul-12	0.017		0.048	1		1.1	1.2	0.01	0.11	0.067
		27-Aug-12	<0.010		0.06	1.5		1.6	1.6	<0.010	0.12	0.091
		24-Sep-12	<0.010		0.08	0.99		1.1	1.1	0.014	0.15	0.1
		17-Oct-12	<0.010		0.13	1.1		1.2	1.2	<0.010	0.25	0.18
EBN27	Wandena Road	18-Jul-12	<0.010		<0.005	0.33		0.34	0.34	<0.010	<0.005	<0.005
		27-Aug-12	<0.010		<0.005	0.34		0.35	0.35	<0.010	0.005	0.005
		24-Sep-12	<0.010		<0.005	0.38		0.4	0.4	<0.010	<0.005	<0.005
		17-Oct-12	<0.010		<0.005	0.44		0.47	0.48	<0.010	0.006	0.006
EBN10	Muchea East	18-Jul-12	0.095		<0.005	0.25		0.34	0.5	0.16	<0.005	<0.005
		27-Aug-12	0.029		<0.005	0.26		0.29	0.32	0.035	0.005	<0.005
		24-Sep-12	0.27		<0.005	0.26		0.53	0.54	0.013	<0.005	<0.005
		17-Oct-12	0.4		<0.005	0.3		0.85	0.86	<0.010	0.009	<0.005
EBN7	Wandena North	18-Jul-12	0.11		<0.005	0.28		0.46	0.57	0.12	0.011	<0.005
		27-Aug-12	<0.010		<0.005	0.27		0.27	0.28	<0.010	<0.005	<0.005
		24-Sep-12	0.019		<0.005	0.17		0.23	0.24	<0.010	<0.005	<0.005
		17-Oct-12	0.044		<0.005	0.35		0.4	0.4	<0.010	<0.005	<0.005
EBN6	Rocky Gully	18-Jul-12	0.013		<0.005	0.6		0.61	0.8	0.19	0.017	0.008
		27-Aug-12	<0.010		0.005	0.71		0.78	0.78	<0.010	0.016	0.009
		24-Sep-12	<0.010		0.007	0.78		0.79	0.83	0.044	0.02	0.01
		17-Oct-12	<0.010		0.011	0.88		0.98	0.99	<0.010	0.024	0.016
EBN21	Lower Yal Yal	18-Jul-12	0.039		0.031	3.6		3.7	3.7	0.015	0.12	0.1
		27-Aug-12	0.035		0.047	3.2		3.8	3.8	0.012	0.2	0.11

Site Ref No.	Site Name	Date Collected	Ammonia as NH3-N	DOC	SRP as P	Organic Nitrogen - Filterable	TOC	Total Kjeldahl Nitrogen (Calc)	Total Nitrogen	Total Oxidised Nitrogen (TON)	Total Phosphorus	Total Phosphorus - Filterable
		24-Sep-12	0.056		0.079	3		3.5	3.6	0.03	0.22	0.14
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN5	Yal Yal	18-Jul-12	0.032		0.005	0.077		0.17	1.4	1.3	0.019	0.006
		27-Aug-12	0.011		0.008	0.28		0.37	1.4	1	0.016	0.009
		24-Sep-12	0.011		<0.005	0.25		0.45	1.2	0.76	0.013	0.008
		17-Oct-12	<0.010		0.007	0.17		0.29	1	0.73	0.02	0.011
EBN28	Upper Yal Yal	18-Jul-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		27-Aug-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		24-Sep-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
		17-Oct-12	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
EBN8	Wandena South	18-Jul-12	0.015		<0.005	0.62		0.9	0.92	0.016	0.053	0.007
		27-Aug-12	0.016		0.019	0.86		1	1	<0.010	0.04	0.021
		24-Sep-12	0.027		0.034	1.1		1.6	1.6	0.052	0.1	0.043
		17-Oct-12	0.021		0.14	4.6		5	5.1	0.057	0.19	0.15
EBN24	Stock Road	18-Jul-12	0.026		0.12	2		2.1	2.1	<0.010	0.17	0.16
		27-Aug-12	0.01		0.13	2.3		2.3	2.3	<0.010	0.21	0.19
		24-Sep-12	0.011		0.12	1.8		2.3	2.3	0.011	0.21	0.2
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN16	Bulls Brook	18-Jul-12	0.029		0.25	1.9		2.2	2.3	0.056	0.32	0.3
		27-Aug-12	0.021		0.24	2.3		2.6	2.6	0.032	0.35	0.31
		24-Sep-12	0.021		0.22	2		2.6	2.6	0.016	0.3	0.29
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN15a	NSP Out	18-Jul-12	0.056		0.57	2.1		2.2	2.2	0.014	0.67	0.64
		27-Aug-12	0.036		0.62	2.3		2.3	2.3	0.031	0.8	0.76
		24-Sep-12	0.032		0.57	1.9		2	2.1	0.014	0.76	0.7
		17-Oct-12	0.021		0.65	2		2.2	2.2	0.012	0.85	0.77
EBN14a	NSP In	18-Jul-12	0.034		0.57	1.9		2.2	2.2	0.018	0.63	0.63
		27-Aug-12	0.026		0.52	2.3		2.3	2.3	0.014	0.81	0.77

Site Ref No.	Site Name	Date Collected	Ammonia as NH3-N	DOC	SRP as P	Organic Nitrogen - Filterable	TOC	Total Kjeldahl Nitrogen (Calc)	Total Nitrogen	Total Oxidised Nitrogen (TON)	Total Phosphorus	Total Phosphorus - Filterable
		24-Sep-12	0.017		0.6	1.9		2.2	2.2	0.013	0.74	0.73
		17-Oct-12	0.011		0.61	2		2	2	0.015	0.81	0.75
EBN11	Muchea North	18-Jul-12	0.097		4.2	6.5		6.6	6.8	0.24	4.6	4.5
		27-Aug-12	0.07		3.1	6.2		6.3	6.4	0.054	3.4	3.4
		24-Sep-12	0.28		3	6.6		6.9	6.9	0.025	3.8	3.8
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN4	Chandala South	18-Jul-12	0.077		0.17	2.4		2.5	2.5	0.024	0.25	0.23
		27-Aug-12	0.068		0.21	2.1		2.2	2.3	0.047	0.3	0.27
		24-Sep-12	0.058		0.23	1.5		1.9	1.9	0.03	0.33	0.29
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN1	Lennard Brook	18-Jul-12	<0.010		0.1	0.034		0.058	2.2	2.1	0.13	0.11
		27-Aug-12	<0.010		0.091	0.15		0.26	2.6	2.3	0.16	0.1
		24-Sep-12	<0.010		0.087	0.15		0.64	2.7	2.1	0.12	0.099
		17-Oct-12	0.011		0.055	0.22		0.34	2.2	1.8	0.1	0.068
EBN3	Chandala West	18-Jul-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
		27-Aug-12	0.035		0.42	3.5		3.6	3.6	0.019	0.67	0.53
		24-Sep-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN23	Peters Road	18-Jul-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
		27-Aug-12	0.083		0.51	3.6		3.7	3.8	0.074	0.62	0.61
		24-Sep-12	0.019		0.41	3.5		4	4	0.017	0.54	0.54
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
EBN9	Brand Hwy	18-Jul-12	0.043		0.066	1.6		1.6	1.7	0.051	0.11	0.094
		27-Aug-12	<0.010		0.073	1.1		1.2	1.2	0.042	0.13	0.087
		24-Sep-12	<0.010		0.096	0.86		0.87	0.88	0.014	0.12	0.1
_		17-Oct-12	0.013		0.15	0.79		0.84	0.86	0.019	0.27	0.19
EBN2	Airfield Road	18-Jul-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
		27-Aug-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D

Ellen Brook Catchment Water Quality Monitoring Snapshot July – October 2012

Site Ref No.	Site Name	Date Collected	Ammonia as NH3-N	DOC	SRP as P	Organic Nitrogen - Filterable	TOC	Total Kjeldahl Nitrogen (Calc)	Total Nitrogen	Total Oxidised Nitrogen (TON)	Total Phosphorus	Total Phosphorus - Filterable
		24-Sep-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D
		17-Oct-12	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D	NS-D

NB: 'NS-D' represents 'no sample taken at this time due to no flow'; 'NA' represents 'not applicable'; '<' represents a value below the limit or reporting (LOR).

Total metal concentrations in surface water within the Ellen Brook catchment 2012.

Site Ref No.	Site Name	Date Collected	Hardness as CaCO3 (Calc)	Aluminium total	Arsenic total	Cadmium total	Chromium Total	Copper total	Iron total	Lead total	Mercury total	Nickel total	Zinc total
Unit			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
LOR			<5		<0.001	<0.0001	<0.001	<0.001		<0.001	<0.0001	<0.001	<0.001
ANZECC				0.055	0.024	0.0002	0.001	0.0014	0.3	0.0034	0.0006	0.011	0.008
EBN9	Brand Hwy	18-Jul-12	210	0.29	0.001	<0.0001	<0.001	0.0012	1.5	<0.001	<0.0001	0.0021	0.0067
		27-Aug-12	230	0.3	<0.001	<0.0001	<0.001	<0.001	1.6	<0.001	<0.0001	0.0022	0.0058
		24-Sep-12	160	0.084	<0.001	<0.0001	<0.001	<0.001	1.4	<0.001	<0.0001	0.0017	0.0028
		17-Oct-12	140	0.13	<0.001	<0.0001	<0.001	<0.001	2.2	<0.001	<0.0001	0.0013	0.0026
EBN17	Warren Road	18-Jul-12	180	0.22	0.0011	<0.0001	0.0018	0.0013	2.2	<0.001	<0.0001	0.0014	0.0062
		27-Aug-12	73	0.51	<0.001	<0.0001	0.0016	0.0013	3.6	0.0012	<0.0001	0.0011	0.0036
		24-Sep-12	170	0.32	0.0011	<0.0001	0.0012	0.0024	4.3	0.0013	<0.0001	0.002	0.0086
		17-Oct-12	NS-D	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry
EBN10	Muchea East	18-Jul-12	1200	4.1	<0.001	<0.0001	<0.001	<0.001	3.7	0.0028	<0.0001	0.017	0.02
		27-Aug-12	1100	3.3	0.0012	0.0001	<0.001	<0.001	3.2	0.003	<0.0001	0.018	0.014
		24-Sep-12	700	2.8	<0.001	<0.0001	<0.001	<0.001	3.5	0.0049	<0.0001	0.022	0.024
		17-Oct-12	1200	3.2	<0.001	0.0002	<0.001	0.0013	5.2	0.0073	<0.0001	0.023	0.035
EBN8	Wandena North	18-Jul-12	930	10	<0.001	0.0001	0.0013	<0.001	4.2	0.0019	<0.0001	0.041	0.052
		27-Aug-12	11000	9.5	<0.001	<0.0001	<0.001	<0.001	2.6	0.0021	<0.0001	0.041	0.045
		24-Sep-12	670	8.8	<0.001	0.0001	<0.001	<0.001	3	0.0021	<0.0001	0.04	0.055
		17-Oct-12	1400	12	<0.001	0.0001	<0.001	<0.001	3.7	0.0039	<0.0001	0.062	0.08
EBN28	Upper Yal Yal	18-Jul-12	1300	16	<0.001	0.0003	0.008	0.013	23	0.0041	<0.0001	0.051	0.052
		27-Aug-12	1300	14	0.0047	0.0004	0.0043	0.016	15	0.0054	<0.0001	0.053	0.05
		24-Sep-12	840	16	<0.001	0.0004	0.0073	0.009	20	0.0028	<0.0001	0.064	0.057
		17-Oct-12	360	14	<0.001	0.0005	0.0047	0.021	15	0.0067	<0.0001	0.06	0.071

Site Ref No.	Site Name	Date Collected	Hardness as CaCO3 (Calc)	Aluminium total	Arsenic total	Cadmium total	Chromium Total	Copper total	Iron total	Lead total	Mercury total	Nickel total	Zinc total
EBN7	Wandena South	18-Jul-12	700	0.13	<0.001	<0.0001	<0.001	<0.001	2.2	<0.001	<0.0001	0.005	0.01
		27-Aug-12	560	0.11	<0.001	<0.0001	<0.001	<0.001	4.3	<0.001	<0.0001	0.004	0.005
		24-Sep-12	340	0.2	0.0012	<0.0001	<0.001	<0.001	11	<0.001	<0.0001	0.0052	0.0051
		17-Oct-12	500	0.45	0.0044	<0.0001	0.0031	0.0017	45	0.0015	<0.0001	0.011	0.008
EBN4	Chandala South	18-Jul-12	120	0.26	0.0019	<0.0001	0.001	0.0018	1.6	<0.001	<0.0001	0.002	0.0049
		27-Aug-12	190	0.21	<0.001	<0.0001	<0.001	<0.001	2.2	<0.001	<0.0001	0.0016	0.0043
		24-Sep-12	160	0.17	0.001	<0.0001	<0.001	<0.001	2.2	<0.001	<0.0001	0.0021	0.0032
		17-Oct-12	NS-D	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry	NS-Dry

NB: ‘NS-D’ represents ‘no sample taken at this time due to no flow’; ‘NA’ represents ‘not applicable’; ‘<’ represents a value below the limit or reporting (LOR).

Appendix B – Freshwater Trigger Values and Guidelines

Trigger values and guidelines for nutrient concentrations and physical properties in lowland rivers and freshwater

Guideline	EC mScm	D0 % Sat	pH	Temp °C	TN mg/L	NO_XN mg/L	TP mg/L	FRP mg/L
ANZECC Water Quality Guideline – Recreational (2000)	-	>80 (>6.5 mg/L)	6.5-8.5	-	-	10	-	-
ANZECC Water Quality Trigger Values - lowland river (2000)	0.12-0.3	80-120	6.5-8.0	-	1.2	0.150	0.065	0.04
ANZECC Water Quality Guidelines – Freshwater (1992)	n/a	>80-90 (>6mg/L)	6.5-9.0		<2 increase	20-30	0.01-0.1	n/a

Trigger values and guidelines for toxicants (metals) in freshwater

* Trigger values not corrected for hardness, ID = insufficient data to have ANZECC water quality guideline

Guideline	As mg/L	Cr mg/L	Cu* mg/L	Fe mg/L	Mo mg/L	Mn mg/L	Ni* mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.05	0.05	1	0.3	ID	0.1	0.1
ANZECC Water Quality Trigger Values Freshwater 99% (2000)	0.001	0.00001	0.001	ID	ID	1.2	0.008
ANZECC Water Quality Trigger Values Freshwater 95% (2000)	0.024	0.001	0.0014	ID	ID	1.9	0.011
ANZECC Water Quality Trigger Values Freshwater 90% (2000)	0.094	0.006	0.0018	ID	ID	2.5	0.013
ANZECC Water Quality Trigger Values Freshwater 80% (2000)	0.360	0.04	0.0025	ID	ID	3.6	0.017
ANZECC Water Quality Guidelines – Freshwater (1992)	0.05	0.01	0.002-0.005	ID	ID	ID	0.015-0.15
Limit of reporting	0.001	0.001	0.001	0.01	0.005	0.001	0.001

Trigger values and guidelines for toxicants (metals) in freshwater

(continued)

* Trigger values not corrected for hardness, ID = insufficient data to have ANZECC water quality guideline

Guideline	Pb* mg/L	Sn	Sr mg/L	Ti mg/L	V mg/L	Zn* mg/L
ANZECC Water Quality Guidelines – Recreational (2000)	0.05	ID	ID	ID	ID	5
ANZECC Water Quality Trigger Values Freshwater 99% (2000)	0.001	ID	ID	ID	ID	0.0024
ANZECC Water Quality Trigger Values Freshwater 95% (2000)	0.0034	ID	ID	ID	ID	0.008
ANZECC Water Quality Trigger Values Freshwater 90% (2000)	0.0056	ID	ID	ID	ID	0.015
ANZECC Water Quality Trigger Values Freshwater 80% (2000)	0.0094	ID	ID	ID	ID	0.031
ANZECC Water Quality Guidelines – Freshwater (1992)	0.001-0.005	ID	ID	ID	ID	0.005-0.05
Limit of reporting	0.001	0.05	0.001	0.01	0.002	0.001

Appendix C – Photographs of Sample Sites

The following pictures were taken in June 2005 (note sites 17-20 are not included):


EBN1- Lennard Brook


EBN2 – Airfield Road


EBN3 – Chandala West


EBN4 – Chandala south


EBN 5 – Yal Yal Brook


EBN7 – Wandena North


EBN8 – Wandena south


EBN9 – Brand Hwy south


EBN10 – Muchea East


EBN11 – Muchea north


EBN12 – Muchea south


EBN 13 – Rutland Road


EBN14 – Bingham Road (NS outflow)


EBN15 – Nutrient Stripping Pond inflow


EBN16 – Bulls Brook


EBN17 – Warren Road


EBN18 – Gauging Station


EBN19 – Belhus Reserve


EBN20 – All Saints


EBN21 – Lower Yal Yal


EBN22 – Ki-it Brook


EBN23 – Peters Road


EBN24 – Stock Road


EBN25 – Sawpit Gully

EBN26 – Egerton

EBN27 – Wandena Road

EBN28 – Upper Yal Yal (Dam)

EBN29 Roxburgh Ave (The Vines)

Appendix D – Salinity measurements & tolerance limits

Salt Measurement Conversions

mS/cm	mS/m	ppm,mg/L	ppt	gr/gal		
0	0	0	0	0		distilled water
0.1	10	55	0.06	4		
0.2	20	110	0.11	8		
0.3	30	165	0.17	12		
0.4	40	220	0.22	15	FRESH	
0.5	50	275	0.28	19		
0.6	60	330	0.33	23		
0.7	70	385	0.39	27		
0.8	80	440	0.44	31		maximum stonefruit, citrus, peas, onion, carrot
0.9	90	495	0.50	35		
1.0	100	550	0.55	39		
1.5	150	825	0.83	58		maximum for hot water systems
2.0	200	1100	1.10	77	MARGINAL	
2.5	250	1375	1.38	96		maximum for people, grapes,tomato, lettuce
2.7	273	1500	1.50	105		
3.0	300	1650	1.65	116		
3.5	350	1925	1.93	135		
4.0	400	2200	2.20	154		
4.5	450	2475	2.48	173		
5.0	500	2750	2.75	193		
5.5	550	3025	3.03	212		maximum for milk cows and poultry,olives, figs
6.0	600	3300	3.30	231		
6.5	650	3575	3.58	250	BRACKISH	
7.0	700	3850	3.85	270		
7.5	750	4125	4.13	289		maximum for pigs
8.0	800	4400	4.40	308		
8.5	850	4675	4.68	327		
9.0	900	4950	4.95	347		
9.1	910	5005	5.01	350		
9.5	950	5225	5.23	366		
10.0	1000	5500	5.50	385		maximum for horses
10.5	1050	5775	5.78	404		
11.0	1100	6050	6.05	424		maximum lambs, weaners & breeder ewes
11.5	1150	6325	6.33	443		
12.0	1200	6600	6.60	462		
12.5	1250	6875	6.88	481		
13.0	1300	7150	7.15	501		
13.5	1350	7425	7.43	520		
14.0	1400	7700	7.70	539		
14.5	1450	7975	7.98	558	SALINE	
15.0	1500	8250	8.25	578		
15.5	1550	8525	8.53	597		maximum septic Tanks
16.0	1600	8800	8.80	616		
16.5	1650	9075	9.08	635		maximum beef cattle
17.0	1700	9350	9.35	655		
17.5	1750	9625	9.63	674		
18.0	1800	9900	9.90	693		
18.5	1850	10175	10.18	712		
19.0	1900	10450	10.45	732		
19.5	1950	10725	10.73	751		
20.0	2000	11000	11.00	770		
20.5	2050	11275	11.28	789		
21	2100	11550	11.55	809		
21.5	2150	11825	11.83	828		
22	2200	12100	12.10	847		
22.5	2250	12375	12.38	866		
23	2300	12650	12.65	886		maximum sheep
23.5	2350	12925	12.93	905		
24	2400	13200	13.20	924		
24.5	2450	13475	13.48	943		
25	2500	13750	13.75	963		
30	3000	16500	16.50	1155		
53	5300	29150	29.15	2041		sea water
64	6400	35200	35.20	2464		sea water
11.97	1197	6584	6.58	461		

Measurement Units
- mS/cm = millisiemens per cm
- mS/m = millisiemens per metre
- ppm = parts per mllion
- mg/L = milligrams per litre
- gr/gal = grains per gallor

Conversion Factors

mS/m	x 100	= mS/cm
mS/m	x 5.5 =	mg/L
mS/m	x 0.385 =	gr/gallon
mS/m	x 10 =	EC uS/cm
gr/gall	x 14.25 =	mg/L

Appendix E – Hardness-Modified Trigger Value calculations based on varying water hardness (Table 3.4.4. ANZECC & ARMCANZ, 2000).

Hardness category (mg/L as CaCO3)	**Water Hardness (mg/L as CaCO3)**	**Cd**	**Cr(III)**	**Cu**	**Pb**	**Ni**	**Zn**
Soft (0-59)	30	TV	TV	TV	TV	TV	TV
Moderate (60-119)	90	*2.7	*2.5	*2.5	*4	*2.5	*2.5
Hard (120-179)	150	*4.2	*3.7	*3.9	*7.6	*3.9	*3.9
Very Hard (180-240)	210	*5.7	*4.9	*5.2	*11.8	*5.2	*5.2
Extremely Hard (400)	400	*10	*8.4	*9	*26.7	*9	*9

Appendix F – Daily, monthly and annual Rainfall (mm) recorded at Pearce RAAF Base

(http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=2012&p_c=-16397241&p_stn_num=009053)Please note that 'nd' represents no data at time of sourcing records

Day	January	February	March	April	May	June	July	August	September	October	November	December
1	0	0	0	0	0	11.8	0	2.8	0	0	0	0
2	0	3.6	0	0.4	0	0	0	7	0	0	0	0
3	0	21.0	0	3.6	0	0	0	7.6	4.2	1.4	0	0
4	0	0	0	0	2.6	0	0	0	18.8	0.2	0	0
5	0	0	0	8.2	0	0	0	0	6.2	0	31.6	0.6
6	0	0	0	0	0	0	0	10.9	1.6	0	0.6	0.6
7	0	0	0	0	13.6	15.8	0	11.2	0	0	0.6	1.4
8	0	0	0	0	7.4	12	0	2.4	0	2	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	4.4	0	10.4	0	0	0	0	0
11	0	0	0	0	0.2	9.8	5	0	1.8	0	0	7.8
12	0	0	0	0	0	7.2	0	0	0	0	0.4	1.2
13	0	0	0	0	0	24.4	0	17.4	0	0	0	28.2
14	0	0	0	0	0.4	1.2	0	0	0	0	0	3.2
15	0	0	0	0	3.4	6	0	3.8	0	2.6	0	0
16	0	0	0	0	1.6	0	3.2	0	0	0	0	0
17	0	0	0	0	0	0	3.6	0	0	0	0	0
18	0	0	0	0	0	3	0	0	2.8	0	0	0
19	0	0	0	3.2	0	13.0	0	0	0.8	0	0	0
20	0	0	0	0	0	26.4	0.	0	1.2	0	0	0
21	0	0	0	0	0	9.6	0	4	1	0	0	0
22	0	0	0	0	0	0.2	0	6.2	0	1	0	0
23	0	0	0	0.4	0	0	1.6	0.2	0	0.4	0	0
24	0	0	0	0	0	0	0.2	0	5.8	0	0	0
25	0	0	0	0	0	0	0	0	6.8	0	0	0
26	0	0	0	0	0	0	0	0	3.8	0	5.4	0
27	2.4	0	0	0	0	2	0	0	14.8	0	0	0
28	0	0	0	0	0	3.6	0	1.2	2	0	4	0
29	0		0	0	0	5.8	0	4.2	0	0	13.2	0
30	0		0.8	32.20	0	0.6	0	0	0	0	1.8	0
31	0		0	0	0		0.4	0		0.2		0
Monthly Total	**2.4**	**24.6**	**0.8**	**48**	**33.6**	**151.8**	**24.4**	**78.9**	**71.6**	**7.8**	**57.6**	**43.0**
Annual Total												**544.5**

Appendix G – Sampling and Analysis Plan

Ellen Brook Water Quality Snapshot 2012

Plate 1: WEBN18 Gauging Station, Ellen Brook Main Channel Upper Swan (EBICG, 2011).

Prepared by Ellen Brockman Integrated Catchment group: May 2012

This project is co-funded by the Australian and Western Australian Government's investment in the Caring for Country administered by the Perth Region NRM.

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1. Background

The Ellen Brook catchment is located 20 kilometres north-east of Perth and is the largest coastal sub-catchment of the Swan-Canning estuary, with an approximate area of 800km² (Figure 33). The Ellen Brook discharges an average of 37 million cubic metres of water annually into the Swan River, which represents 12% of the Swan's total flow. Although a relatively low portion, it contributes 30% of the total phosphorous load and 15% of the total nitrogen load entering the Swan (SRT, 2009).

The Ellen Brook has been identified by the Swan River Trust as a priority catchment with the highest concentration of phosphorous of any of the monitored tributory entering the Swan Riverpark. This makes a significant contribution to the eutrophication and subsequent toxic algal blooms within the system (Horwood, 1997). As a result, the Swan River Trust produced the "Local Water Quality Improvement Plan (WQIP): Ellen Brook Catchment" through the Australian Government's Coastal Catchments Initiative (CCI) in 2009. The document aims to trace the pathway of nutrients through the catchment from their source to the discharge point, and to provide stakeholders with a mechanism to prioritise recommendations and resources, and funding to improve water quality.

Running north-south, the central portion of the catchment has been extensively cleared for agriculture, urban and industrial development. According to SRT (2009) land use is predominantly cattle grazing and horticulture in the north, and small scale light industry including mining and extractive industries together with an expanding region of urban and rural residential development to the south (Figure 34).

Monitoring involves observations and measurements that are analysed and reported for the purpose of providing information and knowledge about catchments and waterways (DoW, 2006). With support from Tiwest and the Department of Water (DoW), the Ellen Brockman Integrated Catchment Group (EBICG) commenced an annual sampling program focusing on nutrients, physical parameters, total suspended solids and heavy metals at a number of sites within the Ellen Brook catchment in 2005. Sampling occurred once per month over a four month period commencing with the first consistent winter flows. As more funding became available, eight strategically identified sites within the Ellen Brook catchment were added to the program in 2007, making a total of 27 sampling sites (Figure 35).

The water quality monitoring program for 2011 will be funded by the Ellen Brockman Integrated Catchment Group and the Swan River Trust. Sampling will be undertaken once a month over four months, and will commence with the first consistent winter flows.

The aim of this sampling and analysis plan is to provide a report on the development of the Ellen Brook water quality monitoring program, to ensure that sampling is conducted according to the relevant guidelines, ensuring that data standards are met and data quality continuity maintained (DoW, 2006). The aim of sampling from twenty-eight strategically identified sites along the Ellen Brook is to determine and monitor the priority sub-catchments, which are those that are contributing levels of nutrients and heavy metals in concentrations above the ANZECC Water Quality Guidelines. The SAP and the sampling program will continue to add to established baseline data for surface water quality within the catchment.

2. Changes to the project

This project commenced in winter/spring of 2005, please refer to the sampling and analysis plan for details of the project in 2005.

In 2006 the following changes were made to the project:

- All chemical analysis was carried out by NMI in 2006; (in 2005 this was done by MPL, through TiWest).
- The suite of heavy metals was changed to Al, As, Cd, Co, Cr, Cu, Fe, Hg, Mn, Mo, Ni, Pb, Se and Zn.
- Total water harness (as Ca and Mg) was included in the chemical analysis from sites where samples were collected for heavy metals analysis.

In 2007 the following changes were made to the project:

- Muchea South (site EBN 12) was removed from the project, as results were consistently low and it was decided the money could be better spent investigating a new site.
- The heavy metals analysis suite was reduced from 14 to 10 metals, specifically Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, and Zn.
- Eight new sites were added to the project (sites EBN 21-28). Sites 21-27 were sampled for physical parameter and nutrients only (the same as for the majority of sites included in the project and water collected from site EBN 28 was analysed for Al, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Zn and total water hardness (as Ca and Mg) only.
- Total and dissolved organic carbon were both added to the list of analysed parameters at the bottom of catchment site only (EBN 20).
- The sampling frequency was every three weeks for 4 events (instead of the previous monthly for 4 events).
- Dissolved organic nitrogen and nitrogen as ammonia were added to the suite of nutrient determined from water samples.

In 2008 the following changes were made to the project:

- One new site Roxburghe Ave (EBN 29) was added to the project. Water samples from this site were analysed for the standard suite of nutrients but also for dissolved organic phosphorus.
- The method for collection of organic carbon samples was changed. Both total and dissolved organic samples are now rinsed three times prior to final sample collection and filled to the top of the bottle with no air bubbles. This is to minimise the differences in collection and sampling methods between two parameters that are often compared.

In 2009 the following changes were made to the project:

- The sampling frequency has returned to monthly over four months.
- Total Filterable Phosphorous will be analysed rather than Dissolved Organic Phosphorous.

In 2010 the following changes were made to the project:

- Swan River Trust will be funding the project given that their funding applications are approved. If not, the program will be funded through the Ellen Brockman Integrated Catchment Group and the Local Government Authorities where possible.
- All Saints Church (EBN20) sampling site will not be sampled in 2010 unless access to the site is reopened to the public. 2009 sampling at this site was cancelled due to the questionable integrity of the stairway that leads down to the Confluence of the Ellen Brook and Swan River. Sampling parameters from All Saints will be sampled from Belhus Reserve (EBN19), which is the main body of the Ellen Brook on Millhouse Road.
- Nutrient Inflow (EBN14) and Nutrient Outflow (EBN15) sampling sites have been shifted further upstream (EBN14A) and further downstream (EBN15). This has been requested by the Swan River Trust due to the nutrient intervention works that have been undertaken at this site. A bund and spillway was installed in 2009/2010 to hold back the water and create a seasonal wetland. New GIS coordinates have been entered in Table 1.
- Nutrient Inflow (EBN14) is now referred to as EBN14A because it was moved greater than 100m from its original position. See Table 1for GIS coordinates. It has been re-registered with WIN database as a 'new' sampling site under this program.

In 2011 the following changes were made to the project:

- All Saints Church (EBN20) sampling site will not be sampled in 2011 unless access to the site is reopened to the public. 2009 sampling at this site was cancelled due to the questionable integrity of the stairway that leads down to the Confluence of the Ellen Brook and Swan River. Sampling parameters from All Saints will be sampled from Belhus Reserve (EBN19), which is the main body of the Ellen Brook on Millhouse Road.
- Chandala West (EBN3) will not be sampled for metals in 2011, It has not had any significant pH or metal concentrations in several years.
- Chandala South(EBN4) will be sampled for the full suite of metals in 2011 to investigate potential cause in decreased pH recorded in 2010

In 2012 the following changes were made to the project:

- Belhus Reserve (EBN19) will not be sampled for metals in 2012, It has not had any significant pH or metal concentrations in previous years.
- Brand Hwy (EBN9) will be sampled for the full suite of metals in 2012 to investigate whether the low pH water coming from the Wandena North (EBN7) Subcatchment is contributing any significant metal concentrations to the main channel of the Ellen Brook.

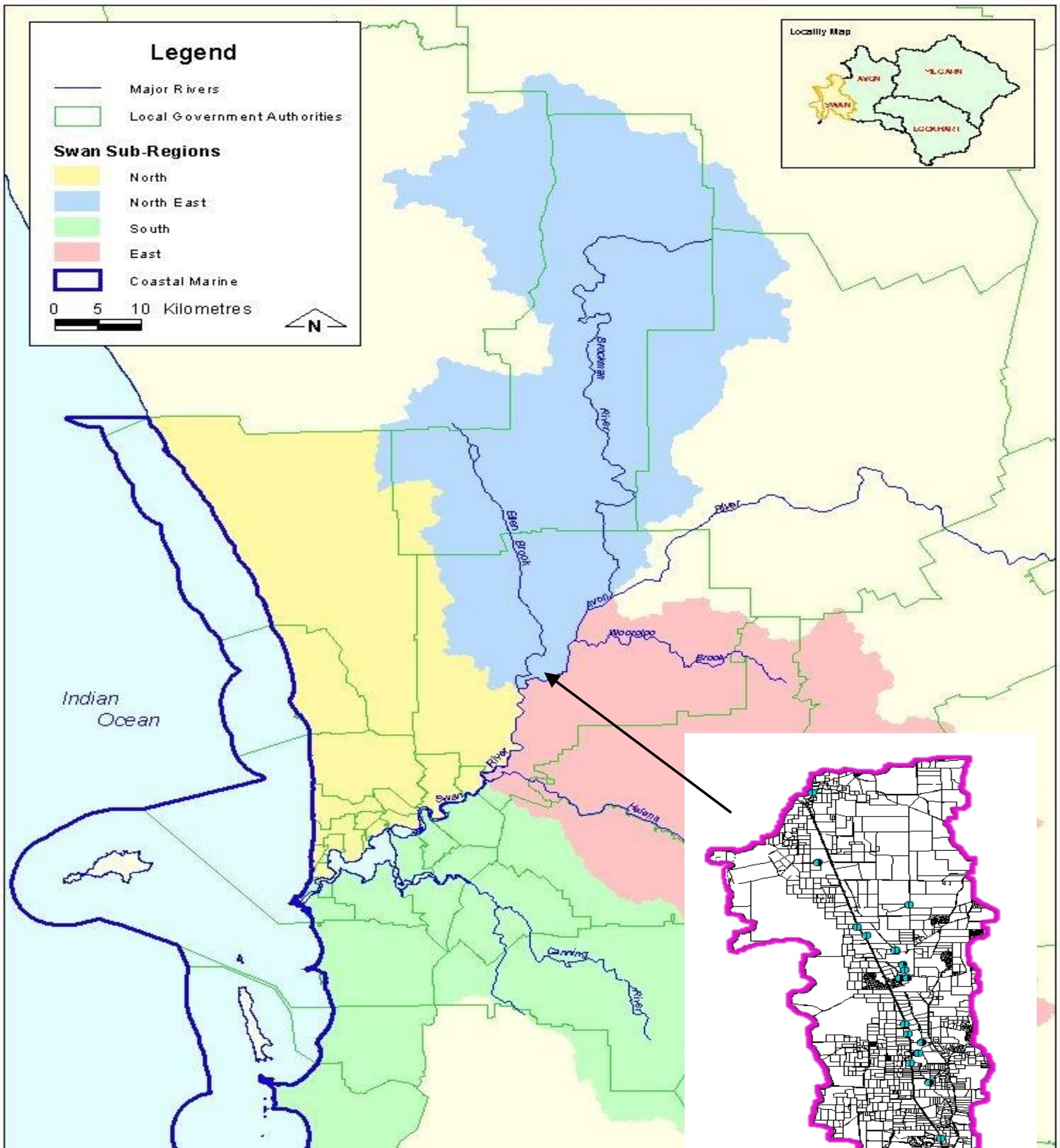

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Figure 33: Location of the Ellen Brook and Brockman River Catchments.

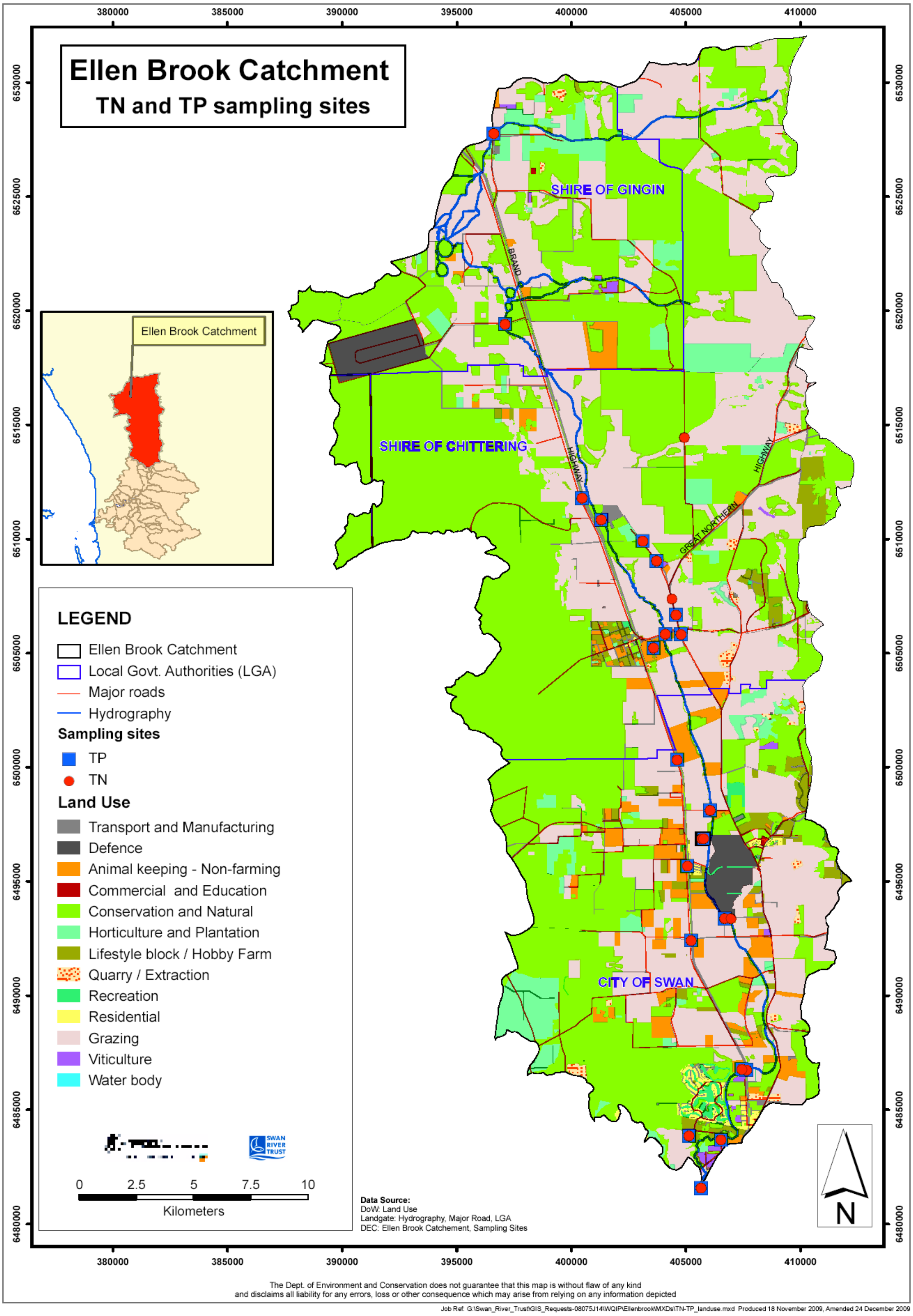

Figure 34: Ellen Brook Catchment land-use map.

3. *Sampling Site Location*

Water samples will be taken from twenty-eight sites within the Ellen Brook catchment (Figure 35). These sites have been selected to be representative of a particular part of the catchment; to determine their relative nutrient and metal contribution to the Ellen Brook; and whether they are situated upstream or downstream of potentially high impact land uses or of likely contaminant sources. Table 8 lists the EBN sampling sites by site number, site name and relative waterway component. Site location is also provided using street names, northings and eastings. It should be noted that GIS coordinates for Nutrient Inflow (EBN14) and Nutrient Outflow (EBN15) were changed in 2010 due to works undertaken by the Swan River Trust's Drainage Nutrient Intervention Program (DNIP). The installation of a bund and native vegetation filter has caused the original sampling points to be shifted a few metres further west (inflow), now sampled at the stock crossing, and east (outflow), this continues indefinately.

Table 8: **Location and description of sampling sites in the Ellen Brook catchment.**

Site no.	Site Name	Waterway section/ Component	Location	Northing	Easting
EBN1	Lennard Brook	Lennard Brook	Lennard Brook Road	6527771	0396613
EBN2	Airfield Road	North Chandala/Ellen Brook (Bambun Lakes)	Airfield Road	6519428	0397101
EBN3	Chandala West	Chandala Brook West	Brand Hwy west loc # 853	6511801	0400463
EBN4	Chandala South	Chandala Brook South	Brand Hwy east / TIWest	6510846	0401302
EBN5	Yal Yal Brook	Yal Yal Brook	Reserve Road	6514458	0404923
EBN6	Rocky Gully Creek	Rocky Gully Creek	Old Gingin Rd	6509047	0403714
EBN7	Wandena North	Waterway to Ellen Brook	Wandena North - Great Northern Highway	6507384	0404384
EBN8	Wandena South	Waterway to Ellen Brook	Wandena South - Great Northern Highway	6506686	0404561
EBN9	Brand Highway Bridge	Ellen Brook - Muchea Central	Bridge on Brand Hwy south	6505838	0404093
EBN10	Muchea East	Waterway to Ellen Brook Muchea East	Great Northern/Brand Highways	6505833	0404780
EBN11	Muchea North	Waterway to Ellen Brook -	Muchea south /Railway Rd 491 chit/swan sign	6500336	0404611
EBN13	Rutland Road	Ellen Brook (upper)	Rutland Road bridge	6498117	0406044
EBN14A	Nutrient Inflow	Waterway – Nutrient stripping inflow taken at stockcrossing	Bingham Road/ Department of Defence	6496881	0405499
EBN15	Nutrient Outflow	Waterway - Nutrient stripping Pond outflow	Bingham Road/ Department of Defence	6496883	0405807
EBN16	Bulls Brook	Bullsbrook	Sth past Strachan on Railway Rd	6495684	0405054
EBN17	Warren Road	Mid Ellen Brook	Warren Road	6493379	0406685
EBN18	Gauging Station	Ellen Brook - Almeria Gauging Station	Almeria Parade/Apple Street	6486743	0407638
EBN19	Belhus Reserve	Lower Ellen Brook	Belhus Reserve Millhouse Rd Bridge	6483685	0406519
EBN21	Lower Yal Yal	Yal Yal Brook South	Old Gingin Road	6509922	0403110
EBN22	Ki-it Brook	Ki-it Brook	Warren Road	6493382	0406959
EBN23	Peters Road	Waterway to Ellen Brook – Muchea townsite	Peters Road	6505232	0403580
EBN24	Stock Road	Waterway to Ellen Brook West	Railway Parade	6492415	0405221
EBN25	Sawpit Gully	Waterway to Ellen Brook – The Vines north	Lot 4/285 Railway Parade, Upper Swan	6486777	0407430
EBN26	Egerton	Waterway from Egerton Estate to Ellen Brook	Corona Way	6483859	0405129
EBN27	Wandena Road	Waterway to Ellen Brook	Corner of Great Northern Hwy and Wandena Road	6502590	0406553
EBN28	Upper Yal Yal	Yal Yal Brook North	Great Northern Hwy	6516783	0409421
EBN29	Roxburghe Avenue	Drain leading to Ellen Brook from The Vines east	Roxburghe Avenue	6486603	0406975

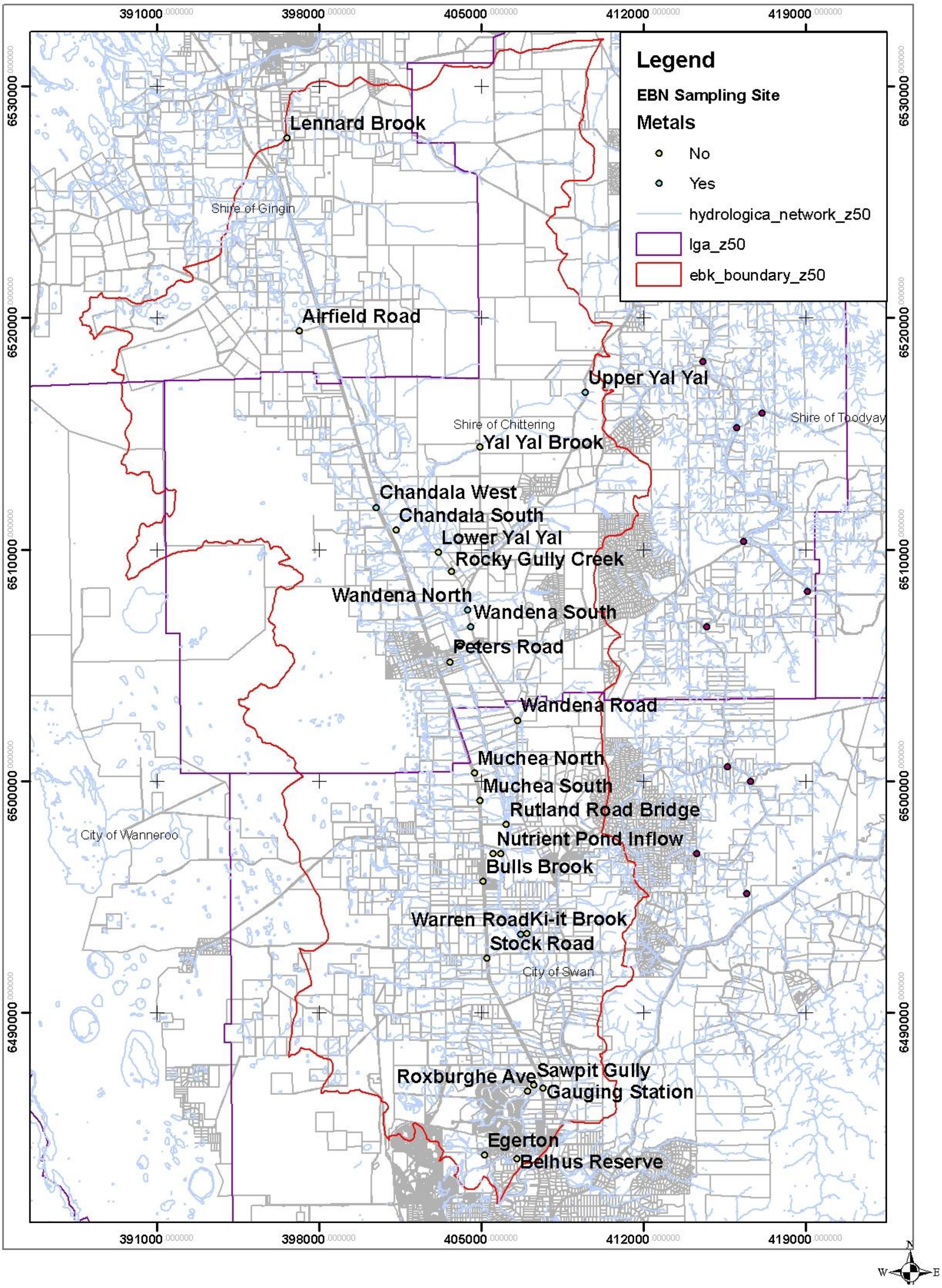

Figure 35: Water Quality sampling sites within the Ellen Brook catchment in 2012

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4. Sampling frequency

Initial sampling will take place from the first consistent winter flows (July) then once every month over a four month period.

5. Measured parameters

All sites, except EBN 28, will be analysed in the field using pH and salinity meters.

All sites, except EBN 28, will also be sampled for the analysis of total suspended solids and nutrients including total phosphorous (TP), total filterable phosphorous (TFP), total nitrogen (TN), Soluble reactive phosphorous (SRP), Soluble organic nitrogen (SOrgN), total oxidised nitrogen (TON) and nitrogen as ammonia (NH4-N). The confluence of the Ellen Brook and the Swan River (EBN 20-All Saints) is no longer accessible, therefore Belhus Reserve will be analysed for dissolved organic carbon (DOC) and total organic carbon (TOC).

Samples will be collected from Upper Yal Yal (EBN28), Chandala South (EBN4), Wandena North (EBN7), Wandena South (EBN8), Muchea east (EBN10), Warren Road (EBN17) and Brand Hwy (EBN9), for analysis of total water hardness and total metals; including iron, aluminium, copper, arsenic, lead, nickel, zinc, chromium, mercury and cadmium at seven sites. Refer to Appendix A for a tabular format of the selected parameters to be measured in surface waters of the sampling sites within the Ellen Brook catchment.

6. Quality Assurance and Quality Control

It is important to collect quality control samples as firm conclusions cannot be drawn from sampling data unless the quality of the data is known. The number and the types of quality control samples depend on the final use of the data, as well as the amount of time and money available for the monitoring program (DOW). This monitoring program will include one field blank and one replicate taken on two sampling occasions to ensure quality assurance and quality control of water quality data.

6.1. Blank Samples

Blanks are clean samples of deionised or distilled water, introduced at various stages of sampling. They are collected to detect and measure contamination in the sampling process as a result of ineffective field procedures, containers, equipment and transport. Often it is not possible to achieve absolutely no contamination, but rather only stable, minimal contamination levels. You need to set acceptable limits for these contamination levels, and when blanks are collected that fall outside this, you have a contamination issue that will require further investigation (DOW).

6.2. Field Blanks (FB)

Extra containers are taken to the site. Take a stock container of deionised/distilled water. On site, containers are opened and closed and the contents handled just as if these were normal samples being collected during transfer and storage, except they are filled with deionised/distilled water (leave or add appropriate preservative in the bottle if required– depending on which parameters the field blank is checking). These detect mainly contamination of sample during the collection procedure. Ideally at least one of these is collected per sampling team, per sampling trip, for all measured analytes (DOW).

6.3. Replicates Samples (RS)

Replicate samples are two or more samples collected from the same site and time, using exactly the same method. They can indicate the natural variations in the environment and variations caused by the field sampling method. It provides the experimental error and thus a measure of sampling accuracy. Two replicates will only indicate that variation exists (if there is any) but three replicates will enable some assessment of precision and bias (DOW).

7. Standard Operating Procedures

To reduce contamination of samples with disturbed sediment, sampling is to begin at the most downstream site within the catchment (Belhus Reserve – EBN19) and to be continued upstream.

Physical parameters will be measured using WTW meters at the same time as the water samples are collected. Calibration of the meters will need to occur prior to and at the end of the sampling with all calibration records kept in a logbook.

Grab surface water samples for chemical analysis of nutrients and metals is collected just below the surface, avoiding any surface scums or debris (DoW, 2006a). Measuring of physical parameters, direct sampling and taking filtered samples are to be conducted using the 'Guideline for Field Sampling for Surface Water Quality Monitoring Programs', by the Water Science Branch, Department of Water (2006a).

7.1. Physical Parameter Sampling (DoW, 2006a).

- Lower the clean, maintained and calibrated data logger into the water body near or at the same site where the water samples were taken. Minimise disturbance to the sediment.
- Ensure that all probes are fully submerged. Ideally the probes should be approximately 10cm under the water surface and 10cm above the sediment.
- The probes should be kept in a gentle motion while taking care not to stir up the sediments.
- If the probe has a built in circulator ensure this is turned on.
- Allow sufficient time for the probe to stabilise, and then take the readings.
- Store the physical results electronically on the instrument's console, or on the Field Observation Form.

7.2. Grab Pole Sampling (DoW, 2006a)

- Ensure that labelling on the bottle to be filled is correct and that the sample number matches the number on the paperwork (Field Observation Form and Chain of Custody form).
- Check that the grab pole sampler is clean.
- Extend the pole sampler so that it will reach the point that you wish to sample.
- Lower the grab sampler into the water with the mouth of the bottle facing upstream into the flow of water to a depth of 15cm. Keep the bottle moving forwards, into the flow of water whilst it is filling (Standards Australia AS/NZS 566.6:1998 5.3.1).
- Allow to partially fill, take the bottle out of the water, swirl around and tip out the rinsate downstream of sampling site.
- Repeat two more times so that the grab pole sampler has been rinsed three times.
- Then, fill the grab sampler at a depth of 15cm, with the mouth of the bottle facing upstream, slowly moving the bottle forward, into the flow of water.
- Use this sample to rinse the labelled sample container three times. Cap, shake well, and pour the rinsate downstream of yourself.
- Remove the cap from the sample container only at the time of sampling and replace the cap immediately after collection of the sample.
- Fill the bottle to the shoulder.

- Metal samples do not require nitric acid in the sample bottles as the laboratory nitrifies the water sample in the lab.
- Do not touch the opening of the sample container with any part of the grab pole bottle or your hands as this can introduce contaminants.
- Cap and store the sample container in an ice-esky overnight. The samples will be delivered (chilled) to NMI laboratory the following day.

7.3. Filtering a Nutrient Sample

Refer to DoW (2006a) for details on setting up a Filter Tower.

- Shake the sample gently before filtering.
- Pour a small amount of the sample into the top of the cleaned and assembled filter tower.
- Use the vacuum pump and the rubber bung.
- Swirl the filtered sample by carefully pouring it through both vacuum ports.
- Put the rubber bung back on and reattach the pump.
- Pour the required amount of sample plus a bit extra (for rinsing the sample container) into the top of the filter tower.
- Use the vacuum pump to filter the sample.
- Once the sample is filtered remove the vacuum from the collection chamber.
- Pour a small amount of the filtered sample into the pre-labelled sample container.
- Remove the cap from the sample container only at the time of sampling and replace the cap immediately after collection of the sample.
- Cap, swirl around the filtrate and discard.
- Repeat twice to ensure that the sample container is well rinsed.
- Fill the labelled sample container with the filtrate to the required level.
- Cap and store the sample container in an esky on ice-bricks.

7.4. DOC/TOC Sampling

- Rinse both DOC and TOC sample bottles three times prior to filling
- When filling the bottles fill all the way to the top (i.e. leave no air bubble).
- As a standard use a filter tower to filter your sample.

8. *Sampling operation requirements*

Table 9: **Measurement parameters analysed at a given number of EBN sites on five sampling runs.**

Sample Run	Field personnel	Number of sites	Measurement parameters
1	Bonny Dunlop Megan O'Grady Sue Pedrick	26/27 (EBN 1-11, 13-27, 29) 1/27 (EBN 19) 7/28(EBN 4, 7, 8, 9 10, 17, 28)	Water Nutrients, physical properties total suspended solids TOC/DOC Metals and total water hardness (from TSS, except site EBN 28, collected separately)
2	Bonny Dunlop Megan O'Grady Sue Pedrick	26/27 (EBN 1-11, 13-27, 29) 1/27 (EBN 19) 7/27 (EBN 4, 7, 8, 9, 10, 17, 28) 1/28 Random site	Water Nutrients, physical properties and total suspended solids TOC/DOC Metals and total water hardness (from TSS, except site EBN 28, collected separately) Field Blank and Replicate
3	Bonny Dunlop Megan O'Grady Sue Pedrick	26/27 (EBN 1-11, 13-27, 29) 1/27 (EBN 19) 7/27 (EBN 4, 7, 8, 9, 10, 17 28)	Water Nutrients, physical properties total suspended solids TOC/DOC Metals and total water hardness (from TSS, except site EBN 28, collected separately)
4	Bonny Dunlop Megan O'Grady Sue Pedrick	26/27 (EBN 1-11, 13-27, 29) 1/27 (EBN 19) 7/27 (EBN 4, 7, 8, 9, 10, 17, 28) 1/27 Random site	Water Nutrients, physical properties and total suspended solids TOC/DOC Heavy Metals and total water hardness (from TSS, except site EBN 28, collected separately) Field Blank and Replicate

9. *Sample bottle requirements*

Table 10: **Number of bottles required to sample for all identified measurement parameters, field blanks and replicates.**

Matrix	Parameters	Bottle type	Sites	Sampling events	Samples/site	Replicates	Field blanks	Total bottles
Water	Total nutrients	250mL plastic	27	4	1	2	2	112
	Dissolved nutrients	250mL plastic	27	4	1	2	2	112
	Total heavy metals	125mL plastic, acidified	7	4	1	2	2	32
	TSS and total water hardness	1L plastic	27	4	1	2	2	112
	TOC	125mL dark glass with Teflon liner cap	1	4	1	1	1	6
	DOC	125mL dark glass with Teflon liner cap	1	4	1	1	1	6

10. *Labelling*

The sample containers should be labelled with sequential sample registration numbers, the date of collection, the type of preservation (if any) and the client identification. Water samples are to be accompanied by field notes, field observation forms and chain of custody forms.

The sample bottle will be labelled prior to the time of sampling and collection in the field to ensure efficiency and organisation.

Sample number	**200638340**
Date	**22/06/2010**
Parameters	**TN/TP**
Agency	**EBICG**
Depth	**0 meters**

Figure 4: Example of bottle label

11. *Personal Safety*

A separate safety plan will be prepared and approved by the Ellen Brockman Integrated Catchment Group prior to field sampling. Field sampling should not commence until the safety plan has been signed off by all parties involved in the sampling. The safety plan will indicate all areas of potential risk to personnel before, during and after the sampling, and develop specific strategies to minimise the risk.

12. Limits of Reporting (LORs) for NMI Laboratory

Table provides the NMI Laboratory method codes and limits of reporting (mg/L) for the measurement parameters selected for the Ellen Brook catchment sampling program. The measurement parameters cannot be detected below these limits provided.

Table 4: **Analysis Methods and Limit of Reporting (LOR) for NMI.**

Method description	LOR (mg/L)
Total phosphorus	0.005
Total nitrogen	0.025
Total organic nitrogen	0.025
Soluble reactive phosphorus	0.005
Total oxidised nitrogen	0.010
Nitrogen as ammonia	0.010
Dissolved organic nitrogen	0.025
Total filterable phosphorous	0.005
Total Suspended Solids	1.0
Total organic carbon	1.0
Dissolved organic carbon	1.0
Total water hardness	1.0
Arsenic – total	0.005
Aluminium – total	0.005
Cadmium – total	0.0001
Chromium – total	0.001
Copper – total	0.001
Iron – total	0.005
Lead – total	0.001
Nickel – total	0.005
Zinc – total	0.005
Mercury – total	0.0001

NMI is an accredited analytical laboratory which has been identified to analyse the water samples for the Ellen Brook water quality monitoring program. Table provides information on the analytical methods and limits of reporting used by the laboratory. Following analysis NMI must produce a laboratory report which must provide details on the following in both electronic and final laboratory reports:

- Date and time of sample analysis
- Method code and description

- All laboratory Quality Control results including analyte recovery, accepted recovery range, lab blanks, lab duplicates, lab blank spike recovery, matrix spike recovery.

13. Sending samples to the laboratory

Collected samples will be stored in an esky chilled to 4 ^{o}C with ice bricks out in the field and overnight in a refrigerator, as the sampling will be conducted over 2 days. The samples will be delivered to NMI in the afternoon of the day after sampling for analysis at the latest. A completed chain of custody (COC) must be included in the esky for the laboratory and a copy kept at the Chittering Landcare Centre. Turnaround time is 10 days from sample date to completion of analysis. Once the samples are received the results will be emailed directly to the Chittering Landcare Centre.

14. Management and Reporting of data

The sampling program and sampling sites will be registered with the Water Information Branch (WIN database) of the Department of Water. Water samples collected from the Ellen Brook will be sent for analysis to the National Measurement Institute (NMI), a laboratory accredited by the National Association of Testing Authorities (NATA) and independently audited by the Department of Water. Analytical results will be returned to the Chittering Landcare Centre. Results will be sent to the Department of Water to be entered onto the publicly accessible Water Information (WIN) database. However, this is dependent on whether or not it will incur a cost. The water quality monitoring results will be validated and verified, collated, analysed and published as a water quality report for the Ellen Brook, where data will be compared to previous years sampling.

15. Comparison of Results with Guidelines

The Australian and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000) provides trigger values for both ecosystems and human health protection, as well as the following environmental values: aquatic ecosystems; primary industries; recreation and aesthetics; and drinking water.

The Guidelines recognise three levels of protection for aquatic ecosystems: areas which high conservation value, slightly to moderately disturbed ecosystems; and highly disturbed ecosystems. To assess the level of toxicant contamination in aquatic ecosystems, trigger values were developed from data using toxicity testing on a range of test species (ANZECC & ARMCANZ, 2000). The trigger values (99%, 95%, 90% and 80%) approximately correspond to the protection levels described above. An exceedance of the trigger value indicates that there is the *potential* for an impact to occur and should thus trigger a management response such as further investigation and possible remediation or adaptation of the guidelines according to local conditions (ANZECC & ARMCANZ, 2000).

The water quality results of the Ellen Brook sampling and analysis program will be compared to the 95% protection level for slight to moderately disturbed ecosystems. This snapshot will compare the results to the guideline trigger values for aquatic ecosystems and for livestock drinking water where appropriate.

16. Roles and Responsibilities

- Ellen Brockman Integrated Catchment Group (EBICG)/Chittering Landcare Centre will have overall responsibility for this project.
- NMI will be responsible for providing the sample bottles and analysing the collected samples.
- EBICG, Shire of Chittering and City of Swan will fund the program with support from Swan River Trust for staff.

Table 5: Costs of water quality analysis of the Ellen Brook catchment 2012 sampling program at NMI.

Parameter	Number of Sites	Number of Sampling Occasions	Cost of Analysis ($)	Total Cost of Sampling ($)
Nutrients			***2012 Prices***	***Based on 2012 Prices***
TSS	27	4	*13.54*	1462.32
TN	26	4	*17.00*	1768.00
TP	26	4	*13.65*	1419.60
Ammonia-N	26	4	*10.09*	1049.36
NOx-N (Total Ox N)	26	4	*8.45*	878.80
SRP	26	4	*8.45*	878.80
DOrganicN	27	4	*17.00*	1768.00
TorganicN	26	4	*0 (Calculated)*	
TFP	26	4	13.65	1419.60
Setup Cost (fee)		4	0	0
Total Metals				
Al	7	4	*6.49*	181.72
As	7	4	*6.49*	181.72
Cd	7	4	*6.49*	181.72
Cr	7	4	*6.49*	181.72
Cu	7	4	*6.49*	181.72
Fe	7	4	*6.49*	181.72
Hg	7	4	*6.49*	181.72
Ni	7	4	*6.49*	181.72
Pb	7	4	*6.49*	181.72
Zn	7	4	*6.49*	181.72
Setup Cost (fee)	27	4	14.63	58.52
Total Water Hardness	7	4	12.98	363.44
DOC/TOC	2	4	58.35	466.80
DOC Setup			0	0
Blanks		2	114.81	229.62
Replicates		2	114.81	229.62
Admin Fee		4	47.6	190.40
Total (not inc GST)				**14000.07**
Total (inc GST)			**1400.007**	**15400.08**

Table 6: **Budget for the 2011 Ellen Brook catchment monitoring project.**

Item	Hours	People	Hourly Rate	Cost
SALARY COSTS				
1. Preparation of SAP	*15*	*1*	*$30.29*	*$508.36*
2. Sampling preparation	*30*	*1*	*$30.29*	*$908.70*
3. Sample collection	*60*	*2*	*$30.29*	*$3634.30*
4. Data management (site & program registration, data entry, verification/validation)	*7.5*	*2*	*$30.29*	*$454.35*
5. Preparation/assistance with Report	*37.5*	*2*	*$30.29*	*$2271.75*
6. Travel costs/courier costs	-	-	-	*$1200*
CONSUMABLE COSTS				
1. Analysis costs – Ellen Brook Water Quality Monitoring Program 2012 (Based on 2012 laboratory analytical prices)	-	-	-	$15400.08
TOTAL (inc GST)				**$24, 377.54**

17. References

ANZECC and ARMCANZ (2000). *National Water Quality Management Strategy: Australia and New Zealand Water Quality Guidelines for Fresh and Marine Water Quality.* Australian and New Zealand Conservation Council, Agriculture and Resource Management Council of Australia and New Zealand

Department of Water. (2006). Section 1: Water Quality Monitoring Program Design; A Guideline to the Development of Surface Water Quality Monitoring Programs. Perth, Western Australia: Water Science Branch, Department of Water.

Department of Water. (2006a). Section 2: Field Sampling Guidelines; A Guideline for Field Sampling for Surface Water Quality Monitoring Programs. Perth, Western Australia: Water Science Branch, Department of Water.

Department of Water. (2006b). Section 3: Technical Appendices; Standard Operating Procedures Water Sampling Methods and Analysis – Parameter Based. Perth, Western Australia: Water Science Branch, Department of Water.

NHMRC & ARMCANZ (1996). *Australian Drinking Water Quality Guidelines*. National Health and Medical Research Council and Agriculture and Resource Management Council of Australia and New Zealand.

PPK Environment & Infrastructure (2000). *Ellen Brook Draft Catchment Management Plan* in association with Acacia Springs Environmental, Land Assessment, Hames Sharley, ERM Mitchell McCotter and V & C Semeniuk Research Group.

Swan River Trust. (2009). *Local Water Quality Improvement Plan: Ellen Brook catchment.*

Appendix A: Analytical Requirements

(To be attached to all COC forms)

Project: SG-C-Ellen Brook

COC numbers: ____________________

Group	Analytes	Special instructions
A	Dissolved Nutrients:	To be reported at standard LORs
	Total Nitrogen	0.05mg/L
	Total oxidised nitrogen	0.01 mg/L
	Nitrogen as ammonia	0.01 mg/L
	Total Phosphorous	0.01mg/L
	Soluble reactive phosphorus	0.005 mg/L
	Total Filterable Phosphorous	0.005mg/L
	Soluble organic nitrogen	0.025 mg/L
B	Total metals:	To be reported at limits of reporting for analysis using ANZECC guideline trigger values:
	Cd & Hg	0.1 µg/L (0.0001 mg/L)
	Cr, Cu & Pb	1.0 µg/L (0.001 mg/L)
	Al, As, Fe, Ni & Zn	5.0 µg/L (0.005 mg/L)
C	Total Organic Carbon & Dissolved Organic Carbon	1.0 mg/L (both)
D	Total Filterable Phosphorous	0.005 mg/L

Please note:

Total water hardness (LOR of 1.0 mg/L) to be extracted from TSS bottle.

Appendix B: Equipment List for Collecting Water Samples (DoW, 2006b)

- Twenty-seven 500ml HDPE bottles. Two of the five sampling runs will require two extra for blanks and replicates. The metal sampling run will require an extra six bottles for Total Water Hardness.
- Calibrated Quanta probe for measurement of in-situ parameters, including the probe cover, protection cap and surveyor (provided by the Department of Water).
- Field filtering equipment – hand pump, filter tower, filter paper and tweezers.
- Deionised water for field blanks.
- Deionised water spray bottle for cleaning the filter tower.
- Tap water for filling the probe protection cap, and drinking water.
- Bucket for measurement probes/surveyor.
- Sampling and Analysis Plan (SAP)
- Safety Plan
- Chain of Custody (COC) forms
- Field Observation (FOF) forms
- Eskies with ice bricks.
- Masking tape
- Nitrile gloves, gumboots, waders, coveralls, safety glasses, sunscreen, hat, and other protective gear.
- Map of sites.
- GPS (if required)
- Permanent marker, pencil and pen

Appendix H - Safety Plan

Ellen Brook Catchment
Water Quality Monitoring Program
2012

Plate 1: EBN18 Gauging Station, Ellen Brook Main Channel, Upper Swan(EBICG, 2011).).

**Prepared by Ellen Brockman Integrated Catchment group:
May 2012**

This project is co-funded by the Ellen Brockman Integrated Catchment Group, and the Australian and Western Australian Government's investment in the Caring for Country administered by the Perth Region NRM.

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1. Introduction

The purpose of the safety plan is to provide personnel undertaking water quality sampling within the Ellen Brook catchment with safety and health requirements. The safety plan indicates all potential areas of risk to personnel before, during and after the sampling and recommends specific strategies to minimise this risk. Occupational health, safety and welfare in the workplace is a shared responsibility and the Chittering Landcare Centre relies on consultation, commitment and participation from all officers.

All employees have the responsibility for ensuring their own health, safety and welfare, reporting hazards in the work area and following established practices and procedures aimed at providing a safe and healthy work environment for all. This plan should be used in conjunction with the Chittering Landcare Centre's Occupational Health & Safety Policy, particularly the following protocol related to officers undertaking field work:

- Before departing the office for field work, the worker must ensure that they;
  - Post their itinerary including specific details of times, location and contact mobile telephone on the staff notice board. If possible a contact landholder name and phone number should be provided.
  - Are suitably clothed with protective clothing and boots for the task.
  - Have all their safety equipment, adequate drinking water and first aid equipment in their vehicle.
  - Have their mobile phone with them and the battery is charged.
  - Have adequate fuel in their vehicle for the task.

- The worker is to contact a staff member at the Chittering Landcare Centre no later than **1 hour** after their nominated time of return. The details of these checks are to be recorded next to the worker's name on the notice board.

- If no contact has been made within one (I) hour of the lone worker's nominated time of return, Chittering Landcare Centre officers are instructed to attempt to make contact with the worker, either by using the contact details posted on the notice board, or the designated mobile telephone.

- If no response is received from the worker following attempts to make contact, inform the staff, Chittering Landcare Centre Manager or a senior officer from the Shire of Chittering (CEO, Deputy CEO or Shire Ranger) whose contact details are posted on the notice board. A search will then be initiated using the lone worker's stated itinerary.

2. Site assessment

All sites involve foreshore environments and are accessed by road, and the issues involved for all sites are included in the "Hazard Identification" Table within this plan. Most sites are publicly available and accessible, with the exception of EBN4 (Chandala South) which is located on Tiwest land. As such, the policies of the mining company must be adhered to whilst sampling at this site. This includes wearing a safety vest, helmet, protective eyewear and signing in/out at reception when entering & exiting the site.

3. Sampling site locations

Table 11: Location and description of sampling sites in the Ellen Brook Catchment

Site no.	Site Name	Waterway section/ Component	Location	Northing	Easting
EBN1	Lennard Brook	Lennard Brook	Lennard Brook Road	6527771	0396613
EBN2	Airfield Road	North Chandala/Ellen Brook (Bambun Lakes)	Airfield Road	6519428	0397101
EBN3	Chandala West	Chandala Brook West	Brand Hwy west loc # 853	6511801	0400463
EBN4	Chandala South	Chandala Brook South	Brand Hwy east / TIWest	6510846	0401302
EBN5	Yal Yal Brook	Yal Yal Brook	Reserve Road	6514458	0404923
EBN6	Rocky Gully Creek	Rocky Gully Creek	Old Gingin Rd	6509047	0403714
EBN7	Wandena North	Waterway to Ellen Brook	Wandena North - Great Northern Highway	6507384	0404384
EBN8	Wandena South	Waterway to Ellen Brook	Wandena South - Great Northern Highway	6506686	0404561
EBN9	Brand Highway Bridge	Ellen Brook - Muchea Central	Bridge on Brand Hwy south	6505838	0404093
EBN10	Muchea East	Waterway to Ellen Brook Muchea East	Great Northern/Brand Highways	6505833	0404780
EBN11	Muchea North	Waterway to Ellen Brook -	Muchea south /Railway Rd 491 chit/swan sign	6500336	0404611
EBN13	Rutland Road	Ellen Brook (upper)	Rutland Road bridge	6498117	0406044
EBN14	Nutrient Inflow	Waterway – Nutrient stripping inflow	Bingham Road/ Department of Defence	6496871	0405690
EBN15a	Nutrient Outflow	Waterway - Nutrient stripping Pond outflow	Bingham Road/ Department of Defence	6496885	0405757
EBN16a	Bulls Brook	Bullsbrook	South past Strachan on Railway Rd	6495684	0405054

EBN17	Warren Road	Mid Ellen Brook	Warren Road	6493379	0406685
EBN18	Gauging Station	Ellen Brook - Almeria Gauging Station	Almeria Parade/Apple Street	6486743	0407638
EBN19	Belhus Reserve	Lower Ellen Brook	Belhus Reserve Millhouse Rd Bridge	6483685	0406519
EBN21	Lower Yal Yal	Yal Yal Brook South	Old Gingin Road	6509922	0403110
EBN22	Ki-it Brook	Ki-it Brook	Warren Road	6493382	0406959
EBN23	Peters Road	Waterway to Ellen Brook – Muchea townsite	Peters Road	6505232	0403580
EBN24	Stock Road	Waterway to Ellen Brook West	Railway Parade	6492415	0405221
EBN25	Sawpit Gully	Waterway to Ellen Brook – The Vines north	Lot 4/285 Railway Parade, Upper Swan	6486777	0407430
EBN26	Egerton	Waterway from Egerton Estate to Ellen Brook	Corona Way	6483859	0405129
EBN27	Wandena Road	Waterway to Ellen Brook	Corner of Great Northern Hwy and Wandena Road	6502590	0406553
EBN28	Upper Yal Yal	Yal Yal Brook North	Great Northern Hwy	6516783	0409421
EBN29	Roxburghe Avenue	Drain leading to Ellen Brook from The Vines east	Roxburghe Avenue	6486603	0406975

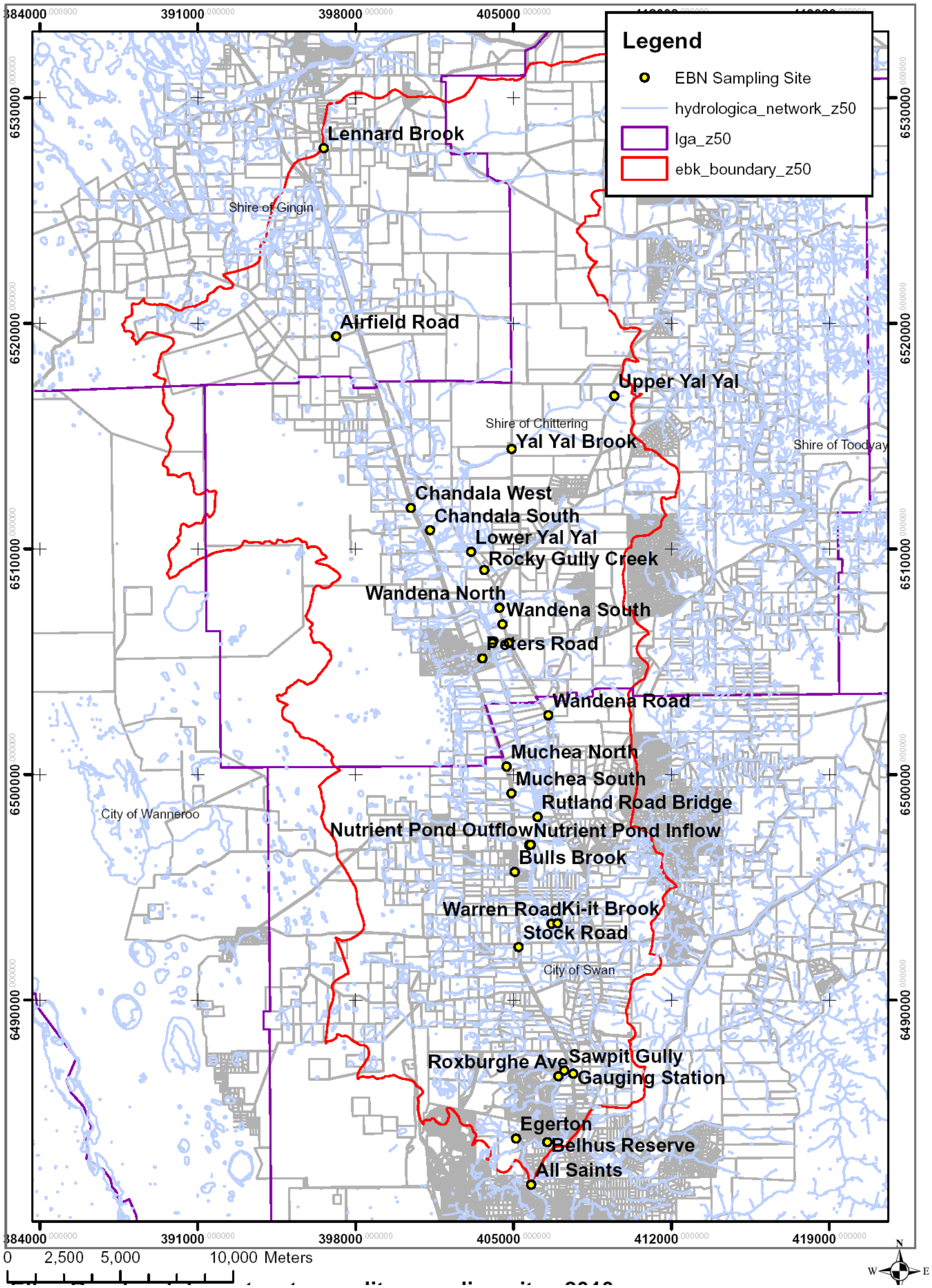

Figure 36: Location of Sampling Sites within the Ellen Brook catchment.

4. Personal protection and equipment

Officers involved in water sampling activities should heed the following to ensure that their personal safety outside of the office is made a priority.

- A mobile phone should be carried so that contact can be made with the office at specified times or for emergency.
- All work vehicles should be equipped with a first aid kit.
- All work vehicles should be equipped with a current fire extinguisher.
- All workers who work in isolated conditions in the field should have a current Senior First Aid certificate or first aid training to suit their particular needs.
- Workers driving four wheel drive vehicles should be trained in driving in such conditions.
- Personnel should wear thin nitrile gloves and eye protection whilst collecting water samples.
- If entering the water, waders or gum boots should be worn. The alternative to gum boots if not entering the water is steel capped, enclosed leather boots.
- Normal sun-protection should be adopted (hat, long sleeves and sunscreen) as the sampling is an outdoor activity. In the case of rain, a raincoat or weatherproof jacket should be worn.
- Adequate water (at least 5 litres) should be carried on board the vehicle at all times and is located in the tray of the Ute. Drinking water regularly when out in the field is vital to prevent dehydration, particularly in warmer months.

5. Access to medical help

At least one of the sampling officers must have a current first aid certificate. In this case, Amy Salmon is the first aid officer. The car used for sampling always has a first aid kit – it is located in the tray of the vehicle in a plastic box. At least one operational mobile phone will be with the officers at all times. If more than simple first aid treatment is required then the **emergency number 000** should be dialled and an ambulance ordered to escort the injured person to hospital.

A map showing direction and routes to the nearest hospital must be provided to all personnel prior to departure in the field.

The nearest hospital is:

Swan District Hospital

Eveline Road
Middle Swan 6056

(08) 9347 5244

To get to the Swan District Hospital, follow the Great Northern Highway south, then right onto Eveline Road.

6. Important Contact Numbers:

If any other situation arises, the following table gives useful contact details.

Table 12: Emergency Contact List

Name/Service	Contact phone	Mobile
Chittering Landcare Centre - Bonny Dunlop-Heague	(08)95710300	0428434351
Chittering Landcare Centre - Kay Reid	(08)95710400	0428528030
Chittering Landcare Centre - Rosanna Hindmarsh (co-ordinator)	(08)95710400	0429887715
Chittering Landcare Centre – Megan O'Grady	(08)95710200	0467243242
Chittering Landcare Centre – Sue Pedrick	(08)95714351	0467243238
City of Swan	(08)92679267	0419192055
Fire Brigade – Lower Chittering (Max Brown)	(08)95718149	0427089677
Fire Station – Muchea (Dennis Harvey)	(08)95714122	0427092356
Medical Centre - Bindoon	(08)95761222	
Police Midland	(08)92221111	
Shire of Chittering – Frank (Ranger)	(08)95760282	0427699700
Shire of GinGin – Michael Pimm (Ranger)	(08)6551286	

Perth Region NRM – Administration	(08)93743333	
Tiwest – James Owen (Environmental Officer)	(08)95719246	0439912908
Tiwest – Reception	(08)95719333	

7. Hazard identification

All personnel must be trained in identification of potential hazards at a sampling site. This involves listing potential dangers to sampling personnel when at the sampling site, such as collapse of stream bank, falling into the stream, and contact with water from the stream, exposure to heat, wind and rain.

All personnel must be briefed of potential hazards at sample sites.

There is a potential for exposure to very acidic waters. Entry into the drains/waterways must be done wearing protective clothing unless pH has been determined to be within safe limits (pH 5.5-8).

Table 13: Risk Assessment

Identified Risk	Precautions
Exposure to chemicals and handling of contaminated samples & sampling or entering potentially low pH waters.	Wear protective clothing at all times: field boots or gum boots, nitrile gloves (waders if expecting to go into water at above ankle level).
Physical injury from falling (especially steep slopes with sandy banks)	Inspect accessibility to site before transferring equipment from car. If site is too steep, unstable or otherwise dangerous do not sample.
Insect, spider, rodent or snake bites.	Inspect site prior to sampling, especially drain culvert openings and wear long pants and high boots for walking through long grass.
Traffic on roads near sites	Bright safety vest with reflective strip should be worn when working along road sides and care should be taken to watch out for traffic at all times. Hazard lights should be left on vehicle whilst sampling.
Manual handling of heavy equipment and eskies/samples	Wear work boots and lift heavy objects ensuring no risk to back. If necessary, use two people to lift larger eskies.
Sampling at sites where algal scums are present	Always wear nitrile gloves when sampling and avoid contact with water. Take care when handling food after sampling.
Sunburn, exposure (dehydration and heat stroke, exposure to cold).	Apply sunscreen, wear hats, rain jackets, work pants, jumpers as appropriate. Take plenty of drinking water (labelled as drinking water and kept separate from sample bottles).

8. Experience of sampling personnel

Samples should only be collected by personnel who have received training from the Aquatic Science Branch of the Department of Environment or a recognised authority.