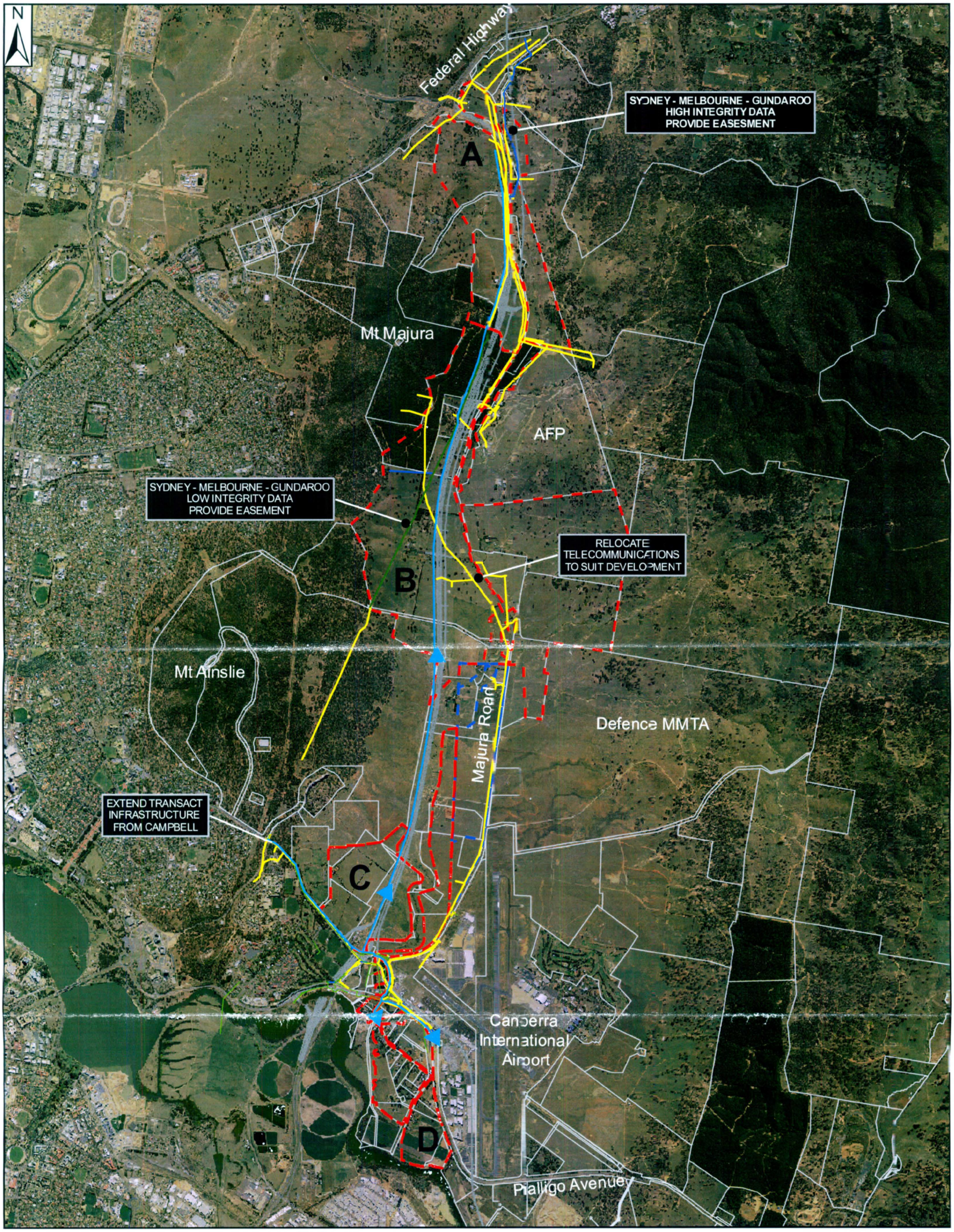

Proposed TransACT
Other Existing Communication Assets
Existing Telstra Optical Fibre
Existing Telstra
Investigation Area Boundary
National Land
Proposed Majura Parkway & VHST Route

MAJURA VALLEY ENGINEERING FEASIBILITY STUDY

TELECOMMUNICATION SERVICES

Source: Telstra (2009), SMEC (2009), ACTPLA (2009)

0 0.5 1 2
Kilometers

APRIL 2010

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8.0 Water Sensitive Urban Design Strategy

8.1 Background and Context

The water sensitive urban design (WSUD) options presented in this strategy are based on analysis and modelling of the existing and post development land use in the Majura Valley and the optimisation of outcomes for both resident businesses and the wider community. The approach to delivering water services that meet key objectives has been framed by the concept and philosophy underpinning the building of Water Sensitive Cities through the creation of water sensitive neighbourhoods or precincts. As the significance of global warming and climate change becomes understood, the realisation that future urban developments need to be able to face the uncertainties in water supply and protection of downstream, urban waterways that result from the combination of climate variability, population growth and climate change. In the case of the Majura Valley, the potential impact on receiving waters is especially pertinent due to Woolshed Creek being a tributary to Lake Burley Griffin. In recent years there have been ongoing water quality issues within Lake Burley Griffin which have resulted in public health concerns and ultimately limitations on its recreation amenity due to closures. Outbreaks of Cyanobacteria (including blue-green algae) have occurred. These are attributable to the combined impacts of nutrient enriched inflows, periods of stratification and mobilisation of internal nutrient loadings, long detention times and increasing spells of elevated temperatures. Urban development within the upstream catchments is a significant source of nutrients. Any further developments which are hydraulically linked with Lake Burley Griffin need to address the ongoing water quality management of the lake and mitigate any adverse impacts which may result from increased stormwater runoff. The concept of the Water Sensitive City is a stated goal of the Australian Commonwealth's National Water Initiative directed at 'Innovation and Capacity Building to Create Water Sensitive Australian Cities' (COAG, 2004, Clause 92, p20).

8.1.1 Landform

Woolshed Creek follows a meandering flow path down the approximate centre of the Majura Valley and has become locally incised with over steepened banks and limited riparian vegetation. Land on either side comprises relic flood plain with a flat to minor grade towards the creek. The investigation areas are contained within this flood plain area. The eastern and western sides of the valley rise in moderately sloping hill country to defined ridgelines running north-south.

Minor east-west ephemeral watercourses are evident in the sloped sections with a small number of defined tributaries extending across the flatter valley section to intersect with the creek. It is considered likely that the valley would have supported dispersed areas of seasonal ponding in either chain of ponds type features or dispersed wetlands. Drainage for pastoral conversion has subsequently confined flows to the formed channel and changing land use has modified the hydrology of the Woolshed Creek system.

8.1.2 Existing Land Use

The Majura Valley is a highly modified landscape comprising pastoral land, forestry and remnant shrubby woodland. The areas identified for development are almost exclusively pastoral land with a small number of buildings present. The two lane Majura Road runs the length of the valley with gravel shoulders and open drainage ditches conveying runoff to the Woolshed Creek.

The valley floor is presently almost entirely occupied as pastoral land with grazing of cattle and sheep. It has been assumed that fertiliser use is not excessive (such as quantities used in horticulture). Limited fencing of the riparian margins of Woolshed Creek allows stock to access the water way and cause damage through land disturbance and excrement. The grass cover appears to be reasonable well maintained with no significant indication of overgrazing. Infiltration of small to moderate rainfall events would be expected with interflow supporting base flows within the creek. Areas of Woolshed Creek inspected suggest that the creek regularly ceases to flow. The conditions range from dry rocky creek bed to pools vegetated with emergent aquatic macrophytes. All the tributaries inspected were dry.

The western slopes include a mixture of protected shrubby woodland and plantation pine. Future harvesting of plantation timber will significantly modify the current runoff volumes and sediment loadings.

The eastern slopes are largely occupied by the Australian Defence Force (ADF) and referred to as the Majura Training Area Range. ADF uses include a number of live firing ranges and large areas of open woodland used for training exercises. The range does not currently include provision for large calibre firing from ground or aerial armaments. This land was formally cleared as pastoral land and includes approximately 300 small earthen dams constructed along the ephemeral watercourses. In recent times the land has been subject to severe overgrazing by Kangaroo populations resulting in very poor grass cover and large areas of exposed erosive soils.

8.1.3 Rainfall Runoff Characteristics

Much of the low lying Majura Valley floor is characterised by a relatively flat grade typical of flood plains in the area. Obvious areas of scour away from the primary east west tributaries were not observed. Based on the topography of the site and the permeability of the relatively deep surface soils it is likely that low to moderate rainfall events will be largely infiltrated to the subsoils with development of only minor flow paths in depressions. High intensity, long duration events will result in sheet flow and runoff to Woolshed Creek. It is likely that any significant runoff events will transport substantial suspended solids loads due to the erosive soils and the incised channels in the upper sub catchment (see below). The banks of Woolshed Creek are relatively steep but appear to be stable with limited evidence of scour observed. The incision of the creek is likely to have occurred shortly after the original clearance of the pre-European vegetation for conversion to pastoral farming.

Inspection was made of the eastern side of the Majura Valley within the ADF area. This area contains a number of tributaries which contribute to flows within the Woolshed Creek. As stated earlier, numerous small dams have been constructed to retain event flows within the upper catchments. At the time of inspection all tributaries were dry with ponded water observed within the dams. Tributaries inspected consist of incised ephemeral streams with clear deposition of alluvial soils/sands. The high gravel load within the natural drainage is indicative of periodic high energy flows and the erosive nature of surrounding soils. It is considered likely that moderate to intense rainfall events will result in significant runoff whilst low intensity, short duration events will preferentially infiltrate into the underlying soils contributing to interflow and ultimately base flow within the Woolshed Creek. Efforts are currently being made to limit the Kangaroo population including culling and the removal of a number of the existing dams. These actions will ultimately impact on the hydrology of the Woolshed Creek catchment as the improved vegetation cover (currently overgrazed) will improve the infiltration rates and reduce erosion of the surface soils whilst the removal of dams will limit the attenuation/retention of event flows and likely increase the episodic flows in the Woolshed Creek water way. The combined impacts of this change in land management within the ADF area will result in noticeable changes in the flow patterns within the Woolshed Creek but will represent a more natural regime for the water shed.

Development of land within the Majura Valley will have a significant impact on the hydrology of the catchment. Transformation from the existing grassed pasture to developed impervious land use will increase both the volume and frequency of runoff and result in contaminants entering the downstream waterways. It will also likely impact on the geomorphic form through erosion and scour and degraded ecosystem character through the altered hydrology. These biophysical impacts will be detrimental to in stream biota and reduce the overall biodiversity and ecological functioning of the system.

Impacts will extend beyond the immediate areas of development with nutrient enrichment and sedimentation likely in downstream water bodies such as Lake Burley Griffin. Strategies and infrastructure should be incorporated into the overall development framework to negate these environmental risks and reduce, and/or remove the potential for negative impacts on the immediate waterways and downstream aquatic habitats.

8.2 WSUD Objectives

An emerging challenge for urban communities is to incorporate design strategies that provide resilience to future uncertainty associated with drought and climate change, while catering for increased demands placed on the supply system due to population growth. In a Water Sensitive precinct, the dynamic interactions between water supply, stormwater, wastewater, land use, climate, social capital and the receiving waterways are strategically integrated into the planning and design process at the outset of development design. This level of integration is applied to the urban landscape across the full spatial scale, from the building scale to whole-of-precinct planning.

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Figure 14 provides a diagrammatic representation of the integrated approach to urban water cycle management whereby the three main urban water streams are fundamentally linked to achieve an integrated water cycle management outcome. The ensuing WSUD response to development within this paradigm will achieve the optimal outcomes in terms of economic, environmental and social benefits.

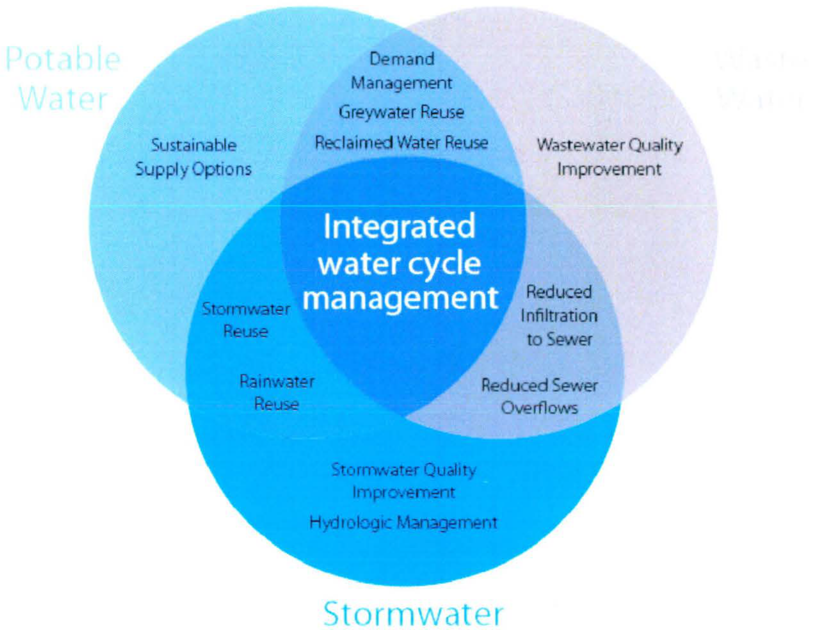

Figure 14 Integrated management of the urban water cycle (adapted from Hoban and Wong, 2006)

WSUD is a holistic approach to sustainable and integrated management of the urban water cycle, encompassing the three urban water streams of potable mains water, sewerage and stormwater, within the context of the urban built form and landscape. WSUD provides the platform for water conservation and protection of aquatic environments. The water servicing strategy proposed for Majura Valley has been guided by the following key principles of Water Sensitive Urban Design:

- Demand for potable mains water should be reduced through water efficient fixtures and appliances, and using alternative sources of water based on matching water quality to uses on a "fit-for-purpose" basis.
- Wastewater disposal should be minimised through a combination of potable mains water demand management initiatives, water efficient processes and possibly wastewater reuse on a fit for purpose basis.
- Urban stormwater is to be treated to meet national stormwater quality objectives for reuse and/or discharge to receiving waterways.

Stormwater should be used within the urban landscape to maximise visual and recreational amenity, and where appropriate influence the micro-climate of the area.

Benefits from one element will have flow on benefits to other elements. For example, demand management will reduce the amount of potable mains water consumed by businesses, as well as reducing the wastewater generated, and thereby the volume of wastewater to be treated. These synergies and symbiotic relationships will permeate through all layers of development as individual components are collectively inter-connected to achieve an ultimate outcome of sustainable development. The relationship between the urban design and built form with the water aspects of design must be cognisant and responsive to other issues such as land use, transport, energy, population, and waste. This inter-connected viewpoint is illustrated in Figure 14. WSUD provides the platform to achieve this overarching ESD objective.

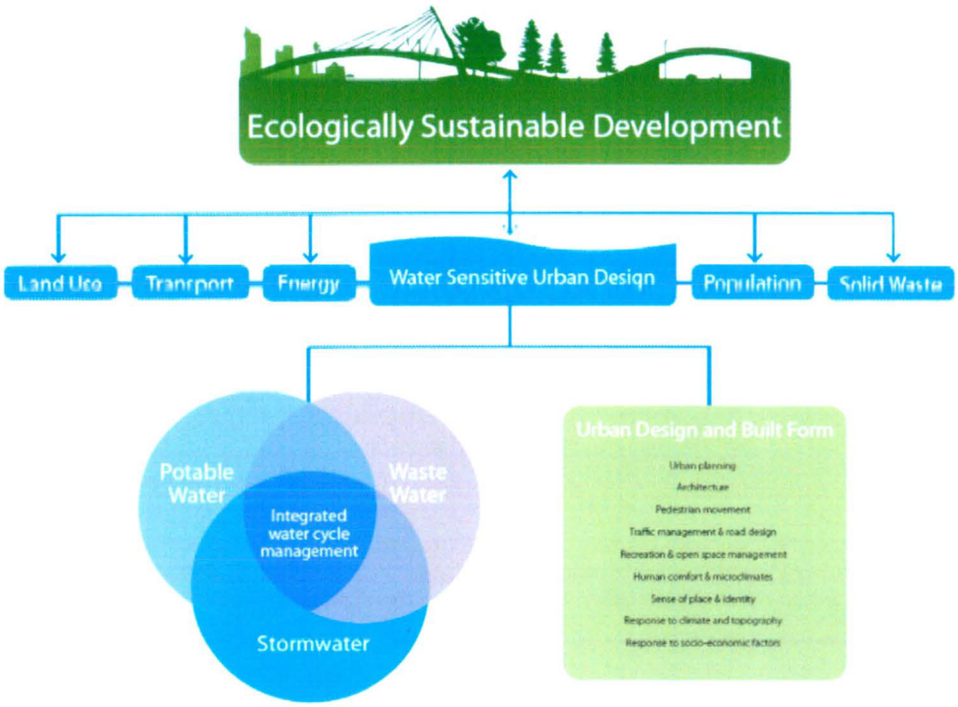

Figure 15 **role of WSUD in achieving Ecologically Sustainable development (Adapted from Hoban and Wong, 2006)**

A strategy built around a diversity of water sources and a diversity of water infrastructure will allow Majura Valley the flexibility to access a 'portfolio' of water sources at least cost and with least impact on downstream water bodies such as Woolshed Creek and Lake Burley Griffin. Water sources include rainwater (collected solely from roof areas), stormwater (collected from roads and other impervious surfaces) and potentially treated waste water from a precinct scale package wastewater treatment plant. Each of the alternative water sources have unique reliability, environmental risk and cost profiles with the tendency for sources of high reliability to also have associated high cost and environmental risk profiles and vice versa. In a water sensitive development, access to these alternative sources should be optimised dynamically (even on a short term basis) through the availability of diverse infrastructures associated with the harvesting, treatment, storage and delivery of the water sources.

The provision of a dual water supply reticulation network for potable and non potable water supply will be an essential underpinning infrastructure if the goal of water sustainability and self sufficiency in water usage is desirable. The opportunity to be a producer of water to service neighbouring users can be realised with future development focused on the provision of fit-for-purpose water servicing to optimise opportunities inherent to Majura Valley in a structured and efficient manner. The harvest and supply of water beyond the development boundaries of Majura Valley will also enable the pre development hydrology to be mimicked by removing the runoff excess which results from the increased impervious land uses.

Water is also an essential element of place making, both from maintaining/enhancing the environmental values of surrounding waterways and in the amenity and cultural connection of the place. Urban landscapes in Majura Valley should encapsulate the opportunities and technologies for resilience to the impacts of climate change, to face future uncertainties in urban water supplies and climatic extremes, and provide ecosystem services to protect/buffer Lake Burley Griffin from the impacts of the combined pressures of development growth and climate change. The initiatives in Majura Valley will represent a reversal in the conventional philosophical approach of urban development drawing on their depleting ecosystems and natural environments. The harvesting of stormwater and recycling wastewater will not only address site generated contaminants, but will also provide micro-climate and amenity benefits extending beyond the immediate project boundaries.

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8.3 WSUD Policy

The ACT has over recent years adopted a number of planning and policy controls to ensure that development is undertaken in a considered and sustainable manner. In 2004 the "***think water, act water"*** strategy was launched to provide guidance for the management of ACT water resources. One of the key objectives of the strategy is the widespread inclusion of WSUD in future land development.

The broader ACT's planning legislation sets out the framework for development related activities within the Territory and prescribes the object of the overall Territory Plan. The Territory Plan provides a strategic framework for the management of development and land use change. The Plan sets out principles to guide development over the next 10-15 years. It sets out strategies in respect to water based planning along with other sustainability focused aspects of development.

In 2009 ACTPLA released the ***"WaterWays: Water Sensitive Urban Design General Code.*** The purpose of this document is to minimise development impacts on receiving water bodies through the provision of robust and effective stormwater management systems and other water quality/quantity initiatives. The code defines performance targets related to stormwater quality which must be met to ensure that the objectives of the code are met. These targets relate specifically to the removal of total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN).

Performance targets

The objectives for stormwater quality management are intended to be achieved by the combination of works undertaken by the Government, through its development and capital works program, and by private sector works undertaken in new developments and redevelopments. The responsibility for meeting targets on development or redevelopment sites lies with the developer or builder, while responsibility for meeting the regional or catchment-wide targets lies with Government. The Government is committed to developing, prioritising and implementing larger-scale WSUD stormwater measures, such as lakes, ponds and wetlands, to ensure that the catchment-wide targets are achieved. The targets stated in the Water Sensitive Urban Design General Code are shown in Table 16. They refer to reduction in pollutant export compared to an urban catchment with no water quality management controls. These targets must be met for all developments greater than 2000 m^2.

In addition to these Water Sensitive Urban Design General Code treatment targets, we have considered the nationally recognised best practice targets of 85%, 45% and 45% reductions in TSS, TP and TN respectively. These targets fall between the two approaches outlined in the Water Sensitive Urban Design General Code and have been shown to provide adequate protection of downstream receiving waterways. These levels of pollutant removal are also consistent with the provision of treated water for non potable applications such as irrigation of open space. Risks associated with inadequate TSS removal relate to suitability of treated water for UV disinfection which is generally required prior to applications which may result in human contact. Harvesting a proportion of treated water for reuse application also provides an effective way of further reducing the pollutant export and 'stretching' the targets towards the ACTPLA regional targets. This approach will enable the regional targets to be met without the increased land areas required to meet these targets with treatment alone.

Table 16 Water quality treatment targets as per the Water Sensitive Urban Design General Code

	Development or redevelopment Sites	Regional or catchment-wide	Recognised Best Practice Targets
Reduction in average annual suspended solids (SS) export load	60%	85%	85%
Reduction in average annual total phosphorus (TP) export load	45%	70%	45%
Reduction in average annual total nitrogen (TN) export load	40%	60%	45%

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In conjunction with the Water Sensitive Urban Design General Code the ACT government released the ***Industrial Zones Development Code*** in January 2010 which applies to all development in the Industrial Zones Codes providing additional planning, design and environmental controls to support the zone objectives and assessable uses in the development tables.

Evidence is also to be provided that demonstrates that for all sites of size greater than 2,000m^2, a reduction of 1-in-3 month stormwater peak run off flow to pre-development levels with release of captured flow over a period of 1 to 3 days can be achieved. The targets stated in the Industrial Zones Development Code are shown in Table 17. They refer to reduction in pollutant export compared to an urban catchment with no water quality management controls. These targets must be met for all developments greater than 5,000 m^2.

Table 17 Water quality treatment targets as per the Water Sensitive Urban Design General Code (Industrial)

	Industrial Development or redevelopment Sites
Reduction in average annual suspended solids (SS) export load	60%
Reduction in average annual total phosphorus (TP) export load	45%
Reduction in average annual total nitrogen (TN) export load	40%

Think water, act water sets the target of a 12 per cent reduction in mains water usage per capita by 2013, and a 25 per cent reduction by 2023 (compared with 2003), achieved through water efficiency, sustainable water recycling and use of stormwater and rainwater. It is considered that the current targets for water reduction do not reflect the technological innovations which have been seen in the industry. These targets can (and should) be raised to reflect the opportunities inherent to Greenfield sites such as the Majura Valley investigation areas. The Building for Sustainability Index (BASIX) NSW State Environmental Planning Policy mandates a 40 percent reduction in potable water use for all new residential developments (free standing and multi unit) as compared to the water use of the average current housing of the same type. BASIX only considers those measures that can be incorporated into the construction of the dwelling, and does not consider water efficient appliances, such as washing machines and dishwashers. While BASIX provides flexibility in the manner in which water consumption (and other) targets are met, residential developments will typically be able to achieve the 40% reduction in potable mains water consumption by including:

- Water conservation - AAA or better water efficient fixtures, such as showerheads, tap fittings and dual-flush toilets.
- Water reuse – a rainwater tank or equivalent communal system of a minimum specified volume, or connection to an appropriate recycled water supply, for toilet flushing and outdoor uses.

These BASIX targets should be adopted for the Majura Valley investigation areas.

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8.4 Stormwater management options

The adoption of WSUD within the Majura Valley investigation areas will involve integrating built and landscaping requirements with urban water management objectives. For example, stormwater attenuation and treatment at the lot scale or within the land development footprint will require space, which contests traditional land development uses such as open space and recreational areas. Through an appropriate design response it is possible to co-locate water quality treatment within open spaces and designate at least a portion of these as part of any required open space designations. Likewise treatment elements may be able to be integrated within the identified buffer areas if suitable to reduce the land take of developable land. A well designed treatment wetland for instance will provide clear visual and aesthetic amenity and can incorporate pathways and viewing platforms to engage residents and therefore fulfil the intentions of stipulated open spaces and/or enhance the visual and environmental integrity of stipulated buffers.

In consideration of an optimal WSUD treatment strategy for the Majura investigation area, a number of key treatment elements must be considered. These are able to be designed and implemented at either the lot scale or precinct wide and all can be readily integrated with stormwater harvesting initiatives.

8.4.1 Treatment ponds

In the context of the ACT and the Water Sensitive Urban Design General Code ponds have traditionally been a favoured approach to water quality. Due to the scale and lack of bathymetry these are typically large open water bodies with fringe vegetation. A number of examples currently exist whereby ponds have been constructed which provide significant storm flow attenuation and provide recreational amenity. Investigations into the water quality performance of large open water bodied ponds confirm reasonably high treatment performance on an event basis. That is, over a short timescale contaminants are removed from the inflows through sedimentation and bioaccumulation by algae and phytoplankton. The outflow water quality on this short timescale therefore indicates effective treatment performance. Over time, algal cells and fine particulates accumulate on the base on the ponds. The risk with the pond as a treatment measure is that during warm periods with limited inflow (summer) stratification can cause biogeochemical change in the sediments and algal cells and resuspend them into the upper water column as a nutrient rich up well. Other Cyanobacteria (including blue green algae) will then capitalise on the source of nutrients and combined with high light conditions and elevated temperatures algal blooms will occur in the water body. As well as presenting obvious public health risks, these blooms result in the discharge of nutrient rich waters to downstream waterways effectively negating the observed good treatment performance from the individual events. Predictions for changing climatic conditions are likely to increase the occurrence of such algal blooms. In recent years such blooms have impacted a number of water bodies throughout the ACT resulting in restrictions in public access, incurred costs for cleanups/public relations and potential harm to downstream waterways. In response to this, we do not typically recommend the use of ponds as water quality treatment elements without integration with other catchment initiatives such as wetlands and/or bioretentions.

In addition to this, the use of large regional ponds will provide no environmental benefits to Woolshed Creek. A large regional treatment system on the lower Woolshed Creek would not provide any protection for upper Woolshed Creek which would also require stabilisation works to accommodate increased flows resulting from urbanisation. Ponds can be used at the downstream end of a treatment train and can provide a good means of treated water storage for regional harvesting schemes with a dual benefit of recreation amenity. Consideration needs to be given to bird establishment (with regards to potential bird strike issues) as large areas of open water are required for particular fowl for landing and takeoff. Open water systems tend to more attractive habitat for large transitory birds that represent a bird strike risk.

8.4.2 Treatment wetlands

Constructed wetlands provide a reliable and robust means of improving water quality and can be implemented on a number of spatial scales from small 'water feature' type systems to large, naturalised systems. Wetlands can provide visual amenity and enhance the landscape with a well considered design form and planting palette. The nature of the biogeochemical processes which provide treatment within wetlands will typically support reliable treatment performance over sustained periods. Through appropriate design of the wetland hydraulics and bathymetry the system is protected during both extreme runoff events and prolonged dry periods. Once established, maintenance of the main wetland body is negligible with periodic (typically every 2 years) cleanout of

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sedimentation forebay and control of any noxious weed species which may migrate into the area. Treatment wetlands are typically designed to remain wet throughout the year although ephemeral systems can also be designed. Water level fluctuations are observed through the engagement of a storage volume above the normal operating water level. The extended detention depth is typically around 350mm and the perimeter batters are well vegetated to mask any change in water level. Therefore, the perimeter batters respond in a similar manner as the edges of the large ACT water quality ponds with event based fluctuations. These variable water levels promote a more biodiverse plant community and provide resilience to the wetland against occurrences such as disease or drought. Wetlands can be designed and constructed to reduce the habitat appeal to large waterfowl which may cause bird strike issues. Smaller dispersed open water bodies should be designed to prevent effective take off and/or landing reaches. Perching sites should be discouraged. Wetlands are well suited to be integrated with stormwater harvesting schemes. This is typically achieved through connection with storage ponds or tanks. During inter-event periods the wetland bodies can be engaged as re-circulation treatment bodies reducing the chances of algal blooms in storages.

Figure 16 and Figure 17 provide examples of constructed wetlands which have been designed to provide best practice treatment of stormwater runoff and designed to respond to the landscape setting.

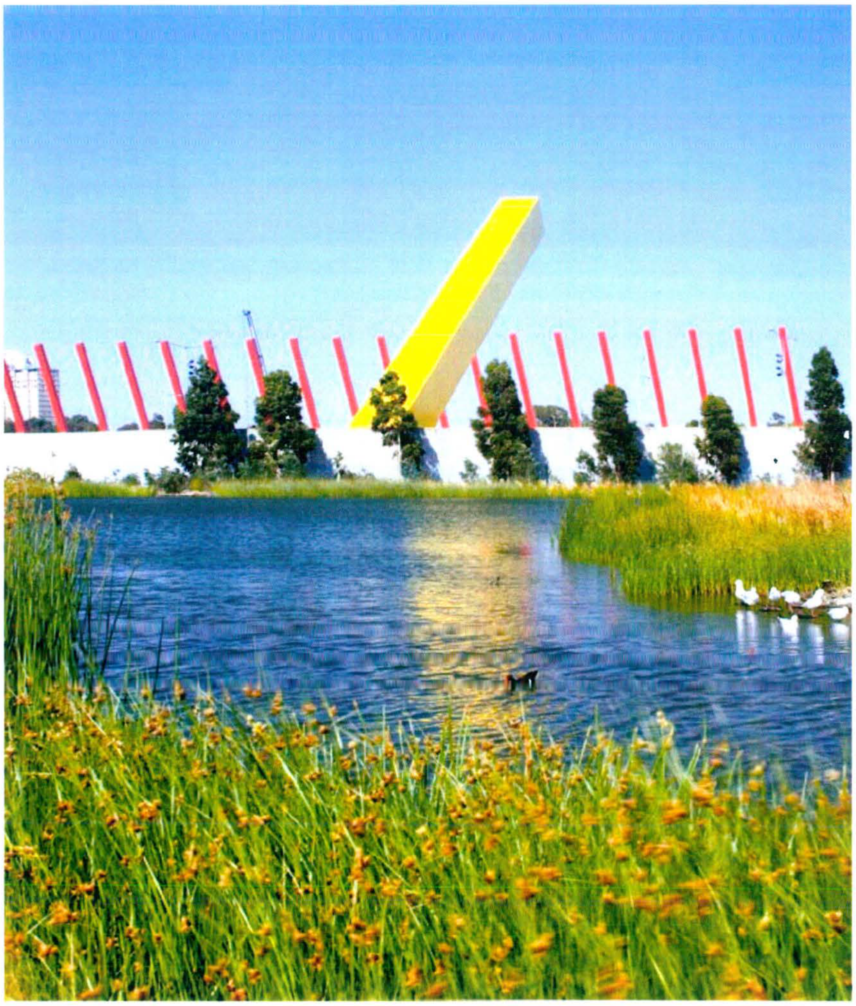

Figure 16 Large open water storage (with fringe vegetation) receiving water from treatment wetland – Royal Park Wetland, Melbourne

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Figure 17 Constructed wetland in landscaped open space – Royal Park Wetland, Melbourne

8.4.3 Bioretention systems

Like wetlands, bioretention systems provide reliable and robust treatment performance. While bioretention systems can be constructed with quite large treatment footprints they are inherently better suited to smaller scale applications such as liner street systems. Bioretention systems are ideally suited to integration into landscaped areas and can readily be designed to complement the overall landscape design objectives. The design of bioretention systems must respond to the local climatic regime to ensure that the area and plant selection is suited to the hydraulic loadings. Bioretention systems typically receive event based runoff and have provision for temporary surface ponding above the filtration media. This ponded water subsequently percolates through the filtration media with treatment provided through a combination of filtration and biogeochemical processes related to the vegetation root zone. Between events, a typical bioretention system will be dry on the surface and appear as a planted garden bed. Long-term maintenance is comparable to any standard garden bed with periodic removal of weed species and litter. Bioretention systems can be integrated with harvesting schemes with treated stormwater directed to storages.

Figure 18 provides an image of a typical linear bioretention system constructed within a road corridor. These systems are well suited to provide treatment of stormwater runoff whilst also enhancing the visual aspects of the street typology. Care is needed when employing bioretention systems in areas with significant plantings of deciduous trees. Bioretention systems are very effective at trapping fallen leaves, but as a result can appear untidy in autumn.

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Figure 18 Street scale linear bioretention system – Victoria Park, Sydney

8.4.4 Other Management Options.

In addition to the specific treatment elements listed previously, a number of other options can be incorporated into the development planning process to optimise the outcomes of the WSUD strategy. These can include initiatives such as:

- Rainwater tanks
- Vegetated swales
- Source control of pollutants
- Reductions in water use
- Provision of recycled wastewater.

Table 18 provides a summary of the different WSUD elements which can be incorporated in to the Majura valley investigation areas at the different spatial scales.

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Table 18 Application of WSUD technologies at the local, precinct and regional scale (adapted from Wong 2006, CSIRO 2005)

Local	Precinct	Regional
Potable water conservation		
• Rainwater tank	• Precinct detention and ponds • Aquifer storage and recharge	• Precinct detention and ponds • Aquifer storage and recovery
Stormwater management (quality)		
• Porous pavement • Sand filters • Bioretention basins • Vegetated buffer	• Porous pavement • Sand filters • Bioretention swales and basins • Vegetated buffer • Constructed wetlands	• Constructed wetlands • Ponds
Stormwater management (quantity)		
• Onsite detention	• Retarding basins • Ponds	• Retarding basins • Lakes
Wastewater minimisation		
• Onsite effluent treatment	• Onsite effluent treatment	• Indirect potable reuse • Direct potable reuse • Dual pipe (provision of recycled water from a regional effluent treatment system)

8.5 WSUD Opportunities

Opportunities exist to incorporate the key principles of WSUD into the development framework of Majura Valley. The location of the investigation areas are broadly dispersed along the drainage corridor for Woolshed Creek. We understand that remaining land outside of the identified investigation areas is unlikely to be considered for future development and will remain largely as vegetated woodland. As such it is considered reasonable that the WSUD strategy to respond to any future development may need to address the water quality targets from a regional or catchment wide perspective. This approach will considerably increase the land areas required for treatment of site generated runoff to achieve the required pollutant removal.

In order to achieve the catchment wide treatment targets, all site derived stormwater shall be treated to reduce mean annual pollutant loads of total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN) by 85%, 70% and 60% respectively. This stringent treatment approach will exceed nationally recognised best practice targets. It is considered that the optimal means of achieving these regional targets is through the reuse of treated water (which effectively further reduces the contaminant export). To support the fit for purpose reuse of treated stormwater, we recommend that the nationally recognised best practice targets (80, 45, 45) are achieved at a minimum prior to harvest. This will ensure the suitability of harvested water for a wide range of application with limited further mechanical treatments required. All stormwater will be treated to improve water quality prior to discharge to land in the form of irrigation or direct to the Woolshed Creek thus significantly reducing the pollutant load discharged the receiving environment and mitigating the potential for downstream impacts.

In the instance that the potential impact of development is not required to be addressed from the catchment scale but rather is approached from a site based approach, all site derived stormwater shall be treated to reduce mean annual pollutant loads of total suspended solids (TSS), total phosphorous (TP) and total nitrogen (TN) by 60%, 45% and 40% respectively.

In implementing technologies and strategies to treat all site generated runoff to meet stormwater quality objectives, opportunities arise to readily harvest treated water for subsequent reuse purposes. This further reduces the nutrient loading to downstream waterways which increases the overall treatment performance of the WSUD strategy. Once further details are available for the investigation areas and volumetric demands for non-potable water (which can be reliably serviced with treated stormwater) are quantified, the ultimate WSUD strategy can be tailored to meet specified water treatment targets factoring for the nutrients removed from downstream discharge through harvest. The harvest of treated stormwater will also reduce the event related runoff which in turn will minimise the post development hydrological impacts.

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The provision of alternative non-potable sources of water will reduce demands on the traditional potable mains supply. This can present economic benefits in terms of the long term cost of potable water supply. The cost of supply for traditional mains water is expected to progressively increase as the reliability of supply from the existing water supply catchments motivates the adoption of more expensive technologies and/or long distance pipelines.

8.5.1 Water Reuse

The projected large areas of impervious land use within the Majura Valley will readily support the harvest of water for both treatment and reuse within the precinct and adjacent areas. By integrating the requirements and objectives of best practice water quality treatment with the infrastructure required to provide an alternative non potable water supply scheme land development can progress with reduced demands on the traditional potable mains supply and reduced impacts on downstream receiving environments. By adopting the fit for purpose approach to water demands and isolating sources of runoff (roof areas versus road/paved surfaces) water of different quality can potentially be harvested as separate streams and used to service different end users. An example of this would be the collection of rainwater from the potentially large areas of roof surfaces to supply internal non potable demands such as toilet flushing and industry applications whilst stormwater is harvested for demands with a lower risk profile such as irrigation of landscaped areas and/or productive gardens.

Rainwater will typically have a more consistent contaminant profile with a better overall water quality than stormwater resultant from road runoff. This will reduce the treatment requirements (filtration should be sufficient) and respond to perception issues which may be inherent with some applications. The reliability of supply of harvested rainwater will depend on the temporal demand patterns (i.e. does the demand for the water vary seasonally or is it largely uniform across the year) and the size of buffer storages used. Modelling has been used to identify a potential maximum rainwater yield for each of the precincts and development scenarios. Sizing of storages will be dependent on further details on site specific potential non-potable demands. Storages could be sized on a building scale or alternatively as more centralised 'reservoirs' (particularly well suited if large industrial uses for harvested water are identified).

Stormwater will typically display significant variation in water quality dependent on rainfall intensity, preceding dry spells and specific land use. Risks associated with spillages and industrial discharges must also be considered in respect to the suitability of end use. As a minimum, treatment should be focused on achieving best practice water quality treatment targets with further improvements guided by the ultimate end use (if applicable) of harvested flows. Treated stormwater could be used to reduce the demand on potable mains water and provide enhanced landscape productivity through irrigation. As with rainwater, the reliability of supply will depend on the size of buffer storages and the demand profile. The use of the treatment wetland as the principle storage is not well suited to servicing of demands throughout prolonged summer dry periods. Storage can be achieved either in underground tanks or additional ponds (subject to evaporative losses). Stormwater can be separated at source and treated in distributed elements (bioretention and/or wetlands) or treated in large scale precinct wide treatment wetlands which receive inflows from all impervious surfaces (including roofs). Large precinct wide wetlands can be integrated with third pipe reticulation to supply water to demands within the Majura Valley or other proposed schemes downstream of the proposed development. Harvesting a proportion of treated stormwater for reuse applications also provides an effective way of further reducing the pollutant export and 'stretching' the targets towards the ACTPLA regional targets. This approach will enable the regional targets to be met without the increased land areas required to meet these targets with treatment alone.

The potential impacts of climate change are often raised as a potential threat to the viability of stormwater harvesting schemes. Depending on the predicted localised impacts of climate change it may eventuate that mean annual stormwater harvest yields diminish. This diminishing water supply is however also likely to be experienced with typical catchment supply dams. In the instance of the ACT and Canberra, the existing potable mains supply is based on the traditional catchment dam approach whereby rainfall is collected from an undeveloped forested catchment. The risk to this approach is also significant as it is reliant in runoff from pervious surfaces which is itself directly related to the soil moisture content. As temperatures increase, the evapotranspiration rates will also increase resulting in increased depletion of soil moisture stores between rainfall events. As a result of this the amount of each rainfall event which is utilised in replenishing the soil moisture content is likely to increase with a resulting decrease in the volume of runoff experienced. Without access to another reliable source of potable water such as desalination, areas such as the ACT will be forced to think laterally and ideally respond with an integrated water management response which capitalises on a number of potential sources. Integral to an approach such as this will be the utilisation of harvested stormwater and potential treated wastewater.

8.5.2 Wastewater Management

The existing Water Sensitive Urban Design General Code does not specify or quantify waste water reuse targets but states that where infrastructure is available, the opportunity is to be taken, where practical, to reuse treated effluent for appropriate uses to replace mains water use. Due to the greenfield nature of the Majura Valley investigation areas and the likely requirement to construct a regional scale sewerage treatment plant (STP) the opportunities will exist for reuse of treated waste water on a fit for purpose basis.

8.5.3 Industrial Ecology

Greenfield development areas such as the Majura Valley provide the opportunity to integrate potential waste streams with demands to reduce the overall net import and export of resources from the area. Industrial ecology seeks to link together industrial processes so that one process makes use of the by-products of another that would otherwise go to waste. In this way resources are used more productively, less hazardous waste and other pollution is generated, and material, energy and water throughput is minimised. This can be readily achieved by identifying synergies between prospective industries and actively pursuing occupancy by complimentary users to capitalise on opportunities. As part of the overall WSUD strategy for the Majura Valley area the principles of industrial ecology can be readily applied with respect to water.

The light industrial land use identified for the area will typically include large impervious areas. These will consist of both roof areas (including large warehouse scale buildings) and paved surfaces (roads, car parking and hardstand). These impervious surfaces will ultimately increase the event based runoff volumes/frequencies and unmitigated, will result in a highly modified hydrology for Woolshed Creek and downstream water bodies. Further, the increased runoff will convey elevated suspended solids and contaminants including nutrients, heavy metals, hydro carbons and other pollutants related to specific industries.

Options exist at the early stage of planning for green field developments such as proposed for Majura Valley to mitigate the environmental impacts through an integrated approach to water management. These measures could include source control of pollutants, building scale treatment of pollutants, precinct scale treatment of pollutants and reduction in the site generated runoff through either harvesting captured rainwater/stormwater or promoting infiltration of runoff water to the underlying subsoils.

Source control of pollutants provides the most efficient and reliable means of controlling downstream impacts in industrial development areas. The most obvious of these is the separation of potential contaminant streams from the stormwater network. Typically this can be achieved by the covering of loading bays and the construction of ring drains which direct any spillages/wash down to trade waste collection tanks. This canopy covering should be stipulated for any areas where potential contaminants are to be handled or stored. This will include loading bays, transfer points and storage areas. The canopy shall be designed to provide sufficient protection from angled rainfall and should be sufficient to reduce the volume of trade waste discharge. The area of these roof/canopy areas will ultimately increase the surface area suitable for harvesting rainwater with associated benefits.

Treatment of pollutants can be adopted at the building scale or larger precinct/ sub-precinct scales. Stormwater runoff from impervious surfaces such as roads, car parks, exposed hardstand and paved surfaces can be conveyed (either via conventional drainage or surface swales) to treatment elements. Depending on the nature of industrial land use, pre treatment with gross pollutant traps (GPT's) may be required to reduce the loadings of coarse sediments and litter. Care will be required to ensure that swales and streetscape treatment elements (such as linear bioretention) are protected from heavy traffic and are located away from turning areas.

8.5.4 Integrated Landscape

Site generated runoff could be treated through either distributed small scale vegetated landscape features integrated into localised streetscapes and/or landscaped public spaces or larger centralised systems within larger open spaces. The strategy for stormwater quality treatment may include any combination of constructed wetlands and/or bioretention systems. The use of natural systems enables the treatment infrastructure to be integrated into the urban landscape and provide a visual amenity in parallel with a practical engineering solution. Factors which will influence the optimal configuration of these treatment elements will include topography, urban form, available open space, financial consideration, proximity to re-use opportunities and development staging considerations. Figure 19, Figure 20, and Figure 21 provide illustration of constructed treatment elements within the landscape

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setting. Further, the harvesting of treated water enables the development to support an increased greenscape from what is typically supported by mains water supply (subject to periodic water restrictions). This can in turn influence the micro-climate of development areas and reduce the impact of the heat island affect from changing land use. Prescribed land areas should be allowed for in any urban planning of the individual properties and public open space within the development. Due to the scale of the site and the requirement for non development areas due to ecological/infrastructure constraints, opportunities exist to co-locate treatment either within the developed areas (residential/employment etc) or the adjacent non-developable areas. Likewise, both bioretention systems and wetlands can be 'nested' in the floor of any retarding basins which are be required for flood attenuation with appropriate hydraulic design.

Figure 19 Urban creek restoration – Clear Paddock Creek, Sydney