

**Learning from Arid Planning and Design History and Practice:
From Woomera to creating the new Roxby Downs Communities**

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ABSTRACT: The principles and knowledge about arid planning and design have much applicability to contemporary Australian planning discourses because of climate change evidence and policy shifts that sketch a hotter and more unreliable future climate with an emphasis upon a semi-arid environment for Australia. Despite this merit and intent, we appear to have learnt little from the past and are failing to draw upon the pioneering planning and design knowledge that underpinned community development and scaffolding in numerous Australian arid and semi-arid communities, and to bring this knowledge into our future planning processes and strategies.

This paper considers the essential attributes and variables of three Australian arid planning and design, drawing upon historical practice and research that have been explored in the planning of semi-arid and arid places including Port Pirie, Whyalla, Monarto, Broken Hill, Port Augusta, Leigh Creek, Andamooka, Olympic Dam Village and Roxby Downs. It specifically reviews Woomera Village (1940s) Shay Gap (1970s) and the proposed extensions to Roxby Downs (2010s) as models of how to better plan and design communities in arid environments. Instrumental in these innovations is the use of landscape-responsive urban design strategies, water harvesting and irregular rainfall capture, arid horticulture, building design, colour and materiality, orientation and shading strategies, and social community construction under difficult isolationist circumstances. The paper points to key strategies that need to be incorporated in future climate change responsive community developments and policy making.

Keywords: Arid settlements, arid planning, Australia, Woomera, Shay Gap, Roxby Downs

Introduction; dilemmas of planning settlements in arid Australia

The dilemmas of planning settlements in arid Australia include isolation, cycles of flood and drought, transience, extreme temperatures, lack of infrastructure, distance from coastal centres and ports, and social sustainability limitations when serving a single industry. The emergence of systematic planning for arid areas has been well identified since the end of World War 2 and extensively documented as various approaches in town planning design were implemented for establishing settlements to service mining, major infrastructure projects and defence purposes. While the current trend is towards fly-in – fly-out for mining encampments, there is a body of literature that questions the regional benefits of a transitory work force in social terms and highlights the difficulties experienced by people seeking to live in arid areas in a socially cohesive way.

This paper focuses upon three Australian arid zone planned townships to draw lessons useful for planners and designers faced with predicted climate change, increased temperatures and extreme weather events. First, an overview of the arid environment is provided, followed by a survey of the designs, management and environmental approaches implemented in the period. Innovations from the past are looked at in greater detail including the attention paid to arid landscaping, water management and social organisation. Examples of planned settlements include comparisons of Woomera Village and Roxby Downs in South Australia (SA) and

Shay Gap in Western Australia (WA). Lessons learnt from the past are then suggested for the sustainable development of remote communities located in arid environments.

Environmental context

Australia is the driest continent on the Earth and most of its human population huddles around its peripheral temperate and semi-tropical edges. More than 85% of the continent has semi-arid to arid environments. Cities like Kalgoorlie (WA), Port Augusta (SA), Broken Hill (NSW South Wales, NSW), Mildura (Victoria, Vic), Mount Isa (Queensland, Qld) and Alice Springs (Northern Territory, NT) struggle to coexist within Mediterranean to desert climates with often less than 250mm of rain per year, very high daytime temperatures and a harsh climate that surprisingly still enables a diverse variety of indigenous plants and animals to survive.

Rainfall in the arid region is low, irregular and infrequent, tending to come in rapid or heavy bursts sometimes years apart, resulting in severe flash floods and damage and the occasional filling of its ephemeral rivers and lakes like Coopers Creek and Lakes Eyre and Torrens. Strong wind gusts and anti-cyclones can be common in the summer months resulting in hot, strong, dust-laden northerly winds that cake residences and gardens in a choking veil of red suffocating dust.

Soils and landforms in arid regions are very diverse and sometimes difficult to identify. While topographical changes can be subtle the colours can vary markedly from deep reds to bright oranges to the blinding whites of the salt lakes. The physical landscape varies from sandy deserts to salt lakes to gibber deserts to low incised mountain ranges. Consistently, topsoil depth is minimal with very low levels of organic matter content and usually an alkaline pH. Notwithstanding this, where water is reliably available soils can be fairly productive with appropriate management, although, high alkaline pH levels and the existence of surface salt can limit plant establishment and development.

With the variation of rainfall, temperatures and soils, the flora of arid Australia is varied, complex and quite subtle in its forms and colours. Steppe vegetation is common in much of arid Australia but over the last 200 years much of it has been extensively ravaged by over-grazing and feral animals, resulting in a succession of spinifex and less nutritious ephemeral species of trees, shrubs and grasses in some areas. Western Myall (*Acacia papyrocarpa*) in chenopod shrublands occupies much of the southern arid zone and in the arid hummock grasslands acacia open woodlands of Mulga (*Acacia aneura*) are common. Open calcareous soils and gibber deserts also occur in much of arid Australia. On sandy soils and ridgelines open woodlands of Black Oak (*Allocasuarina* sp) and Native Pine (*Callitris glaucophylla*) occur with saltbush and bluebush (Chenopod) understoreys along with many native grasses. Along dry river and watercourse edges or on the flanks and hollows of mountain ranges River Red Gum (*Eucalyptus camaldulensis*), open Mallee (*Eucalyptus* sp) and Native Pine dot the landscape with Gum Barked Coolibahs (*Eucalyptus intertexta*), Black Oak, *Eremophila* sp and *Dodonea* sp. At places of recent human settlement introduced Athel Trees (*Tamarix aphylla*), Pepper Trees (*Schinus molle* var *areria*) and occasional introduced palms have taken hold. Introduced grasses (e.g. Buffel Grass, *Cenchrus ciliaris*) have overtaken vast areas and along with over-grazing of much of the landscape the original vegetation has been compromised.

A diversity of landscape types and plant communities results in a varied and rich native wildlife. New species continue to be identified in the arid areas of Australia, for early surveys

and assessments concentrated on palatable plant species for stock, with many arid areas still yielding biodiversity data. Over the last 200 years however total grazing pressure has led to an enormous decline of known native species, but increased reliability of water has enabled an increase in some populations. The impact of these changes is evident in the role of the dingo-proof fence that wends its way across arid Australia and the benefit of the spread of poly-pipe watering systems upon native bird populations.

History of Settlement Establishment

Early Australian planning trends during the 20th century and leading up to World War 2 included design concepts based upon garden city and suburb theory in proposed new settlements. Many designs were progressive in their planning but few were realised in practice (Noonan, 2007: 6; Hall, 2005: 109-121; Freestone, 1989, 2010).

After 1945 expanded industrial activities, new mining extraction techniques and nuclear research gave fresh impetus to establish new ventures necessitating the need to provide places for workers to live. Australian post war recovery was based upon a desire to build a better society with national interest in how housing and new living areas would be planned (Darian-Smith & Willis, 2007; Freestone, 1989; Hutchings & Garnaut, 2005). Those built in the first three decades after 1945 reflected a period when the process of national reconstruction was undertaken by conservative governments and supported by an increasingly urbanised, consumer society.

The design and planning for settlements in arid landscapes after 1945 demonstrate a variety of living arrangements, including fully planned townships, temporary construction camps and military bases. Planning and design of new townships were quite often aerially surveyed and part of a systematic and multi-disciplinary approach of which planning was but one component and mainly applied in drafting exercises (Pribble, 1984; Lonsdale & Holmes, 1981). Light weight prefabrication, speed of construction and use of aluminium and asbestos were considered ideal for constructing accommodation for workers in arid conditions and contrasted with established towns and their extensions that had significant impacts historically on their surroundings. New towns included some examples of sociological surveys to assess the needs of skilled workers to be accommodated, for example Leigh Creek South. Private ownership was disallowed generally in company towns and consequently discouraged long term ageing of communities found in the earlier mining town such as Charters Towers (Qld), Broken Hill (NSW), Kalgoorlie (WA), and the copper triangle townships of Burra, Moonta and Kadina (SA).

The development of new communities in arid environments has often involved the imposition of garden city town principles to create something that is not conducive, relevant nor responsive to the arid landscape. In addition services, infrastructure, and building forms more suited to non-arid environments are introduced. This strategy disregards historical precedents and has been compounded with the advent of mining in arid Australia that sought to apply non-arid logic in town, house and landscape design in the 1950s-70s resulting in the transposition of a Canberra suburban model in the Pilbara (including Paraburdoo, Kambalda, Leinster, WA), Moranbah (Qld) and Jabiru (NT). The subsequent fall from grace of the Radburn concept evident in the Canberra model as applied in the Pilbara region highlights the deficiencies in application – namely a lack of facilities in ‘nucleated’ housing areas around a town centre, inappropriately long cul-de-sacs resulting in highly vehicular speeds in a climate unsuited to pedestrian rambles and the imposition of significant infrastructure costs. Table 1 indicates the time frames involved in building remote settlements.

There is an extensive literature, mainly from the 1970s and 1980s, describing the characteristics of mining settlements when the model of ‘transferred suburbia’ was subject to critical debate (Newton & Brealey, 1977; Newton, 1985; Burnley *et al*, 1980; Lea, 1986; Lea & Zehner, 1987; Loveday & Webb, 1989). Sociological studies to assess the needs of skilled workers were undertaken in some cases such as Leigh Creek South (SA) where resident surveys were possible during the planning phase for a town. The majority of planned towns were tightly controlled by the company and dependency within single purpose towns constrained community involvement in governance. The more socially successful towns were able to diversify and serve within a region servicing the needs of pastoral and other businesses, environmental and cultural tourism (Oeser, 1974; Lea & Zehner, 1986).

Table 1: Historical Evolution of Arid – Semi-Arid -- Remote Settlements in Australia (WRR= Woomera Rocket Range)

Years	Western Australia	South Australia	Northern Territory	New South Wales	Queensland	Victoria
Pre-1900	Kalgoorlie Coolgardie Marble Bar Boulder	Port Augusta Maree Lake Harry Kadina Moonta Burra Port Pirie	Alice Springs Hermannsburg	Broken Hill Kambalda I	Birdsville Mount Isa Charters Towers	Mildura
1900-1945		Leigh Creek I Andamooka Coober Pedy Iron Knob	Batchelor	Lightning Ridge		
1945-2000	Dampier, Port Hedland South Hedland Kambalda Shay Gap Pannawonica Paraburdoo Karratha Tom Price Kambalda East & West Leinster Argyle Dam Village	Woomera Village (WRR) Emu (WRR) Koolymilka (WRR) Maralinga (WRR) Iron Knob Radium Hill Whyalla Moomba Leigh Creek South Roxby Downs I, II Monarto (not built) Prominent Hill Village	Yulara Jabiru (Ranger) Nhulunbuy		Mary Kathleen Weipa Dysart Moranbah	

Typological Frameworks

The typology of settlements, their purpose and duration servicing the three sectors of public infrastructure projects, mining company operations and Cold War defence purposes are provided in Table 2. At least thirteen of the settlements were closed to the public and many were demountable and transportable. There is no clear chronological progression of design styles which included a variety of orthogonal, rectilinear plans and Radburn based neighbourhood layouts (Figure 1) (Brealey, Neil & Newton, 1978; Iwanicki (2011).

Wittenoom

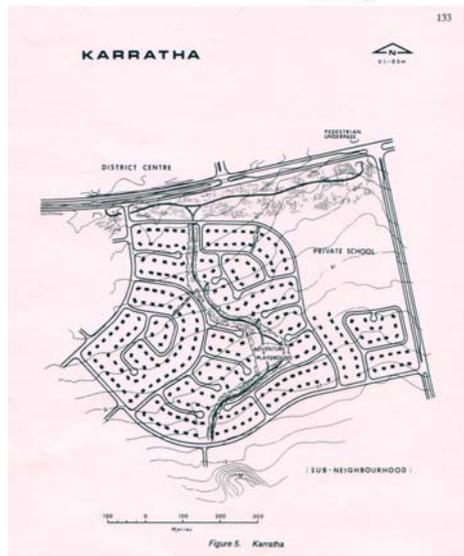
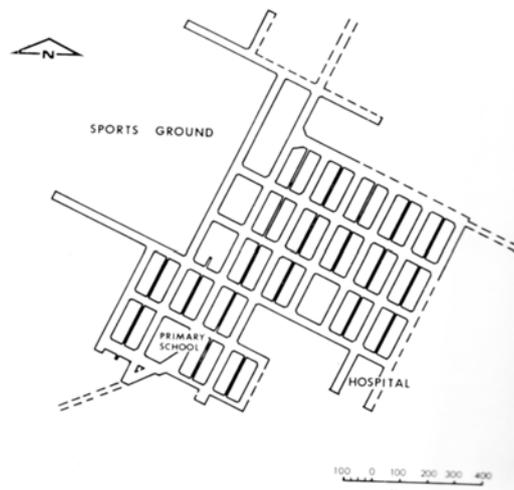


Figure 1 Varied town layout examples of Wittenoom (top), Bulgarra (middle) and Karratha (bottom) (Source: Brealey, T B, Neil, C C & Newton, P. W. (eds) (1988) *Resource communities: settlement and work force issues*, CSIRO)

The distribution and typology of arid settlements is summarised in Table 2.

Table 2 Typological Framework of Arid – Semi-Arid -- Remote Settlements in Australia

Years	Western Australia	South Australia	Northern Territory	New South Wales	Queensland	Victoria
Public Infrastructure Projects	Ord River irrigation scheme	Port Augusta				Mildura
Oil, Gas & Mining Public & Private Company Operations	Dampier Port Hedland South Hedland Kalgoorlie Coolgardie Boulder Kambalda Shay Gap Pannawonica Paraburdoo Karratha Tom Price Kambalda East & West Leinster Argyle Dam Village	Iron Knob Whyalla Moomba Leigh Creek South Roxby Downs I, II Kadina Moonta Burra Leigh Creek I Andamooka Coober Pedy Prominent Hill Village	Jabiru Nhulunbuy	Lightning Ridge Broken Hill	Weipa Dysart Mount Isa Charters Towers Moranbah	
Cold War defence related		Woomera Village Radium Hill Emu Koolymilka Maralonga			Mary Kathleen	
Other Recreation, Pastoral / Agricultural	Marble Bar	Maree Lake Harry Monarto (not built)	Yulara Batchelor Alice Springs Hermannsburg		Birdsville	Mildura

The typology of settlement design, whether formal, informal/organic and consciously planned in Table 3 also demonstrates the volume of mining-related settlements that have been established since World War II.

Table 3 Planning Typologies of Arid – Semi-Arid -- Remote Settlements in Australia

Years	Western Australia	South Australia	Northern Territory	New South Wales	Queensland	Victoria
Pre-planner planned Formal subdivision pattern (SA towns planned on Light/Goyder Parklands model)	Dampier Port Hedland South Hedland Marble Bar Kalgoorlie Coolgardie Boulder	Port Augusta Kadina Moonta Burra Marree Lake Harry	Batchelor Alice Springs	Broken Hill	Mount Isa Charters Towers Birdsville	Mildura
Informal / organic subdivision pattern		Andamooka Coober Pedy	Hermannsburg	Lightning Ridge		
Consciously planned settlements	Kambalda Shay Gap Pannawonica Paraburdoo Karratha Tom Price Kambalda East & West Leinster Argyle Dam Village	Woomera Village Emu Koolymilka Maralinga Radium Hill Iron Knob Moomba Leigh Creek Leigh Creek South Roxby Downs I, II Monarto (not built) Prominent Hill Village	Jabiru Nhulunbuy Yulara	Moranbah	Weipa Dysart Mary Kathleen	
Historical amalgamations of Patterns		Whyalla				

Three examples of consciously designed townships responsive to their arid setting include the earliest modernist settlement of Woomera (SA) (1948), the transitory town of Shay Gap (WA) (1970) and the current planning for a permanent settlement at Roxby Downs (SA) (1982-2000s).

Woomera Village

Nestled in the south eastern corner of the Woomera Rocket Range (WRR) and 500 kilometres north of Adelaide, Woomera Village was planned to accommodate the scientists, technicians and support staff working on WRR projects and their families in 1947-48. The site of the town was selected predominantly because of drainage requirements on the Arcoona plateau and sloped gently to the south east to an encircling creek bed (Figure 1). The Commonwealth Department of Works and Housing team of architects responsible for the design were fully cognisant with international planning theories in 1946 and applied them in responding to the demands of a high security settlement and the intended creation of a ‘model community’. Radburn design aspects incorporated an innovative sewage treatment system of reedbed filtration and ponding east of the town in 1948 and an experimental Arboretum devoted to

trialling and propagation of arid land species for resident gardens and public landscaping. Treated water was distributed via an underground reticulation system to points within the Village where water trucks collected and watered extensive street and perimeter tree plantings to shade and shelter the town.

A management structure was set up to service a ranked military system with an increasing civilian population and govern the town. Ultimate responsibility resided with a military appointed resident Village Superintendent (later Administrator) who had management of the Village and an elected Woomera Board comprising residents and service personnel to manage recreation and other services and advise the Superintendent on village issues.

Attention to community needs encompassed the provision of education, medical, spiritual and physical aspects. Housing allocation was based upon need and status and rents fixed at reasonable levels. The community, although predominantly transient and subject to high security, was well serviced with over seventy clubs, sports, religious and recreational/cultural activities. These were partly funded from facilities managed by the Board and partly by Defence (Iwanicki, 2011). Hailed as an 'oasis in the desert' in its heyday (Garnaut, Johnson & Freestone, 2004), the Village is a casebook of Commonwealth housing designs over its sixty four year history; the most notable including the surviving north orientated two-storey apartment blocks and various detached housing designs many of which have been removed but are extensively documented. Other significant buildings surviving from the period include the Jazza mess complex, the ELDO motel and accommodation blocks, the Woomera 600 seat theatre, hospital and school complex. The Arboretum and public park is located on the edge of the northern perimeter road (Figure 1).

In 1970 the Village became the residential base for the US Nurrungar base nearby and adaptations were made to educational, housing and recreational facilities to accommodate the combined American/Australian population and culture. Retrofitting of apartment blocks and housing has occurred, while many earlier buildings were later demolished, or sold to be relocated at seaside and other rural locations. Significantly, between 1970 and 2000 the USAF bankrolled the maintenance needs of the Village with undergrounding of services, paving and resurfacing roads, refurbishment of many buildings, provision of gymnasias, upgraded infrastructure, and building a new swimming complex and Oasis Centre despite the decline in population.

Now reduced to a third of its maximum size, the Village nevertheless has retained the morphology of its original design. An early advisory Town Plan Committee ensured the plan was adhered to during its building and development. Lessons learnt from this unique settlement over a sixty five period include the importance of landscaping, the desirability of verandahs and shading, orientation of buildings, water treatment, reuse and recycling of buildings, the fostering of community spirit and integration and undesirability of asbestos. Past and present residents continue to identify with the cultural heritage of the place, despite continuing restrictions on allowing property ownership, intergenerational continuity or diversification (Iwanicki, 2011).



Figure 2 (Top)Woomera Village as it was designed (Source: NAA MP 1922/3 NN, Album. The Joint UK-Australia LRWP in Australia, Department of Supply, Commonwealth of Australia, 30 April 1949), (middle) as it was in 1972 and as in 1986 (Source:Mapland). Further removals have occurred since.

Shay Gap

Shay Gap is an early example of clustered housing of organic design, utilisation of colour coding for orientation and the minimisation of connector roads - significant departures from both the basic gridded 1950s town designs and the defining road hierarchy featured in neighbourhood unit design, which came to be the norm during the 1960s.

The WA mining town was designed and established in 1970 in manner referential to Middle Eastern layouts as well as modernist forms for medium density living and responsive to cost constraints as the town was intended to function for 10 year period. An architectural firm Lawrence Howroyd & Associates was responsible for its design for Goldsworthy Mining Limited. Howroyd was critical of mining settlements as being 'the expediency of the familiar - or transferred suburbia' and the over reliance placed on aerial photography for site planning. His belief was that 'a designer should be able to see his product as a space, not linear diagrams on plane surfaces, an architectural truth rarely applied to town planning'.

In response to considerations of personal space and comfort the town was situated on land between two large mesas consistent with the theory that a variation of two storey buildings, reflective roofs, and volumetric air changes in combination with the location between two radiating mesas would accentuate air turbulence to the comfort of residents (Figures 3 and 4). Difficulties in providing services were overcome by using underground PVC conduits in a common trench; an umbilical cord terminating in a concrete block at each building site.

Based on a prototype that could be built in a day, the dwellings for family accommodation were flat-roofed structures clustered close together for shelter from sun and wind. Two walled courtyards in each dwelling were shaded at different times of the day by the overhang of the upper level on one side, and shade from the neighbouring building on the other. Courtyards were fenced with a 'transparent' screen wall; namely a screen of angled timbers making it possible to see out while providing privacy. Connector roads were eliminated and dedicated play areas for children were considered unnecessary; for without roads and traffic, children had 'play spaces galore'. Cost savings were achieved by eliminating internal road layouts or street numbers in residential areas beyond a circular road. Housing precincts were identified by geometric shape and colour with centralising services such as the public hall, library, and community workshop in the design of the school, whose classrooms were designed to be interchangeable with theatre functions (Howroyd, 1974; Brealey, Neil & Newton, 1988).

The town's siting, infrastructure and housing design appeared to have been an effective response both environmentally and economically. There is however, no tangible evidence of the effectiveness of the design and social planning upon community morale, given the transience of the settlement.

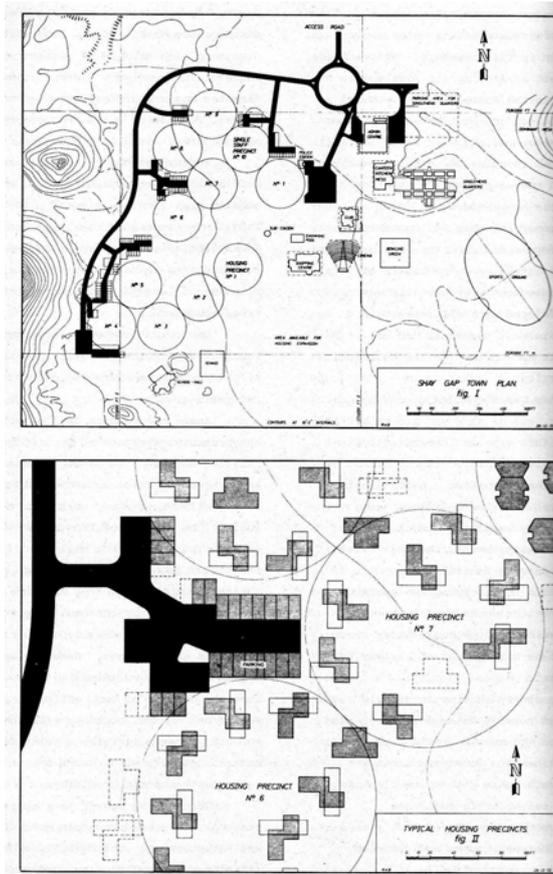


Figure 3: Plan of Shay Gap (Source: Howroyd, Lawrence R, 'Shay Gap', *Architecture in Australia* June 1974.

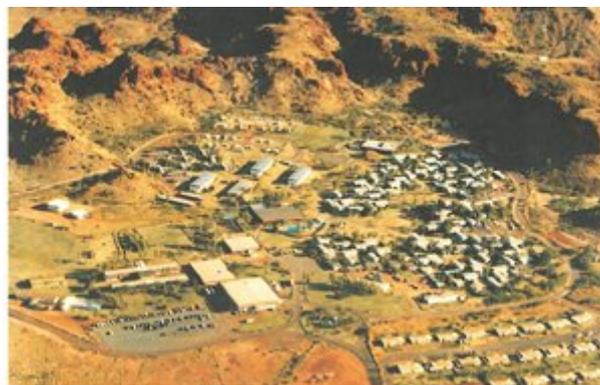


Figure 4: an oblique photo of Shay Gap

(Source:

[http://www.google.com/imgres?um=1&hl=en&sa=N&biw=1181&bih=654&tbn=isch&tbnid=d33GS1BoI0bD\)GM:&imgrefurl=http://abc.net.au/local/audio/2010/08/16/2984088.htm&docid=4xqzAJpDpl9tBM&imgurl=http://www.abc.net.au/reslib/201008/r620462_4160857.jpg&w=340&h=191&ei=XBt5T7vuN_GXiAeZjdXLCA&zoom=1&iact=rc&dur=574&sig=109257988593121693731&page=1&tbnh=108&tbnw=192&start=0&ndsp=15&ved=1t:429,r:0,s:0&tx=116&ty=39](http://www.google.com/imgres?um=1&hl=en&sa=N&biw=1181&bih=654&tbn=isch&tbnid=d33GS1BoI0bD)GM:&imgrefurl=http://abc.net.au/local/audio/2010/08/16/2984088.htm&docid=4xqzAJpDpl9tBM&imgurl=http://www.abc.net.au/reslib/201008/r620462_4160857.jpg&w=340&h=191&ei=XBt5T7vuN_GXiAeZjdXLCA&zoom=1&iact=rc&dur=574&sig=109257988593121693731&page=1&tbnh=108&tbnw=192&start=0&ndsp=15&ved=1t:429,r:0,s:0&tx=116&ty=39)

Roxby Downs

Situated in the arid zone of northern South Australia (SA), Roxby Downs was originally developed by Western Mining Corporation (WMC) to accommodate their workers and their families involved in the Olympic Dam uranium mining project. The mine and town – comprising *Mark 1* -- were established through the *Roxby Downs (Indenture Ratification) Act 1982*, with subsequent amendments in 1996 – comprising *Mark 2* – by the SA state government, and Kinhill-Stearns Roger undertook the preparation of the *Olympic Dam Project Draft Environmental Impact Statement* (Kinhill-Stearns Roger 1982) on behalf of Roxby Management Services Pty Ltd for the overall project.

In preparing the brief for a new settlement to service Olympic Dam, WMC consciously determined to vary from the traditional fly-in fly-out mining settlement model to adopt a permanent settlement model. Their aim was to service a perceived production capacity of 150,000 tonnes per annum of copper, a permanent on-site workforce of 2,400 with an additional 700 supporting services and government staff. This scenario gave rise to a proposed town of 8,000-9,000 residents supporting 3 pre-schools, 3 primary schools, 1 high school together with associated library, hospital, government services, commercial facilities, recreational facilities resulting in a in overall land reservation “to accommodate an ultimate population of 30,000” (BHP Billiton 2009: 11-2). With this scenario in mind, WMC commenced planning evaluation studies to identify a feasible town site. Interestingly, at this feasibility stage, WMC consciously expressed a “conceptual design” that paid attention “to the effects of climate and to the preservation of vegetation and sand dunes at the town site” (Kinhill Stearns 1982: 2-63; BHP Billiton 2009: 11-2;).

In investigating sites for a town associated with the Olympic Dam venture, 6 sites were considered adjacent to the mine (Table 4). The requisite given by WMC to the principal director and engineer Brian Mackay of Kinhill was to create “a typical South Australian country town or a suburb of Adelaide” in character, image, services and quality of lifestyle “to encourage people to stay” but which was “relevant and responsive to the arid environment” it was to be situated within. Mackay saw the planning in three threads – social planning, engineering, and economic – and correctly perceived engineering as the most important in determining a successfully structure for the town and informing the road and drainage networks (Mackay pers. comm. 2005). By 1997 the re-named WMC Resources had decided to double the mining operations and commissioned a feasibility study and EIS as prepared by Kinhill Engineers (KBR 1997). This EIS validated the existence and role of Roxby Downs as servicing the mining operations but also proposed extensions to the town to the south and east that enabled a different town character to evolve. This was an important shift in the urban design philosophy of the town resulting in what can be termed the *Mark 2* expansion of the town. *Mark 1* town was seen as rotating from a central lineal core, with relatively standard typical Adelaide allotment sizes, curvilinear road patterns, conservation of significant Western Myall (*Acacia papyrocarpa*) trees, overall road and house construction and planting by WMC in a co-ordinated manner, and a single storey environment set within a parkland setting. *Mark 2* in contrast sought a much lower density, a set of subdivision estates that were further from the central core, varied allotment sizes, varied and more sweeping road patterns and introduced roundabouts, varied the logic of the parkland setting to one of a much more open landscape setting, and enabled individual builder developments in an estate that was constructed by WMC. Thus, the philosophical character of *Mark 2* developments was much different than *Mark 1* and today is aesthetically different in terms of the appearance of density and housing form (Kinhill Engineers 1997).

Table 4: Original Planning Decision Matrix for the Selection of a Site for Roxby Downs

	Amount of Land Amenable to urban development	Impact of town location on land severance of adjoining pastoral properties	Proximity to existing services corridor	Ease of construction of urban facilities	Flood-prone areas	General amenity	Horticultural aspects
1 Lake Blanche	@1,600ha	Severance problems	Poor location	Reasonable ease of construction	Least disadvantaged	Abundant treed dune landscape; grazing damage evident	Better placed for horticultural activities
2 Myall Dam West	@1,600ha	Severance problems	Poor location	Reasonable ease of construction	Minimal	Saltbush chenopod landscape	
3 Myall Dam East	@ 2,000ha	Severance problems	Poor location	Reasonable ease of construction	Minimal	Saltbush chenopod landscape	
4 Axehead Dam	@ 2,000ha	Least impact	Best location	Reasonable ease of construction	Least disadvantaged	Abundant treed dune landscape	Better placed for horticultural activities
5 Phillips Ridge	@700ha	Least impact	Best location	Steepness of dunes	Excessive areas of depressed land	Abundant treed dune landscape; grazing damage evident	
6 12 Mile Dam	@2,000ha	Severance problems	Poor location	High rock horizon	Least disadvantaged	Gibber plain landscape	

On 1 September 2005 WMC Resources was officially acquired by BHP Billiton, and BHP Billiton has been proceeding to enable the expansion of the Olympic Dam and has determined that the fly-in-fly-out strategy is inappropriate wishing to create a quality residential environment adjacent to the mine for its employees and service contractors (Roxby Downs Act; Wilson 2005: 9).

BHP Billiton prepared the *Olympic Dam Expansion Environmental Impact Statement* (EIS) (BHP Billiton 2009), and with associated public consultation processes, prepared the *Olympic Dam Expansion Supplementary Environmental Impact Statement* (SEIS) (BHP Billiton 2011) as a response to public and private representations, including questions about the expansion of Roxby Downs and the proposed new Hiltaba village.



Figure 4: c.2005 aerial photo of Roxby Downs. Source: by permission of the Roxby Downs Town Council

Lessons and Directions

This discourse has reviewed the planning and design approach employed in contemporary arid zone settlement design in Australia. The three examples offer aspects of responsive design for small temporary, medium and larger arid settlements that are relevant to contemporary arid planning.

Common aspects shared by the 1947-48 Woomera Village (SA), the 1970's Shay Gap (WA) and the 1980s-2000 Roxby Downs (SA) town and extensions include attention to landscape character, soils, climate and vegetation. Howroyd's point that the designer should engage fully with the landscape in a three dimensional, physical and social sense reinforces the philosophy of McHarg's *Design with Nature* (1969). Landscaping and infrastructure responses include working with the environment through sustainable water use and arid species selection, cutting costs through the co-location of services and facilities and improved accessibility in design of streets and movement systems. Design responses to accommodate a level of liveability provide lessons in how to approach landscaping and provide efficient, deliverable and accessible housing that is reusable in different locations.

Through the far-sighted work of Albert Morris – the 'father' of arid zone rehabilitation science – in establishing fenced regeneration areas or *shelter belts* including local native species, around Broken Hill (NSW) from 1936, the dust problem gradually abated and greatly improved the quality of life for residents (Jones 2010). This desert reclamation was successful and demonstrated the value of growing appropriate arid zone native species. Over the years the lessons learnt have been effectively applied in many other arid zone communities. Indeed, the mining industry, often accused of environmental damage, was

instrumental in the greening of many arid zone towns long before landcare and the environment became popular causes.

At Woomera, the first Commonwealth experimental and propagation Arboretum in the arid lands was established under the direction of the Commonwealth Arboriculturist A.B. Patterson. Patterson's first known botanic survey of the surrounding landscape, sourcing of suitable plant species from other places and knowledge of Morris' work in Broken Hill ensured that Woomera Village was the first of a number of post-war remote settlements that gave priority to designing, propagating and establishing landscaping to benefit the residential environment. As in Broken Hill there was considerable trial and error. Kambalda (WA) was noteworthy in that existing trees and shrubs were carefully protected during town construction and incorporated into the landscape of the new town. Such knowledge was also applied in the design of Leigh Creek South (SA) in 1979-1982 for ETSA to accommodate staff and families working on the Leigh Creek coal mines. Completed in 1985, the town was proposed to accommodate 2,000 residents but has dropped to 600 recently. Following completion the town attracted design awards as being "an excellent example of arid zone town planning, incorporating effective water conservation techniques, whilst maintaining a high standard of public landscaping" (Wren 1987). The model also informed the rationale of the *Development Guide for Arid Areas in South Australia* (den Ouden & Chandler 1983), around which water sensitive landscape design treatments were identified as essential. This rationale was more extensively detailed by Jones & Zwar in 'Water Conservation and Arid Landscape Design' (2003). This approach has subsequently been successfully undertaken at other new arid zone towns including Olympic Dam Village (SA) and Roxby Downs (Zwar 2004), Leinster (WA), and has been incorporated in proposed extensions to Roxby Downs and the new Hiltaba village (SA) (ARUP *et al* 2009).

The history of remote mining ventures suggest that governance and economic structures encouraging a resilient sense of community ownership and identity, capacity to diversify at a regional level and create intergenerational employment warrants consideration (UNESCO, 1973, Oeser, 1974; Loveday & Webb, 1989; Beer & Pritchard, 2003; Genoff, 2010).

Future planning directions to address the trend for more extreme climatic conditions could learn from the examples above and incorporate:

- a more robust appreciation and comprehension of environmental conditions especially water and dust minimization and the enhancement of shade and vegetation growth;
- a need to ensure integrated environmental, social and cultural aims and outcomes in settlement design and planning;
- careful attention to dust minimization and flash flood management;
- environmentally sensitive housing design; capable of relocation and reuse options
- spatial design configurations that support community activities and interactions without compromising privacy; and
- ensure robust family facilities and services where non-fly-in fly-out work arrangements are employed

Woomera's arid planning and design strategies successfully established a landscaped environment and a village community despite the extremely variable population influxes and shifts in the village due to defence planning decisions. The plan accords with the above conclusions.

Shay Gap (WA) presents an alternate perspective on Australian arid zone design and planning as it draws reference to the intense Middle Eastern and Mediterranean village plans where intensity, communality, and very careful conservation and manipulation of light, shade and water was successfully achieved. Socially it resulted in different outcomes pointing to the effectiveness of a community building as a community and behavioural focal point lacking in the original village plan (Howroyd & Coleman, 1988)

In terms of Roxby Downs (SA), demonstrably the design hypothesis employed has repeatedly proven its worth and foresightedness. Such hypothesis was lost when KBR, without continued engagement of and consultation to Mackay, sought to design *Mark 2*, but has been re-awakened in the Hassell proposal for *Mark 3*. This ‘desert oasis’ strategy, directly responsive to the east-west dunal ecology, captures the essence of Ian McHarg’s (1969) ecological determinism theory embodied in *Design for Nature* that was expressed in the conceptual design for Monarto in 1972. Monarto Development Corporation (MDC) staff and consultants consciously applied McHarg’s thesis in the formulation of their conceptual design for Monarto, a future semi-arid settlement to host some 500,000 residents, and a unique architectural ethos was also devised by the MDC for which architect Philip Cox latter successfully appropriated in his acclaimed Yulara village (NT) design and building assemblage. Such was also carried forth in the Leigh Creek South (SA) exemplar for which the original Roxby town design was benchmarked against in terms of its environmental setting and social-physical design.

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