Response to Reviewers' Comments: Manuscript HESSD -2013 - 198

In the document below we have listed the reviewer's comments in italics. This is followed by our response in non-italic text and where applicable by the amended manuscript text in quotation marks (with new page and line numbers). In the revised manuscript the green highlighted text indicates where the manuscript has been modified to address the comments of Anonymous Referee #1. Yellow highlighted text indicates where the manuscript has been modified to address the comments of Anonymous Reviewer #2.

Anonymous Referee #1

> - *Page 1/6695 (Spatial and temporal distribution of drainage and solute leaching in heterogeneous urban vegetation environments). Only two locations have been considered. That's too less data to conclude on spatial distribution, let alone of speaking of heterogeneity. Likewise, the temporal distribution seems to refer to 12 monthly measurements throughout a year. From the title I expected much more data, ie. (more) replicates.*

This paper describes a major research project undertaken in collaboration with SA Water and Adelaide City Council. Field installations involving lysimeters in urban public parks always require very careful planning and implementation and this restricted the testing time to one year. A total of four lysimeters were installed in Veale Gardens but two did not perform satisfactorily and so we are presenting the results from the two that did work properly. There are always some of restrictions when undertaking field work in public parks that limit the number of sampling points unlike quite often in agriculture and forestry studies. The authors are the first research group that have focused entirely on the evapotranspiration rate of mixed vegetation in urban parklands (Nouri et al, 2012; Nouri et al., 2013). In particular, we are not aware of other published research that focuses on the impact of vegetation cover on drainage characteristics in urban parks using a direct drainage collection method such as an in-situ lysimeter. While we acknowledge that a longer study period would produce more data we have included in this paper all of the experimental results collected in this study, which was always planned over one year, covering all seasons. Other studies in urban green spaces with a focus on residential landscapes have had similar or less duration of data collection, including Qin et al. (2013) who studied nutrient leaching from mixed species in a Florida residential landscape. They measured flow-weighted samples for one year to study nutrient leaching of established residential landscapes. Also, Loper et al. (2013), who studied the nutrient leaching during establishment of simulated residential landscapes, collected the data from March 2008 to March 2009. Rooij and Stagnitti (2002) stated that the spatio-temporal leaching process can be described by a curved surface. The mathematical relationships between the scaled leaching surface and the spatial solute distribution curve were established based on 70 days of data collection.

Also early research studies on the quality of drainage water influenced by growing conifers were undertaken using two lysimeters (Tollennat and Ryckborst, 1975). Later, Martin et al. (1998) used two stainless steel drainage lysimeters to evaluate irrigation and nitrogen interactions in cotton production. In a recent study, Schneider et al. (2010) investigated the ability of two different types of process description for water flow to quantify the water balance in a Soil-Vegetation-Atmosphere system using genetic algorithms. Soil water content for this study was derived from drainage collection using two lysimeters. Their outcomes showed that the model using drainage values obtained from these lysimeters could reliably simulate water balances for long time periods.

This paper describes the first research in an urban park evaluating the impact of vegetation zoning on drainage quantity and quality in two pan lysimeters to best represent the leachates behaviour under natural conditions. We believe that in view of the study area being 9.6 hectare of urban parklands which do not show a high variation of soil properties, rainfall and irrigation rates, the two lysimeter sites most clearly demonstrate the importance of vegetation type on the quality and quantity of drainage water.

In response to this comment, we have reworded the manuscript title, as well as some sentences and paragraphs that previously focused on the spatio-temporal heterogeneity of drainage and nutrient leaching.

The following paragraphs were added:

"This research investigates the relative impact of landscape variation on drainage and solute leaching in a public park containing heterogeneous urban landscape vegetation that is irrigated with recycled wastewater. For this purpose, two pan lysimeters were designed and installed in two different landscape zones." (Lines 107-110 of the revised manuscript).

"In order to minimize the effect of spatial heterogeneity of soil salinity on the outputs in the initial stage of field work, the experiment was run in the low EC zone (less than 1.2 dS/m). In the low salinity zone, two zero tension lysimeters containing undisturbed soils were placed horizontally below ground to study the volume and quality of drainage as a function of landscape variation for 12 months." (Lines 147-152 of the revised manuscript).

"The outcomes of other research conducted at the same experimental site confirm that the irrigation application was the optimally matched to the water requirements of mixed landscape vegetation to produce an acceptable level of plant health and aesthetics (Nouri et al., 2013). Thus, the potential excess nutrient loading cannot result from over-irrigation." Lines 346-349 of the revised manuscript).

"This study has examined the variation of drainage quantity and quality in a heterogeneous urban vegetation environment. Differences in vegetation landscape cover lead to differences in evapotranspiration rates, canopy interception losses, as well as depth, density and distribution of vegetation roots.” (Lines 362-365 of the revised manuscript).

> *- Page 4&5/ 6698 &6699 (The zero tension lysimeter is a passive sampler in a pan shape, without large side walls, that 25 freely collects the drained water, measuring drainage volume and solute leaching simultaneously below an undisturbed soil column (Weihermuller et al., 2007; Robison et al., 2004; Zhu et al., 2002). It minimizes the surrounding matric potential fluctuations and potential bypass flow resulting in the conservancy of natural and regular method rather than introduction percolation patterns if sprinkler irrigation is uniformly applied in an area larger than the lysimeter area (Lehr et al., 2005). method rather than introduction*

This text has now been moved to the Methods section, which has also been re-structured. (Lines 120-234 of the revised manuscript).

“2.1. Study Area

The study was carried out in Veale Gardens within the Adelaide Parklands, South Australia (Fig.1). Veale Gardens has an area of 9.6 hectares irrigated by recycled wastewater from the Glenelg wastewater treatment plant that is delivered to the Adelaide Parklands through the Glenelg to Adelaide Parklands (GAP) scheme. GAP recycled water is subject to strict quality standards and has been assessed as class A recycled wastewater (Martin et al., 2008).

BOM (2012) report that the long-term (1981-2010) mean annual rainfall for Adelaide is 546.1 mm while the mean pan evaporation per annum is 1600 mm. Adelaide experiences warm summers (December–February) with a mean temperature of 29.4ºC in February and fairly cold winters (June–August) with a mean temperature of 7.5ºC in July.

Veale Gardens contains more than 60 different species, size, and type of landscape trees and shrubs and a broad coverage of Kikuyu turf grasses. Kikuyu is a dominant species in most parks due to its adaptability and invasiveness (Tanji et al., 2007). There were two types of vegetation cover on the site consisting of areas dominated by grasses and areas dominated by a mixture of different species of trees and shrubs accompanied by grasses.

A preliminary soil survey was conducted using EM38 soil mapping that provided rapid field measurement of apparent electrical conductivity (Hossain et al., 2010; Padhi and Misra, 2011). This enabled development of an Electrical Conductivity (EC) soil map through geostatistical analysis in ArcGIS (Rodríguez Martín et al., 2006; Sarangi et al., 2006; Huang et al., 2013; Li et al., 2012). In October 2011, adjacent to each lysimeter, two bores were drilled down to 2 m and two intact core soil samples (50 mm internal diameter) were extracted for soil physical and chemical analysis. Standard methods were followed for sample preparation, packaging, labelling and storage (Handreck and Black, 2002). Based on the soil EC map, soil sample analysis and landscape variation in Veale Gardens, two different zones of low and high EC and two landscape zones of mostly grasses with few trees and shrubs (MG) and mostly trees and shrubs covered with intermittent grasses (MT) were defined. In order to minimize the effect of spatial heterogeneity of soil salinity on the outputs in the initial stage of field work, the experiment was run in the low EC zone (less than 1.2 dS/m). In the low salinity zone, two zero tension pan lysimeters containing undisturbed soils were placed horizontally below ground to study the volume and quality of drainage as a function of landscape variation for 12 months.

2.2. Field and Laboratory Measurement of Soil and Leachate Properties

EM38 soil mapping and spatial analysis produced a soil zoning map for Veale Gardens. Several previous studies have categorized salinity thresholds from sensitive to tolerant plants.

A soil salinity tolerance level of 1.8dS/m was reported by Handreck and Black (2002) in a very sensitive media for ornamental plants and turf grasses. Miyamoto et al. (2004) selected 1 dS/m as a threshold of sensitivity for landscape plants. Stevens et al. (2008) selected 1.3 dS/m as a moderate sensitive threshold for irrigation of amenity horticulture with recycled water. Martin et al. (2008) categorized the plant species in the Adelaide Parklands according to various soil salinity tolerance ranges. Considering a salinity tolerance range of 0.8-1.6 dS/m for most of the 60 different species of trees, shrubs and turf grasses in Veale Gardens, a soil salinity threshold of 1.2 dS/m was adopted for Veale Gardens. Two different zones of low and high EC are illustrated in Fig. 3. Two positions in the low EC zone (less than 1.2 dS/m) were marked in the field and later tested by a service locator company to ensure there was no conflict with existing assets and underground services, particularly irrigation pipes. Soil samples were taken from four bores immediately adjacent to the pan lysimeters.

Drainage water quality and nutrient availability were analysed for each season for certain chemical characteristics including pH, EC, Sodium Adsorption Ratio (SAR), Total Dissolved Solids (TDS), potassium, nitrite, nitrate, total nitrogen, total phosphorus, and ionic balance. Soil pH was monitored with an automated system (PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. Soil salinity and TDS were determined in an aqueous extract of a 1:5 soil-water suspension at 25°C using an EC meter. Total phosphorus was measured using a Discrete Analyser. Nitrate was reduced to nitrite by way of a cadmium reduction column followed by quantification by the Discrete Analyser. Nitrite was determined separately by direct colorimetry. Total N was analysed using a traditional Kjeldahl digestion followed by determination by the Discrete Analyser. The ionic balance was calculated based on the major anions and cations. The major anions were determined using the PC Titrate and Discrete Analyser. Major cations were measured using an inductively coupled plasma atomic emission spectroscopy (National Environment Protection (NEPM) - Assessment of Site Contamination, 1999).

The importance of macronutrients (N, P and K) is due to their fundamental role in plant functionality. Nitrogen is a component of protein and enzymes and controls almost all biological processes (Arauzo et al., 2010;Rafizul and Alamgir, 2012). Phosphorus is responsible for energy transfer in the plant, plant development, and photosynthesis (Djodjic et al., 2000). Potassium regulates the water usage of plants and their resistance to diseases (Kolahchi and Jalali, 2007). The SAR measures the ratio of sodium to calcium and magnesium ions and can be used to evaluate the effect of irrigation on soil structure (Goatley, 2011). Ionic balance represents the characteristics of the water in terms of principal dissolved salts. The required nutrients for landscape plants vary widely due to the broad numbers of species of trees, shrubs and turf grasses. For instance, turf grasses need a large amount of nitrogen for green growth while most flowering plants need more potassium and phosphorus (Tanji et al., 2007).

2.3. Zero-tension Pan Lysimeter Design and Installation

A field investigation was employed to study the quantity and quality of drainage water using zero-tension pan (also known as equilibrium-tension) lysimeters. This was due to the advantages of pan lysimeters compared to other methods, including the low complexity of design, reduced disturbance of the soil during installation, and simple and cheap operation (Zhu et al., 2002). The zero-tension lysimeter is a passive sampler in a pan shape, without large side walls, that freely collects the drained water, measuring drainage volume and solute leaching simultaneously below an undisturbed soil column (Weihermuller et al., 2007; Robison et al., 2004; Zhu et al., 2002). It minimizes the surrounding matric potential fluctuations and potential bypass flow resulting in the conservancy of natural and regular percolation patterns if sprinkler irrigation is uniformly applied in an area larger than the lysimeter area (Lehr et al., 2005).

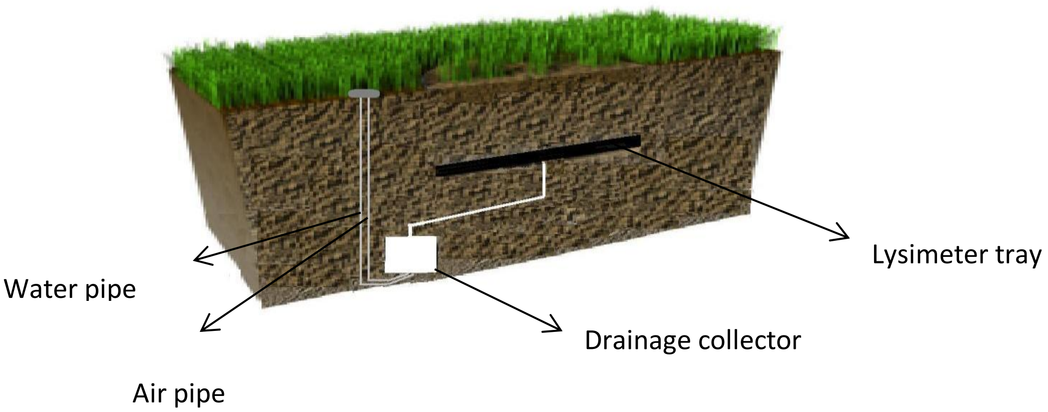
The lysimeter is typically placed under the ground either at a shallow or deep depth, depending on the effective root zone of the plant (Donn and Barron, 2012;Barron and Donn, 2010). The fill material in the tray has a substantial impact on the water potential gradient and water bypass (Weihermuller et al., 2007). The main sources of errors in pan lysimeters derive from diversion in water flow around the lysimeter as well as the complexity of installation.

The method of installation of the zero-tension lysimeter involved the excavation of a trench with a backhoe down to 150 cm depth which is mostly below the effective root zone of the plants (Fig. 2-a). A small cavity of dimensions 120 cm × 55 cm × 30 cm was excavated in the long side wall of the trench with a horizontal distance of 100 cm from the edge of the trench (Fig. 2-b). The cavity was precisely levelled in all five walls to prevent adding tension to the system (Fig. 2-c). A galvanized metal tray of size 120 cm × 55 cm with geotextile on top (Fig. 2-d) was precisely jacked up and fitted to the upper wall of the cavity in order to adequately maintain the capillary connection of the tray and above lying soil (Fig. 2-e). The drainage collection bucket was placed at the base of the trench at a depth of 150 cm and a rigid PVC pipe connected the lysimeter tray to the collection bucket (Fig. 2-f). The drained water was collected in the buried bucket through a rigid PVC pipe and two access tubes (Fig. 2-g). To complete installation of the lysimeter, a plastic sheet was placed on the long side wall of the trench to protect the cavity from damage and to ensure separation of the undisturbed and disturbed soil (Fig. 2-h). The backfilled soil was compacted by a leg rammer in layers to prevent soil subsidence (Fig. 2-i).

The leachate was collected in buckets below the drainage compartments and was regularly extracted from the buckets to the flask by a vacuum hand pump. The volume and salinity of collected water in each bucket was measured monthly during the period December 2011 to November 2012. "

- *Page 5/6999 (the collection tray). refer to a schematic (yet to be built in addition or as substitute to Fig. 2)*

A schematic picture was added to Fig 2.



2-a

2-b

2-c

2-d 2-e 2-f

2-g 2-h 2-i

Fig. 2 Pan lysimeter installation, 2-a trench excavation, 2-b cavity digging, 2-c cavity levelling, 2-d lysimeter tray, 2-e placing the tray, 2-f placing the collecting bucket and connect the tray and bucket by a PVC pipe, 2-g PVC pipe and access tubes, 2-h plastic sheet for protecting the cavity, 2-i compacting the backfilled soil.

- Page 5/6699 (Two pan lysimeters).one replicate is far too less to provide significant data

Please see our response to the first comment.

- Page 6/6700 (measurement of apparent electrical conductivity). If combined with soil samples/testing, also soil texture, soil water content, and hence, plant available water can be derived. This is partly mentioned later, but never described in this section.

Plant available water is not in the scope of this paper, since this manuscript mainly focuses on soil water and drainage quality and quantity. However, we would consider this aspect in our future studies.

- Page 6 /6700 (function of time and space).
Monthly measurements at two locations can hardly be denoted as "function of time and space".

This paragraph has now been reworded as follows:

"In order to minimize the effect of spatial heterogeneity of soil salinity on the outputs in the initial stage of field work, the experiment was run in the low EC zone (less than 1.2 dS/m). In the low salinity zone, two zero tension pan lysimeters containing undisturbed soils were placed horizontally below ground to study the volume and quality of drainage as a function of landscape variation for 12 months." (Lines 147-152 of the revised manuscript).

- Page 6 /6700 (field work, the experiment was run in the low EC zone (less than 1.2 dSm^{-1}).
Why not running the experiment (and further replicates) at the high EC zone as well. I understand that this might be limited due to financial limitations. But at this stage the experimental design and data output are simply not robust.

The reason for selecting the low EC zone rather than the high EC zone is now explained in the following paragraph:

"In order to minimize the effect of spatial heterogeneity of soil salinity on the outputs in the initial stage of field work, the experiment was run in the low EC zone (less than 1.2 dS/m). (Lines 147-149 of the revised manuscript).

- Page 7/6701 (Results and discussion).
While this chapter reasonably describes the result, it certainly lacks of any discussion. That being said, (i) answer the questions asked in the introduction, (ii) support your conclusions with your data (not possible based on the limited data availability) and compare to others' data (ie. discuss!), (iii) defend your conclusions, and (iv) give the big picture (partly done in the last chapter).

The following paragraphs were added to the Results and Discussions.

"These results are consistent with a previous study by Qin et al. (2013) who evaluated the effect of vegetation cover (turf grasses vs. woody ornamental) on drainage rates and nutrient leaching collected from lysimeters. Three different vegetation zones 60% turf - 40% ornamental, 75% turf - 25% ornamental and 90% turf - 10% ornamental were investigated. One year of data collection showed that drainage from the 90% turf zone was higher than the other two zones. They stated that their outcome from measured N and P concentrations and loads showed the importance of woody plants in reducing nutrient leaching in urban areas. Wohlfart et al (2012) found that soil properties were the strongest factor explaining heterogeneity of nutrient loading. However, their findings were for a homogeneous distribution of cropland. Woods et al. (2013) reported a significant change in deep drainage and salt transport in response to changes in soil water balance conditions while at larger scales the changes were more influenced by surface topography. This finding is consistent with the outcomes of Loper et al. (2013) who investigated the effect of vegetation cover types on leaching from early established landscape plots. They reported that different leachate volumes and nutrient leaching were primarily because of differences in root density and shoot biomass resulting in different rates of water availability to the plants. Their results showed a greater leachate volume under woody species than turf grasses during the period when woody ornamentals are still establishing. This is also supported by the findings of Erickson et al. (2005) who studied the factors affecting nutrient leaching including landscape vegetation and quantity and timing of fertilization. They indicated that mean seasonal drainage of mixed species vegetation was significantly less than monoculture Augustine grass." (Lines 267-289 of the revised manuscript).

- *Page 8/6702 (Water drainage section).- Merge the two tables and condense this section accordingly.*

The two tables were merged and this section was restructured. (Lines 237-254 of the revised manuscript).

"3.1. Soil Properties

Soil samples from four bores adjacent to the lysimeters were tested. The results showed a texture of silty loam from the ground to 100 cm with a pH range of 8.0 to 8.5 and EC less than 1.2 dS/m for lysimeter MG. For lysimeter MT, a texture of sandy loam was recorded from the ground to 100 cm with a pH range of 8.0 to 8.8 and EC less than 0.6 dS/m. These results are consistent with a previous SA Water Corporation report (Martin et al., 2008). Goatley (2011) indicated that loamy texture is the most ideal soil for most turf grasses and landscapes to ensure adequate water accessibility and aeration. Moreover, moderate soil pH (6.5-7.5) provides a suitable environment for optimum biological activity and nutrient availability, particularly for potassium and phosphorus. It is anticipated that the alkalinity of the soil may result in lower availability of nitrogen and phosphorus but should have no effect on potassium availability (Goatley, 2011).

3.2. Drainage Water Quality

The seasonal volume of drained water in the MG and MT zones for four seasons of summer (December 2011 to February 2012), autumn (March 2012- May 2012), winter (June 2012 - August 2012) and spring (September 2012- November 2012) is shown in Table 1."

Table1. Records of drained water from lysimeters and input water (mm)

Landscape zone	Summer	Autumn	Winter	Spring
MG zone				
Seasonal rainfall (mm)	78.8	160	262.7	53.7
Seasonal irrigation (mm)	331.11	123.8	0	177.28
Seasonal drainage (mm)	1.33	24.75	206	95.51
MT zone				
Seasonal rainfall (mm)	78.8	160	262.7	53.7
Seasonal irrigation (mm)	403.27	150.82	20	215.91
Seasonal drainage (mm)	0	0.022	25	0.025

- Page 9/6703 (The differences in lysimeter performance mainly could be related to the heterogeneity of vegetation or/and soil characteristics. The variation in landscape plants will have led to differences in evapotranspiration, canopy interception rates and root 5 distribution). Speculative. Use a model (e.g. Hydrus) to verify.

We agree that modelling with software such as Hydrus is one way to assess performance but we have chosen to use direct in-situ drainage measurement as an input to a Soil Water Balance as the main approach for this research.

More discussion has now been added to the revised manuscript as follows:

- Page 9/6703 (A strong positive correlation coefficient of 0.90 was found). But there is no peak in October in Fig. 5 for MT. Is R2 only so high due to the small sample size (12) and frequently occurring values of zero? Please elaborate on these uncertainties.

The following sentence was added:

"This confirms that there was a similar trend of drainage volume within the four seasons of the study period except for a peak that was observed for the MG zone in October (Fig 4). It should be noted that the high correlation of the MT and MG zones is influenced by the frequent occurrence of zero values for the MT zone. Thus, both the MT and MG drainage data were normalized based on the mean and standard deviation of the entire group of data. The correlation of normalized MG and MT data showed a positive correlation coefficient of 0.70." (Lines 297-303 of the revised manuscript).

- Page 9/6703 (The electrical conductivity of each water sample was measured using an EC meter).

How many samples/locations?

The following sentence was added.

“Every month, two samples were collected and the EC value was taken as the average of three EC readings (Table 2). “(Lines 320-321 of the revised manuscript).

- Page 10/6704 (monthly and the seasonally, and averaged values are reported in Table 3).
So the temporal distribution is based on three values?

“Temporal distribution” was deleted throughout the manuscript.

- Page 10/6704 (A comparison of seasonal salinity for zones MG and MT indicated a strong positive correlation (R = 0.97) with the lowest salinity in autumn for both lysimeters. No cor5 relation was found between seasonal drainage volume and seasonal salinity in either lysimeter.).
Speculative and /or not robust unless detailed information is provided regarding statistical analyses (number of samples (spatially, temporally), significance test(s), p-values, etc.)

The following sentences were added.

“Every month, two samples were collected and the EC value was taken as the average of three EC readings (Table 2).” (Lines 320-321 of the revised manuscript).

“The unavailable value of drainage salinity for the MT zone in summer was predicted using linear regression. The predicted value was calculated of 3.06 dS/m. A new comparison of seasonal drainage salinities between the MT and MG zones using the predicted value for the MT zone in summer showed a very strong positive correlation (R=0.995).” “(Lines 323-327 of the revised manuscript).

- Page 11/6705 (For zone MT, the amount of collected leachate was too small to allow an accurate nutrient analysis.).

Then there is nothing to speculate on.

- Page 11/6705 (Hence, investigation of the temporal variation of all water quality parameters apart from salinity was not possible in MT zone.).
Same as above

We agree and we have only presented nutrient results for zone MG.

- *Page 12/6706 (The results of the soil physical analysis indicated a minimal effect from differences of soil properties compared to the much stronger influence of vegetation heterogeneity on drainage variations. This is in contrast with the finding of Wohlfart et al. (2012) that found that soil properties are the strongest factors explaining heterogeneity of nutrient loading.).*
elaborate/discuss

This was reworded to the following paragraph:

"These results are consistent with a previous study by Qin et al. (2013) who evaluated the effect of vegetation cover (turf grasses vs. woody ornamental) on drainage rates and nutrient leaching collected from lysimeters. Three different vegetation zones 60% turf - 40% ornamental, 75% turf - 25% ornamental and 90% turf - 10% ornamental were investigated. One year of data collection showed that drainage from the 90% turf zone was higher than the other two zones. They stated that their outcome from measured N and P concentrations and loads showed the importance of woody plants in reducing nutrient leaching in urban areas. Wohlfart et al (2012) found that soil properties were the strongest factor explaining heterogeneity of nutrient loading. However, their findings were for a homogeneous distribution of cropland." (Lines 267-277 of the revised manuscript).

- *Page 17/6711 (Table 1)- merge with table 2*

Tables 1 and 2 have now been merged.

- *Page 19/6713 (Table 3)- On how many samples is this table based on? NA is Not publishable.*

The following sentence was added:

"Every month, two samples were collected and the EC value was taken as the average of three EC readings (Table 2)." (Lines 320-321 of the revised manuscript).

- *Page 21/6715 (Fig 1)- Use a map with scale and north arrow.*

A north arrow and scale were added to Fig 1.

- *Page 22/6716 (Fig 2)- Use a schematic to depict the design and function of a pan lysimeter. Consider the photos for the supplement.*

A schematic picture was added to Fig 2.

- *Page 23/6717 (Fig 3)- Redundant*

Fig 3 was removed.

- *Page 24/6718 (Fig 4)- Add scale.*
What are the two EC categories based on? Provide more information.

The following paragraph was added:

"A soil salinity tolerance level of 1.8dS/m was reported by Handreck and Black (2002) in a very sensitive media for ornamental plants and turf grasses. Miyamoto et al. (2004) selected 1 dS/m as a threshold of sensitivity for landscape plants. Stevens et al. (2008) selected 1.3 dS/m as a moderate sensitive threshold for irrigation of amenity horticulture with recycled water. Martin et al. (2008) categorized the plant species in the Adelaide Parklands according to various soil salinity tolerance ranges. Considering a salinity tolerance range of 0.8-1.6 dS/m for most of the 60 different species of trees, shrubs and turf grasses in Veale Gardens (Martin et al., 2008), a soil salinity threshold of 1.2 dS/m was adopted for Veale Gardens." (Lines 157-165 of the revised manuscript).

- *Page 25/6719 (Fig 5)- Redundant (title of the graph) Be consistent with units. In table 1 and 2 drainage is in m*

The title of the graph was removed. The units in Fig 4 were changed to mm.

Anonymous Referee #2

General comments:

The manuscript presents a study aimed at understanding temporal and spatial patterns of drainage and leaching in an urban park irrigated with recycled wastewater.
Although the topic might be of interest to the readers of HESS, the study in its present form presents several limitations that do not allow the Authors to address the issues presented as research questions in the manuscript.

As we have described in response to Reviewer #1, the title was changed. Some sentences and paragraphs that focused on the spatio-temporal heterogeneity of drainage and nutrient leaching were also re-worded or removed. All these changes were applied to show this research has been done to show the importance of vegetation variability on the quality and quantity of drainage water.

Specific comments:

- Introduction: some parts of the introduction belong to the methods (e.g., P6698, L1-L5; P6698, L20-L28.

Some parts of the Introduction were moved to the Methodology. (Lines 170-214 of the revised manuscript).

"Drainage water quality and nutrient availability were analysed for each season for certain chemical characteristics including pH, EC, Sodium Adsorption Ratio (SAR), Total Dissolved Solids (TDS), potassium, nitrite, nitrate, total nitrogen, total phosphorus, and ionic balance. Soil pH was monitored with an automated system (PC Titrate) using pH 4.5 for indicating the total alkalinity end-point. Soil salinity and TDS were determined in an aqueous extract of a 1:5 soil-water suspension at 25°C using an EC meter. Total phosphorus was measured using a Discrete Analyser. Nitrate was reduced to nitrite by way of a cadmium reduction column followed by quantification by the Discrete Analyser. Nitrite was determined separately by direct colorimetry. Total N was analysed using a traditional Kjeldahl digestion followed by determination by the Discrete Analyser. The ionic balance was calculated based on the major anions and cations. The major anions were determined using the PC Titrate and Discrete Analyser. Major cations were measured using an inductively coupled plasma atomic emission spectroscopy (National Environment Protection (NEPM) - Assessment of Site Contamination, 1999).

The importance of macronutrients (N, P and K) is due to their fundamental role in plant functionality. Nitrogen is a component of protein and enzymes and controls almost all biological processes (Arauzo et al., 2010;Rafizul and Alamgir, 2012). Phosphorus is responsible for energy transfer in the plant, plant development, and photosynthesis (Djodjic et al., 2000). Potassium regulates the water usage of plants and their resistance to diseases (Kolahchi and Jalali, 2007). The SAR measures the ratio of sodium to calcium and magnesium ions and can be used to evaluate the effect of irrigation on soil structure (Goatley, 2011). Ionic balance represents the characteristics of the water in terms of principal dissolved salts. The required nutrients for landscape plants vary widely due to the broad numbers of species of trees, shrubs and turf grasses. For instance, turf grasses need a large amount of nitrogen for green growth while most flowering plants need more potassium and phosphorus (Tanji et al., 2007).

2.3. Zero-tension Lysimeter Design and Installation

A field investigation was employed to study the quantity and quality of drainage water using zero-tension pan (also known as equilibrium-tension) lysimeters. This was due to the advantages of pan lysimeters compared to other methods, including the low complexity of design, reduced disturbance of the soil during installation, and simple and cheap operation (Zhu et al., 2002). The zero-tension lysimeter is a passive sampler in a pan shape, without large side walls, that freely collects the drained water, measuring drainage volume and solute leaching simultaneously below an undisturbed soil column (Weihermuller et al., 2007; Robison et al., 2004; Zhu et al., 2002). It minimizes the surrounding matric potential fluctuations and potential bypass flow resulting in the conservancy of natural and regular percolation patterns if sprinkler irrigation is uniformly applied in an area larger than the lysimeter area (Lehr et al., 2005).

The lysimeter is typically placed under the ground either at a shallow or deep depth, depending on the effective root zone of the plant (Donn and Barron, 2012;Barron and Donn, 2010). The fill material in the tray has a substantial impact on the water potential gradient and water bypass (Weihermuller et al., 2007). The main sources of errors in pan lysimeters derive from diversion in water flow around the lysimeter as well as the complexity of installation.“

Methods: the spatial (2 location) and temporal (monthly) resolutions are not enough to achieve the goals stated in the title and introduction.

We agree and the manuscript has been revised to explain that spatially we are only comparing two vegetation coverages and temporally we are only looking at monthly variations. We have also changed the title to reflect this. Please also see our response above to this reviewer’s general comment and to our response to the first reviewer.

- P6700, L3-L6: I would specify the period used to calculate the averages.

The period is now specified as follows:

“BOM (2012) report that the long-term (1981-2010) mean annual rainfall for Adelaide is 546.1 mm while the mean pan evaporation per annum is 1600 mm.” (Lines 127-128 of the revised manuscript).

- *P6702, L1-L22: this should be in the section on the methods.*

This section was moved to the Methodology Section, which was also restructured. (Lines 170-214 of the revised manuscript).

- *P6703, L17-L23: this is rather well known.*

The following sentence was added.

"These findings confirm a well-known hypothesis and are consistent with the findings of Loper et al. (2013) who stated that under both vegetation types of woody plants and turf grasses, a large portion of input water (either irrigation or rainfall) was retained as soil moisture or subject to ET rather than drainage loss." (Lines 310-314 of the revised manuscript).

- *P6704, L1: '...monthly and seasonally...'. Aren't these the same?*

The following paragraph was added:

"The seasonal volume of drained water in the MG and MT zones for four seasons of summer (December 2011 to February 2012), autumn (March 2012- May 2012), winter (June 2012 - August 2012) and spring (September 2012- November 2012) is shown in Table 1." (Lines 251-254 of the revised manuscript).

- *P6704, L15-L20: move to methods.*
- *P6704, L21-L29: this is well known. These comments are speculative and are drawn from the experiment presented here.*

These two paragraphs (L15-L20 & L21-29) were moved to the Methodology section, which was also restructured and some parts were deleted.

- *Tables 1, 2: I would specify somewhere which months are associated to the different seasons. Also, I would report first rainfall, then irrigation and lastly drainage.*

The seasons are now explained in the revised manuscript. (Lines 251-253 of the revised manuscript).

Also, the suggested changes were applied in Table 1 and Table 2.

Table1. Records of drained water from lysimeters and input water (mm)

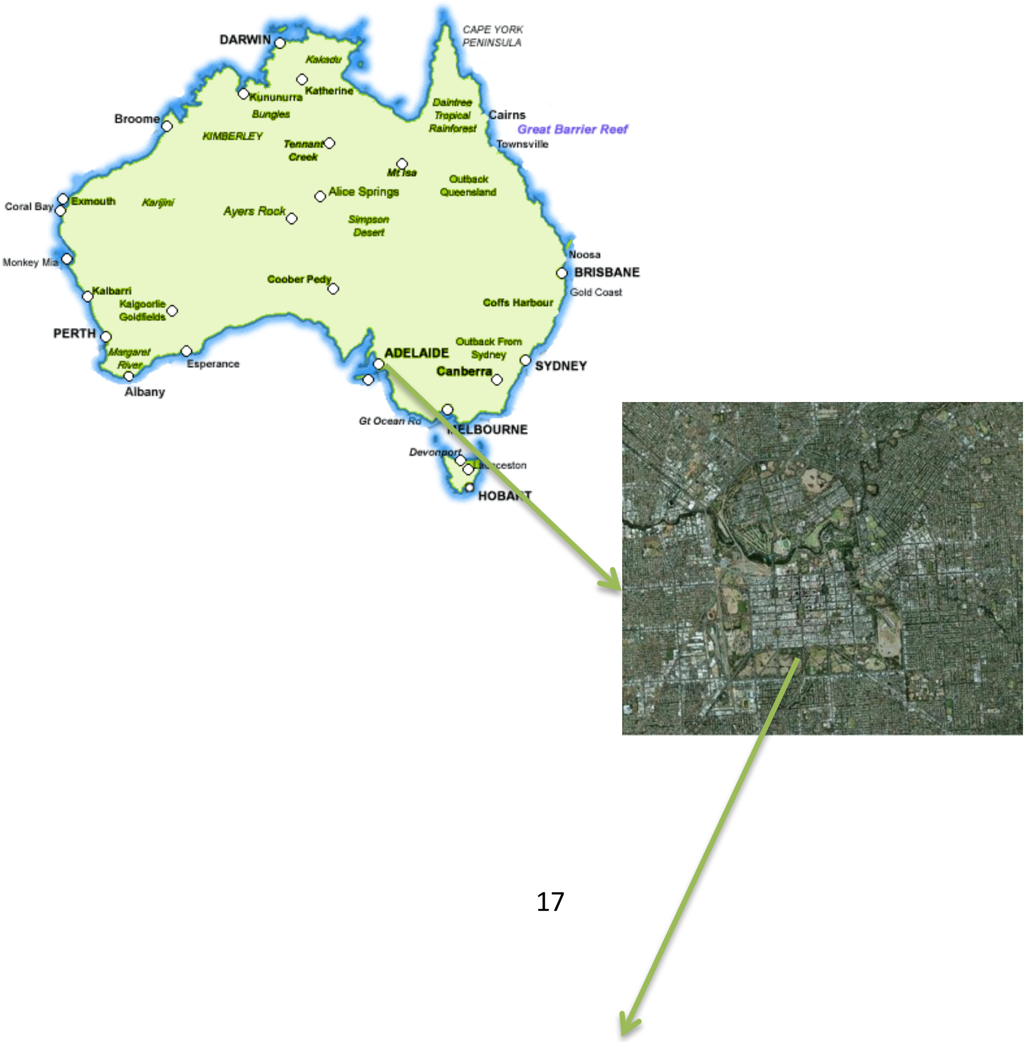
Landscape zone	Summer	Autumn	Winter	Spring
MG zone				
Seasonal rainfall (mm)	78.8	160	262.7	53.7
Seasonal irrigation (mm)	331.11	123.8	0	177.28
Seasonal drainage (mm)	1.33	24.75	206	95.51
MT zone				
Seasonal rainfall (mm)	78.8	160	262.7	53.7
Seasonal irrigation (mm)	403.27	150.82	20	215.91
Seasonal drainage (mm)	0	0.022	25	0.025

- Table 4; Figure 7: TDS is not a nutrient. Also, I don't think nitrite and nitrate are nutrients.

This was re-worded in the manuscript and Table 4, Fig 5 and Fig 6 have been amended accordingly.

- Figure 1: add a map of Australia to show where Adelaide is located.

A map of Australia showing Adelaide was added in Fig 1.



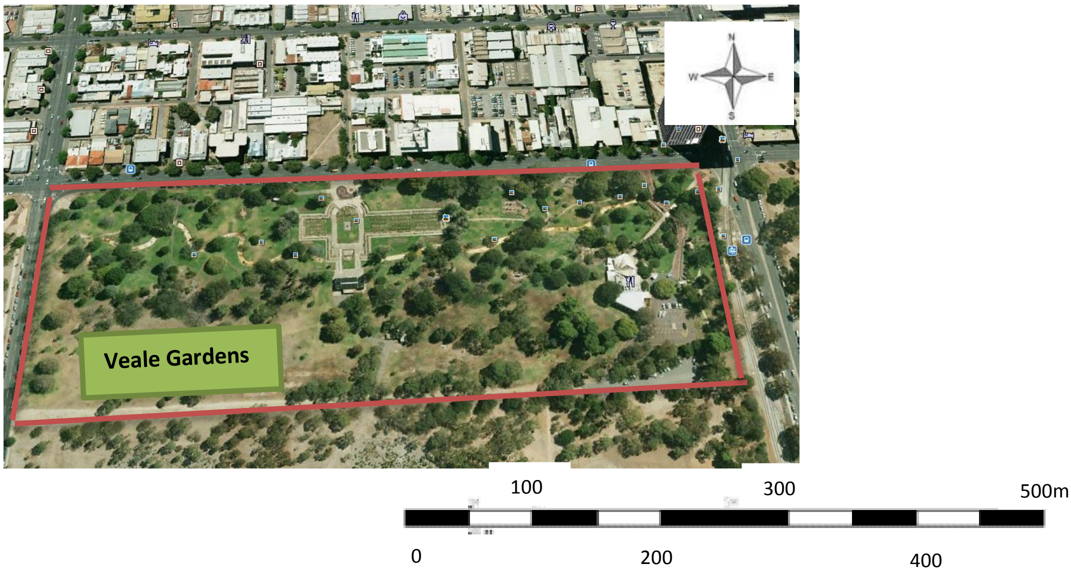


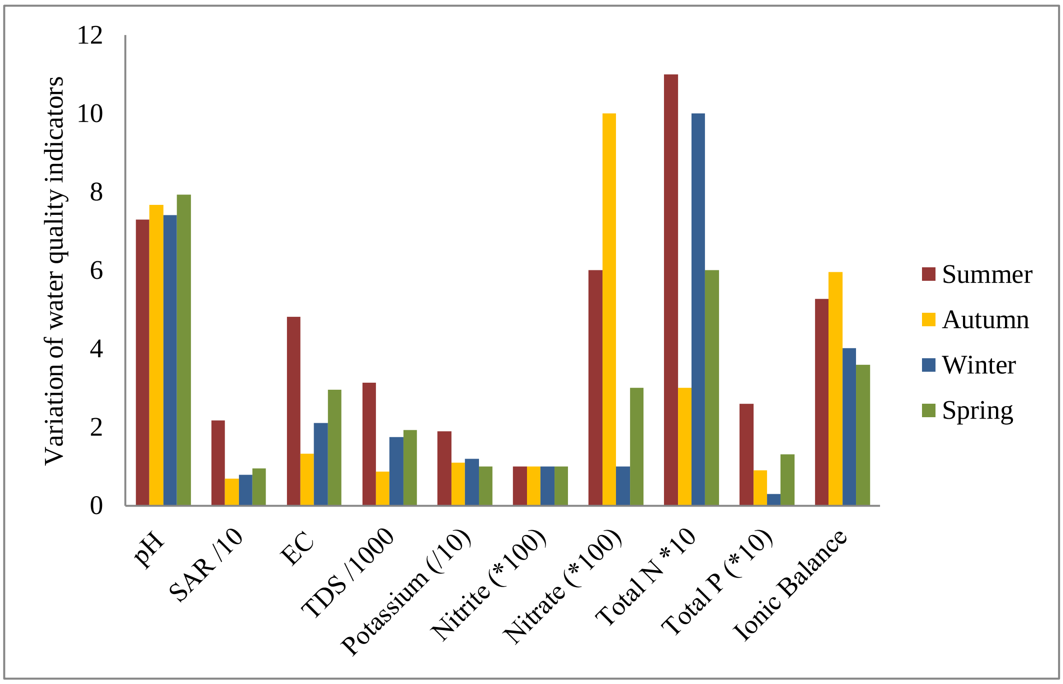
Fig.1 Veale Gardens in the Adelaide Parklands

- *Figure 3: not useful.*

Figure 3 has now been deleted.

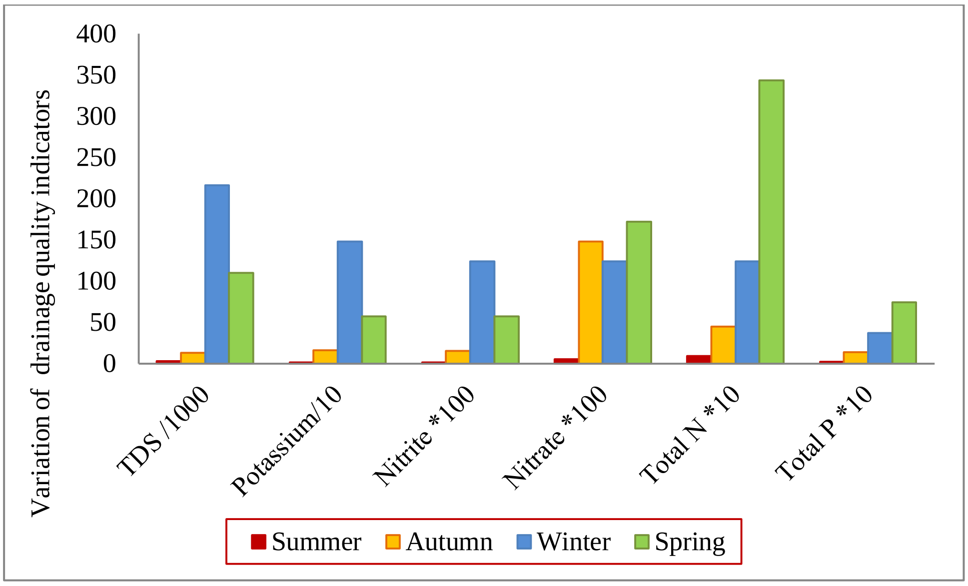
- *Figure 6: the unit in the vertical axis are not correct. For example, pH, SAR, and EC are not in mg/L.*

This was corrected in both Fig 5 and Fig 6.



*Potassium, nitrite, nitrate, TDS, total N and P are in mg/lit and EC is dS/m.

Fig 5. Seasonal variation of water quality indicators in zone MG



* Potassium, nitrite, nitrate, TDS, total N and P are in grams.

Fig 6. Seasonal water quality indicators through cumulative drainage

References:

Martin, E.C, Pegelow, E.J., Watson, J. : Using Drainage Lysimeters to Evaluate Irrigation and Nitrogen Interactions in Cotton Production, publication AZ1006: "Cotton: A College of Agriculture Report," College of Agriculture, The University of Arizona, Tucson, Arizona, 85721, http://ag.arizona.edu/pubs/crops/az1006/az10065c.html, 1998.

Rooij, G., Stagnitti, F. : Spatial and temporal distribution of solute leaching in heterogeneous soils: analysis and application to multisampler lysimeter data, Journal of contaminant hydrology, 54, 329-346, Elsevier Science BV, Netherlands, 2002.

Tollennat, P., Ryckborst, H. : The effect of conifers on the chemistry and mass balance of two large lysimeters in Castricum (The Netherlands), Journal of Hydrology, 24, 77-87, 1975.