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UPPER FLINDERS RIVER IRRIGATION PROPOSAL

By

E. J. Turner and K. K. Hughes

QUEENSLAND
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Queensland Government Technical Report

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UPPER FLINDERS RIVER
IRRIGATION PROPOSAL

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SUMMARY

The irrigation potential of the Flinders River region was assessed by a reconnaissance survey at 1:250 000. The survey indicates the brown and grey cracking clays of the Mitchell grass plains have some potential for irrigated crop production. The massive red and yellow earths of the Baronta plateau have only limited potential for irrigated horticultural tree crop production. Areas which may be considered for future detailed soil surveys include the open Mitchell grass plains (i) between 'Koonkool' and 'Glentor Downs' (ii) south west of Hughenden and (iii) the Jardine Valley.

Intensive research is essential before the proposal is recommended or promoted. Detailed soil surveys at 1:25 000 of selected lands are necessary to characterise the soils. Geohydrological studies, agronomic and irrigation research and the establishment of pilot farms are essential to both understand the environment and evaluate the consequences of irrigation in this tropical semi-arid environment.

Marketing studies together with an economic investigation of the overall scheme are warranted to establish priorities on a State wide basis.

1. INTRODUCTION

Interest in Bradfield's concept of 1938, which involved the interbasin transfer of coastal river waters over the Great Dividing Range, was again revived during 1982/83. This water was originally intended for recharging the aquifers of the Great Artesian Basin and to provide some measure of drought protection to the pastoral industry in western Queensland.

Recent interest centred on using these coastal waters for an inland irrigation scheme. Preliminary studies showed the scheme was physically possible but the capital and operating costs were extremely high and compared very unfavourably with other established and proposed schemes in Australia.

A modified irrigation scheme was then proposed, which involved the damming of the Flinders River and irrigating riparian lands. A reconnaissance survey of land which could be commanded by a dam on the Flinders River at 'Glendower', Prairie was undertaken to assess the irrigation potential of the region.

The survey relied to a great extent on aerial photograph interpretation, with limited field sampling.

This report presents the findings of the survey and includes recommendations for future studies associated with the proposal.

2. PHYSICAL ENVIRONMENT

2.1 Climate

The climate of the area is tropical arid to semi-arid, and is characterised by a concentration (approximately 80%) of rainfall during the warmer months of October to March.

Median monthly rainfall data for Hughenden and Torrens Creek are given in Table 1.

Table 1 Median monthly rainfall (mm).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Hughenden	101	77	38	7	3	10	1	0	2	10	25	47	489
Torrens Creek	93	97	38	12	6	13	1	1	0	12	20	66	497

* Source: Bureau of Meteorology

Rainfall variability. The incidence of rainfall depressions associated with tropical cyclones and the convective origin of much of the inland rainfall contributes to high rainfall variability. Droughts are a feature of this environment. Rainfall values equalled or exceeded in one in ten years, five in ten years and nine in ten years, for Torrens Creek, are given in Table 2.

Table 2 Specified rainfall (mm).

Probability	J	F	M	A	M	J	J	A	S	O	N	D	Annual
10%	258	313	170	90	60	56	47	23	52	62	112	181	929
50%	93	97	38	12	6	13	1	1	0	12	20	66	497
90%	24	7										9	266

* Source: Bureau of Meteorology

Rainfall seasonality. Rainfall in the summer months from December to March exceeds 70% of the annual average with the months of January and February recording the highest values. Rainfall declines during April and May, increases slightly in June and decreases to a minimum in August and September. Thunderstorm activity is common over the basalt plateaux to the north and north-east of Hughenden, where, on average, 40 to 60 thunderdays are experienced each year, mainly in late spring and summer. Thunderstorm activity results in increased rainfall during October.

Low rainfall, high variability and seasonality severely limit dryland agricultural activities in this region.

Temperature. Temperature data for Hughenden are given in Table 3.

Table 3 Hughenden - temperatures.

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Av. max. ^{o}C	36.3	35.1	33.8	31.7	28.1	25.0	25.1	27.5	31.4	34.9	36.3	37.4	31.9
Av. mean ^{o}C	29.1	28.2	26.8	24.0	20.3	17.4	16.0	18.7	22.4	26.1	28.1	29.5	24.0
Av. min. ^{o}C	21.9	21.3	19.9	16.3	12.4	9.8	8.1	9.8	13.4	17.3	20.1	21.5	16.0
Av. number days													
max. 32^{0} or more	26.5	22.6	22.8	13.5	1.2	0.2	0.2	1.4	10.2	25.4	27.4	28.0	179.4
max. 38^{0} or more	8.7	6.5	1.3						0.1	5.5	11.7	12.3	46.1
min. 0^{0} or less						0.1	0.2						0.3

* Source: Bureau of Meteorology

Heat wave conditions are common, commencing in September and peaking in November and December. Mean monthly minimum temperatures are lowest in July, and frosts are generally light and infrequent.

Humidity. Average relative humidity for Hughenden is given in Table 4.

Table 4 Average relative humidity (%).

	J	F	M	A	M	J	J	A	S	O	N	D	Year
9 a.m.	55	59	57	52	54	60	56	47	42	36	38	44	50
3 p.m.	33	37	35	29	31	37	32	26	24	22	22	28	30

* Source: Bureau of Meteorology

Lowest 9 a.m. humidities occur from September to November and then steadily increase through December. The movement of the 3 p.m. readings parallels the 9 a.m. values.

The combination of high temperatures and low relative humidities result in high potential evaporation rates and low effective rainfall.

Wind. Wind direction is north east to south east for most of the year, with a more southerly component in surface wind direction evident during the winter months.

Evaporation. Estimates of average evaporation rates for Hughenden are given in Table 5.

Table 5 Estimated average evaporation (mm).

J	F	M	A	M	J	J	A	S	O	N	D	Annual
254	203.2	203.2	152.4	152.4	114.3	114.3	139.7	190.5	228.6	254.0	279.4	2 286

* Source: Department of National Development

There is a pronounced trough from April to September with a peak in December. The lowest values occur in June and July. At Hughenden, annual precipitation is exceeded by evaporation by approximately 3.6:1.

Moisture deficits. Estimates of monthly moisture deficits given in Table 6 are made by comparing monthly crop evapotranspiration* (Et) to median monthly rainfall.

Table 6 Monthly moisture deficits (mm).

	J	F	M	A	M	J	J	A	S	O	N	D
Rainfall	101	77	38	7	3	10	1	0	2	10	25	47
Et	203	162	162	121	121	91	91	111	152	182	203	223
Deficit	102	85	124	114	118	81	90	111	150	172	178	176

* Et = 0.8 x E est.

The data clearly indicate there is insufficient moisture in any one month to support agriculture without supplementary irrigation.

2.2 Geology

The geology of the region has been described by Vine and Paine (1974) while studies on surficial geology and geomorphic evolution of the area through the late Cainozoic have been reported by Coventry (1979, 1982).

The gently dipping Permian and Triassic sedimentary rocks of the Galilee Basin outcrop east of Burra. Generally, these rocks are masked by an extensive Cainozoic cover of unconsolidated sediments. In the west, the Galilee Basin sediments are overlain by the Jurassic and Cretaceous rocks of the Eromanga Basin, which forms part of the Great Artesian Basin.

The geological units occurring in the survey area include:

- Quaternary alluvia. Alluvial deposition is mainly associated with the Flinders River and to a lesser extent, with Skeleton, Prairie and Bullock Creeks.

- Post Miocene sediments.
  (a) Unconsolidated sediments occur on the Baronta plateau and consist of sheet deposits which mask the underlying geology.
  (b) Basalt flows overlie Cretaceous beds north of Hughenden. These areas remain relatively intact as plateaux.

- Cretaceous sediments. Weathering and erosion of these argillaceous sediments have produced the gently rolling Mitchell grass plains.

2.3 Landforms

Three major landforms or landscape units occur in the region.

2.3.1 Alluvial plains

This constructional landform of recent alluvium consists of both active and prior streams and broad interchannel areas. The soils comprise grey clays and sandy solodics on the interchannel areas and back plains, with deep sands and gravels on prior streams and levees and underlying the interchannel soils. Scalding is extensive and gully erosion prominent locally.

2.3.2 Plains

This mature erosional landform of gently undulating plains has formed on Cretaceous sediments. Mitchell grass open tussock grassland predominates, with minor areas of gidgee and boree open woodland fringing the upper slopes and scarp retreat zones.

2.3.3 Plateaux

This erosional landform of gently sloping plateaux is derived from terrestrial deposits and supports eucalypt open woodland and spinifex. The western sector, between Skeleton Creek and Bullock Creek displays an intricate network of shallow, anastomosing, treeless, clay drainage depressions with a north north west - south south east orientation. These drainage depressions represent the braided channels of a former flood-out area of the Flinders River. Small, isolated basalt outcrops occur west of Prairie Creek and also between the Baronta scarp and Skeleton Creek. These outcrops represent the eroded remnants of volcanic plugs or flows.

Basalt plateaux also occur, north of the Flinders River. They have not been considered in this survey due to the extensive and dense cover of basalt boulders and rocks.

Each major landform was mapped into its component units, each of which displayed a unique combination of geology, soils and vegetation. These individual mapping units (map 1) provided the basis for assessing the irrigation potential of the region.

2.4 Hydrology

Surface hydrology. The survey area comprises two major catchments. The Flinders River with its headwaters in the Great Dividing Range, drains into the Gulf of Carpentaria. Bullock, Prairie and Skeleton Creeks on the Baronta plateau are the headwaters of the Thomson River system which eventually drains via Cooper Creek into Lake Eyre. Stream flow in all cases is highly seasonal.

Subsurface hydrology. The north eastern part of the Great Artesian Basin underlies the survey area. The sandstones of the Jurassic to early Cretaceous sequence are the most commonly tapped aquifers. The sandy alluvium of the Flinders River and Porcupine Creek has also been tapped by sand spears to supply stock water. A bore on the Flinders River is currently licenced for limited irrigation supplies.

3. SOILS

3.1 Survey Methodology

A reconnaissance survey with a mapping scale of 1:250 000 was chosen as the only practical approach to compile an inventory of the physical resources of the region. Black and white aerial photographs at 1:25 000 were examined to plan traverses and soil sampling sites. Areas obviously unsuited to cropping, due to topographic or other limitations, were excluded from the assessment. The boundaries of the survey area were not rigidly defined. On the Baronta plateau, the Flinders Highway and Bullock Creek were taken as the southern and eastern boundaries respectively. On the plains, the boundary was extended to some 20 km either side of the Flinders River, so the clay soils derived from all the mudstone sediments occurring in the region, could be assessed.

3.2 Soil Profile Classes

Soils were examined and described at 130 sites and 63 representative soil profiles were selected for chemical and physical analysis. The soils were grouped into 15 soil profile classes based on morphological descriptions and analytical results. Soil profile classes are groupings of soils such that the variation in certain profile features within the group is much less than the variation between the groups. In general, each soil profile class is restricted to one major landscape unit (Tables 7, 8). The soil profile classes, together with geology and vegetation provided the basis for mapping each landscape unit into its components (map 1). One soil profile class usually dominates each of these unique mapping units or land resource areas.

The suitability for irrigation of these individual land resource areas, based on an evaluation of component soil profile classes, is shown on map 2.

The major distinguishing features of the soil profile classes are given in Table 7, while the location of soil sampling sites is shown on map 1.

3.3 Land Use Potential

The land use potential for a region can be gauged by either land capability classifications or by crop-soil suitability assessments for either specific soils or specific crops. Neither of these methods ranks soils on potential yield differences but rather the soils are assessed on their inherent limitations to sustained agricultural production.

TABLE 7 MAJOR DISTINGUISHING FEATURES OF THE SOIL PROFILE CLASSES

SOIL PROFILE CLASS	MORPHOLOGICAL FEATURES	PPF*	GREAT SOIL GROUP	LANDFORM
Strathglass	Shallow to deep, self-mulching black cracking clays with basalt rocks on and in profile. Linear gilgais. Alkaline soil reaction trend.	Ug5.12	Black earth	Baronta plateau. Weathered basalt knolls. Slopes 1-4%.
Bullock Creek	Shallow (40-60 cm) gritty fine sands. Dense ironstone nodular layers at shallow depths. Slightly acid profiles.	Gn2.81	Grey earth	Baronta plateau east of Bullock Creek. Slopes 0-2%.
Penrice	Moderately deep (60-120 cm) fine sands to loamy sands. Ironstone nodular layers and mottling at depth.	Uc5.22 Gn2.21	Yellow earth (sandy)	Baronta plateau. Slopes 0-1%.
Karoon	Moderately deep (80-120 cm) sandy loams. Abundant ironstone nodules, mottling at depth.	Gn2.22 Gn2.25	Yellow earth (loamy)	Baronta plateau. Slopes 0-1%.
Glendower	Shallow to deep (45-120 cm) loamy sands. Ironstone shot throughout. Quartz pebbles at depth. Basalt rock remnants (outcrops).	Gn2.12 Gn2.42 Dr3.22	Red earth (sandy)	Baronta plateau. Slopes 0-1%.
Blantyre	Deep (> 120 cm) sandy loams to sandy clay loams. Ironstone shot throughout.	Gn2.12	Red earth (loamy)	Baronta plateau. Slopes 0-1%.
Coolibah	Moderately deep (90-120 cm) brown cracking clays. Mudstone outcrops, ironstone, quartz pebbles and rocks on surface. Incipient gilgais.	Ug5.31 Ug5.32	Brown clay	Wooded Mitchell grass plains. Slopes 1-3%.
Mt. Devlin	Deep (> 120 cm) brown and grey cracking clays. Stone cover of silcrete, conglomerate. Gravel layers. Incipient gilgais. Strongly alkaline profiles.	Ug5.32 Ug5.21	Brown and grey clays	Gidgee plains. Slopes 1-5%.
Ellington	Shallow brown (5-10 cm) non-cracking clays. Limestone rocks on surface.	Uf6.31	No suitable group	Timbered ridges on clay plains. Slopes 2-5%.
Sussex	Moderately deep to deep (90-120 cm), strongly self-mulching brown and grey cracking clays. Alkaline throughout. Overlie weathered mudstone, shale.	Ug5.32 Ug5.22	Brown and grey clays	Mitchell grass plains. Slopes 0-3%.
Nicoleche	Shallow (< 60 cm) brown self-mulching clays. Alkaline profiles. Mudstone outcrops.	Ug5.31	Brown clay	Crests in Mitchell grass plains. Slopes 4-7%.
Glenmoan	Deep to very deep (> 120 cm) layered sands. Gravel layers.	Uc1.23 Uc5.21	Alluvial soils	Infilled channels of Flinders River alluvium.
Rosevale	Brown duplex soils with loam to clay loam A horizon. Hard setting surfaces. Alkaline soil reaction trend. Extensive permanent scalding.	Db1.15 Db1.43	Solodic soils	Flinders River alluvium.
Mt. Beckford	Deep self-mulching grey clays. Alkaline profiles. Gravel layers. Overlie sand beds.	Ug5.35 Ug5.24	Brown and grey clays	Flinders River alluvium.
Fernlees	Deep self-mulching grey clays. Alkaline profiles. Frequently gilgaied. Ironstone, quartz pebbles on surface.	Ug5.24	Grey clays	Baronta plateau. Ancient Flinders River alluvium.

* Principal profile form.

TABLE 8 SUMMARY OF SOIL PROPERTIES AND IRRIGATED LAND CAPABILITY CLASSES

LANDSCAPE UNIT		BARONTA PLATEAU							PLAINS						ALLUVIUM (FLINDERS RIVER)		
GREAT SOIL GROUP		BLACK EARTH	GREY EARTH	YELLOW EARTH		RED EARTH		GREY CLAY	GREY AND BROWN CLAYS						SOLODIC	GREY CLAY	ALLUVIAL SOIL
SOIL PROFILE CLASS		STRATHGLASS	BULLOCK CK.	PENRICE	KAROON	GLENDOWER	BLANTYRE	FERNLEES	ELLINGTON	NICOLECHE	MT. DEVLIN	COOLIBAH		SUSSEX	ROSEVALE	MT. BECKFORD	GLENMOAN
MAPPING UNIT OCCURRENCE		T5	T3	T2,3		T1,2,6		A2	P2	P3	P6	P5		P1,3,4	A1	A1	A1
Soil Factors	Depth	2	3	2	1	1	1	1	4	3	1	2		2	4	1	1
Affecting	Surface crust	-	3	3	3	3	3	-	3	-	-	-		-	3	3	3
Irrigation	Soil variability	-	3	4	4	3	3	4	-	-	-	-		-	4	4	4
Suitability*	Surface texture	-	2	2	-	2	-	-	-	-	-	-		-	-	-	3
	Salinity	-	-	-	-	-	-	3	-	-	3	3		3	-	-	-
	Sodicity	-	-	-	-	-	-	3	-	-	2	2		2	-	-	-
	Topography	4	2	2	2	2	2	1	4	4	3	2		3	1	1	1
	Rockiness	5	-	-	-	-	-	-	4-5	5	4	3		-	-	-	-
	Microrelief	2	-	-	-	-	-	2	-	-	2	1		1	-	-	-
	Wetness	-	-	-	-	-	-	3	-	-	-	-		-	-	2	-
	Erosion	3	4	4	4	4	4	2	3	4	3-4	3		3	4	2	4
	Other Factors		Dense ironstone nodular layers. Poorly drained. Pan development likely. Subject to wind erosion. Nutrients easily leached. Very low water holding capacity. Fernlees SPC interspersed throughout.			Ironstone nodules. Freely drained. Pan development likely. Subject to wind erosion. Nutrients easily leached. Very low water holding capacity.		Seasonal flooding. Workability, trafficability problems.	Value as shade areas for stock, and gravel reserves.	Value as shade areas for stock, and gravel reserves.	Salinisation likely downslope.	Value as shade areas for stock, and gravel reserves. High gypsum levels at depth.		Salinisation likely downslope. Good water holding capacity. High levels of gypsum at depth.	Severely scalded. Very shallow A horizons. Gravel layers. Poorly drained. Poor infiltration.	Overlie sand and gravel beds. Surface ponding. Very limited, highly fragmented area.	Massive structure. Very limited, highly fragmented area. Presently extensively eroded.
	Irrigated Land Capability Classification	5 Unsuitable	4	4 Suitable with severe limitations	4	4	4	5	5 Unsuitable	5	4 Suitable with moderate / severe limitations.	3		3	5	5 Unsuitable	5
	Possible Crops	n/a	Horticultural tree crops. Mangos, avocados, lychees, macadamias, citrus with grassed inter-row areas.					n/a			Field crops. Grain sorghum, wheat, cotton, oil seeds.					n/a	

* Based upon values in Irrigated Land Capability Classification in Appendix 1.

<u>Land capability classification.</u> These are broad assessments of an area's potential for general arable agriculture. This scheme lacks in not considering specific crop-soil interactions, but it is still useful in land use planning at the regional level.

The irrigated land capability classification used in this report is given in Appendix 1. Five classes are considered:

Class 1. Arable. Suitable for irrigation with no or few limitations.
Class 2. Arable. Suitable for irrigation with slight limitations.
Class 3. Arable. Suitable for irrigation with moderate limitations.
Class 4. Arable. Suitable for irrigation with severe limitations.
Class 5. Non-arable. Unsuitable.

The evaluation of the 15 soil profile classes based on this classification is given in Table 8.

<u>Crop-soil suitability assessments.</u> Specific crop - mapping unit suitability assessments, based on an evaluation of the dominant soil profile class occurring within each mapping unit, are given in Table 9.

The soil properties which may cause management problems include:

- Soil chemical properties. Sodicity, salinity and general fertility.
- Soil physical properties. Surface crusts, soil structure and effect on germination, clay percentage, pan development.
- Soil water related properties. Impeded internal drainage, low water holding capacities, shallow water tables.
- Topographic limitations. Length and gradient of slopes, susceptibility to erosion. Gilgais. Drainage line densities.
- Stoniness.
- Soil variability and effect on crop selection/management and irrigation management.

In general, Table 9 indicates the cracking clay soils of the Mitchell grass plains are moderately suitable for irrigation of field crops while the massive earths of the Baronta plateau, although highly erodible, may be suited to trickle or spray irrigation of horticultural tree crops, provided large continuous areas are available.

Little is known at this stage of the possible crops, agronomic practices, irrigation needs and methods, salinisation potential and specifications for soil conservation works in this tropical semi-arid environment. Research into these and other aspects will be required before the implementation of any scheme, if future problems are to be minimised or even avoided.

TABLE 9 SPECIFIC SOIL LIMITATIONS, POSSIBLE CROPS AND MANAGEMENT NEEDS UNDER IRRIGATION OF MAPPING UNITS OF FLINDERS RIVER REGION

MAPPING UNIT	IRRIGATION SUITABILITY	SOIL LIMITATIONS	POSSIBLE CROPS	MANAGEMENT NEEDS
A1	Not suitable	High soil variability. Extensive scalding. Impeded drainage.	--	--
A2	Not suitable	Gilgaied, water ponding. Seasonally flooded. Moderate soil variability. Sodic beyond 30 cm. Very low to low fertility.	--	--
P1	Suitable with moderate limitations	Erosion potential. Stone outcrops on crests. Strongly sodic beyond 60 cm. Often saline beyond 90 cm. Low phosphorus, nitrogen, organic carbon levels.	Cotton, wheat, oil seeds, grain sorghum.	Waterway stabilisation and crop establishment may be difficult. Contour banks, grassed waterways essential for erosion control. Furrows to be of low gradient, draining into grassed waterways. Upper limit of cropping at 2%. Soil workability.
P2	Unsuitable	Very shallow soils.	--	--
P3	Suitable with moderate limitations	Erosion potential. Stone outcrops on crests. Strongly sodic beyond 60 cm. Often saline beyond 90 cm. Low phosphorus, nitrogen organic carbon levels.	as for P1.	as for P1.
P4	Suitable with moderate limitations	Erosion potential. Basalt knoll remnants (Koonkool). Drainage line densities (Mt. Agnes). Strongly sodic beyond 60 cm. Often saline beyond 90 cm. Low phosphorus, nitrogen, organic carbon levels.	as for P1.	as for P1.
P5	Suitable with moderate limitations	Erosion potential. Rock outcrops. Occasionally sodic by 90 cm.	as for P1.	as for P1.
P6	Suitable with severe limitations	Erosion potential. Dense stone cover. Gilgais. Termites. Strongly sodic by 60 cm. Saline beyond 90 cm. Low nitrogen, organic carbon levels.	as for P1.	as for P1. Stone picking.
T1	Suitable with severe limitations	Erosion potential. Basalt outcrops. Soil variability. Surface crusts. Ironstone nodule layers. Low plant available water. Massive structure. Pan development likely. Very low nutrient levels, termites, ant hills.	Horticultural tree crops: mangoes, avocados, citrus, lychees, coffee, macadamias.	Suitable for trickle or spray irrigation only. Maintenance of ground cover essential for wind, water erosion control. Improve, maintain soil fertility.
T2	Suitable with severe limitations	Erosion potential. Very high soil variability. Surface crusts. Dense ironstone nodule layers, mottling. Low plant available water. Massive structure. Pan development likely. Very low nutrient levels. Termites, ant hills, shallow water tables.	as for T1.	as for T1. Subsurface drainage may be required.
T3	Suitable with severe limitations	As above.	as for T1.	As above.
T4	Unsuitable	Excessive slopes. Rock outcrops. Very shallow soils.	--	--
T5	Unsuitable	Rocks, boulders. Very shallow soils.	--	--
T6	Suitable with severe limitations.	as for T1.	as for T1.	as for T1.

<u>Soil analytical results</u>. The ratings of Bruce and Rayment (1982) are used in Tables 10 and 11 to summarise chloride content, sodicity and nutrient levels in the soil profile classes sampled for analysis.

The results indicate the clay soils of the plains are sodic and have medium to high salt levels by 60 cm. Experience with similar soils in other irrigation areas has shown such soils are manageable and productive.

Gypsum is frequently the dominant salt at depth and it could cause corrosion of cement irrigation pipes and fittings. Gypsum could also be associated with the development of perched watertables, causing salinisation downslope.

The soils of the clay plains are moderately fertile and artificial fertilisers would be required for optimum crop production. The red and yellow earths of the Baronta plateau are strongly leached of nutrients and would require considerable amounts of fertiliser to improve and maintain fertility.

Table 10 Ratings for chloride and sodicity*

SPC	20-30 cm	50-60 cm	80-90 cm	110-120 cm
Strathglass	VL.NS	VL.S	L.S	L.S
Bullock Creek	VL.NS	VL.NS	-	-
Penrice	VL.-	VL.-	VL.-	VL.-
Karoon	VL.-	VL.-	VL.-	VL.-
Glendower	VL.-	VL.-	VL.-	VL.-
Blantyre	VL.NS	VL.NS	VL.NS	VL.NS
Coolibah	VL.NS	VL.S	VL.S	VL.SS
Mt. Devlin	L.S	H.S	H.SS	H.SS
Ellington	VL.NS	VL.NS		
Sussex	VL.NS	M.S	H.SS	H.SS
Nicoliche	VL.-	VL.-		
Rosevale	VL.NS	L.NS	M.S	M.SS
Mt. Beckford	VL.-	VL.-	L.-	M.-
Fernlees	VL.SS	L.NS	M.S	H.S
Glenmoan	VL.-	VL.-	VL.-	VL.-

* VL - very low, L - low, M - medium, H - high, NS - non sodic, s - sodic, SS - strongly sodic

Table 11 Ratings* for nutrients.

SPC	P acid.	P bicarb.	K extr.	C org.	N tot.	S tot. (%)	Cu ppm	Zn ppm	Mn ppm
Strathglass	M	VL	H	L	L	L	M	VL	M
Bullock Creek	L	VL	M	L	VL	L	M	L	M
Blantyre	VL	VL	H	L	L	L	M	M	M
Coolibah	VH	M	VH	L	L	M	M	L	M
Mt. Devlin	H	M	VH	L	L	H	M	L	M
Ellington	VH	M	H	L	L	M	M	L	M
Sussex	H	M	VH	L	L	M	M	L	M
Rosevale	H	H	VH	L	L	M	M	M	M
Fernlees	VL	VL	M	VL	VL	L	M	VL	M

* VL - very low M - medium VH - very high
L - low H - high

Table 12 Chemical data for soils of the landscape units.

Landscape Unit	G.S.G.	Depth cm	pH Range	Mean	E.C. $mScm^{-1}$ Range	E.C. Mean	E.S.P. Mean
Baronta plateau	Red and yellow earths	0-10	5.9-6.8	6.2	.01-.04	.02	1
		50-60	5.9-7.2	6.5	.01-.01	.01	1
		80-90	6.2-7.2	6.7	.01-.02	.01	1
	Grey clays	0-10	7.0-7.4	7.2	.03-.03	.03	5
		50-60	8.6-8.8	8.7	.10-.11	.10	3
		80-90	8.0-8.0	8.0	.48-1.1	.79	8
Alluvium	Solodics	0-10	7.0-7.5	7.2	.03-.06	.04	3
		50-60	7.2-8.9	8.2	.02-.67	.22	3
		80-90	8.1-9.2	8.8	.03-.50	.25	9
Plains	Brown and grey clays (Mitchell grass)	0-10	7.3-8.9	8.1	.04-.15	.08	3
		50-60	7.2-9.5	8.4	.08-1.9	.85	12
		80-90	7.5-9.4	8.4	.09-3.2	1.42	18
	(gidgee)	0-10	7.1-8.6	8.2	.06-.16	.12	7
		50-60	8.0-9.2	8.7	.40-2.5	1.16	24
		80-90	7.9-8.7	8.3	.91-2.4	1.72	24

3.4 Chemical and Physical Characteristics

Soils from 63 representative profiles were sampled for analysis. The results of these analyses are now summarised.

Salinity, sodicity and pH. The data are summarised in Table 12.

All soils analysed were non-sodic in the surface (0-10 cm) and the red and yellow earths were non-sodic throughout. These soils also have very low electrical conductivity and chloride values, reflecting their history of leaching.

The clay soils of the Mitchell grass plains are sodic with medium to high salt levels by 60 cm while chloride levels are moderate by 90 cm. Gypsum is often the dominant salt at depth and its presence in such amounts could cause corrosion of cement irrigation pipes and fittings. Gypsum could also be associated with the development of perched watertables under irrigation leading to salinisation downslope.

The clay soils of the gidgee areas are strongly sodic with high salt levels by 60 cm and are often sodic by 30 cm.

The clay soils of the Mitchell grass plains are derived from four rock units of Cretaceous age - Allaru Mudstone, Toolebuc Limestone, Ranmoor Member and Doncaster Member. Analytical data for the cracking clay soils derived from the three mudstone units are given in Table 13.

Table 13 Chemical data for the clay soils derived from mudstone sediments

Rock Unit	Depth cm	pH Range	Mean	E.C. $mScm^{-1}$ Range	Mean	Cl Mean %	E.S.P. Mean %
Allaru	0-10	8.2-8.7	8.4	.08-.12	.10	.001	4
Mudstone*	50-60	8.0-9.1	8.7	.21-1.6	.88	.017	10
	80-90	8.0-8.7	8.3	.94-2.2	1.48	.045	14
Doncaster	0-10	7.5-8.1	7.7	.05-.09	.07	.002	3
Member**	50-60	7.7-9.5	8.3	.13-1.6	1.14	.054	18
	80-90	7.9-9.4	8.5	.44-1.9	1.41	.095	24
Ranmoor	0-10	7.3-8.9	8.0	.04-.15	.07	.003	3
Member*	50-60	7.2-9.1	8.4	.09-1.9	.68	.043	14
	80-90	7.5-8.9	8.2	.59-3.2	1.55	.127	21

* 6 profiles ** 9 profiles

The data indicate general trends only and at this level of sampling, the cracking clay soils derived from Allaru Mudstone sediments appear marginally less sodic and saline than the clay soils derived from the other mudstone beds.

Calcium and magnesium. Calcium is the dominant cation throughout the profiles of all soils sampled, although magnesium assumes greater prominence at depth in the alluvial solodics.

Total phosphorus, potassium and sulphur. The values for the major soils of the landscape units are listed in Table 14.

Table 14 Total phosphorus, potassium and sulphur values.

Landscape Unit	Soil	Total P %	Total K %	Total S %
Baronta plateau	Red, yellow earths	.022	.29	.011
	Grey clays	.009	.10	.008
Alluvium	Solodics	.062	1.66	.034
Plains	Grey and brown clays			
	- (Mitchell grass)	.067	1.13	.042
	- (gidgee)	.054	.80	.195

The oldest soils, the red and yellow earths recorded the lowest values. The values appear adequate although sulphur may be marginal for the soils on the Baronta plateau. No significant differences occurred in the levels of these elements for the clay soils derived from different mudstone beds.

Organic carbon and nitrogen. The values for the surface (0-10 cm) layer are given in Table 15.

Table 15 Organic carbon and total nitrogen

Landscape Unit	Soil	O.C %	Tot. N %	C/N
Baronta plateau	Red, yellow earths	.8	.04	20
	Grey clays	.4	.04	10
Alluvium	Solodics	.5	.06	8
Plains	Grey and brown clays			
	- (Mitchell grass)	.8	.09	9
	- (gidgee)	.8	.09	9
Mean all Soils		.7	.07	10

The data indicate low values of organic carbon and total nitrogen for all soils. The highest carbon : nitrogen ratio of 20 was obtained with the red and yellow earths, indicating their general infertility.

Exchangeable calcium, magnesium, potassium and extractable phosphorus. The data is summarised in Table 16.

Table 16 Exchangeable cations, extractable phosphorus

Landscape Unit	Soils	Ca	Mg	K	Bicarb. P
		meq/100g			ppm
Baronta plateau	Red, yellow earths	2.9	1.0	0.17	4
	Grey clays	17.0	14.5	0.66	3
Alluvium	Solodics	9.7	3.3	1.40	69
Plains	Grey and brown clays				
	- (Mitchell grass)	43.0	3.4	1.50	30
	- (gidgee)	28.0	3.1	0.91	46

The results indicate the phosphorus status of the massive earths and grey clays on the Baronta plateau is very low while exchangeable potassium for the massive earths also appears marginal.

Copper, zinc, iron and manganese. The amounts of these elements for the surface (0-10 cm) soil are summarised in Table 17.

Table 17 Copper, zinc, iron and manganese

Landscape Unit	Soil	Cu	Zn	Fe	Mn (ppm)
Baronta plateau	Red, yellow earths	.4	.6	17	44
	Grey clays	.8	.2	17	36
Alluvium	Solodics	1.1	1.4	19	26
Plains	Grey and brown clays				
	- (Mitchell grass)	1.6	.7	7	14
	- (gidgee)	1.2	.6	11	20

The results indicate zinc may be marginal for all soil groups.

Particle size and available water capacity. The clay contents for the soils are summarised in Table 18.

Table 18 Clay percentages.

Landscape Unit	Soil	Depth (cm) 0/10	20/30	50/60	80/90
Baronta plateau	Red, yellow earths	18	23	30	38
	Grey clays	41	43	44	44
Alluvium	Solodics	28	37	36	33
Plains	Grey and brown clays				
	- (Mitchell grass)	63	64	61	60
	- (gidgee)	59	53	53	55

The available soil water capacities of the soils at these same depths are given in Table 19.

Table 19 Available soil water capacities (%).

Landscape Unit	Soil	Depth (cm) 0/10	20/30	50/60	80/90
Baronta plateau	Red, yellow earths	5	6	7	10
	Grey clays	11	12	13	15
Alluvium	Solodics	8	12	13	13
Plains	Grey and brown clays				
	- (Mitchell grass)	22	22	23	23
	- (gidgee)	17	20	21	21

The data indicate the grey and brown clays of the Mitchell grass plains have the highest moisture capacities and would require fewer irrigations than the massive earths.

The Plant Available Water Capacities (PAWC) for the self-mulching clays and massive earths were calculated, using the regression equations of Shaw and Yule (1978). Values of 11.8 cm and 7.9 cm were estimated for the clay soils and the massive earths respectively. In general, soils with high PAWC values are preferred for irrigation as they are easier to manage. Irrigation should be applied when accumulated evapotranspiration is about 60-80% of PAWC. Assuming average potential evapotranspiration of 1 cm/day during the growing season, irrigation frequencies should range about every 7 to 9 days for the clay soils and every 4 to 6 days for the massive earths.

Clay activity ratio. The clay activity ratio (CEC/clay m. equiv. per g. of clay) gives an indication of clay mineralogy. The grey and brown clays of the plains have high ratios (0.7 to 0.9) indicating montmorillonite clays while lower ratios of 0.3 to 0.5 occur in the massive earths, indicating older soils with more weathered clay minerals.

4. SOIL SALINITY

4.1 Salt Distribution

The main source of salts occurs in the clay soils derived from the Cretaceous mudstones. After the winter rains in 1983, white salt accumulations coated exposed subsoils in many road cuttings, road sides and creek banks. Samples of salts and soil from 19 of these occurrences showed 8 samples had high to very high chloride values, while 11 samples had low to very low chloride values. The soil analyses from the resource mapping of this area show significant chlorides in subsoils of many of the clay soils. Characteristics of the clay soils on Cretaceous mudstones relevant to this assessment are shown in Table 20.

Table 20 *Salinity data for clay soils on Cretaceous mudstones

Depth (cm)	Kla	Kla_t	Kld	Klq	QS/Klq
		R1 (Dispersibility)			
0 - 10	.37	.34	.43	.48	.46
20 - 30	.43	.38	.48	.50	.64
50 - 60	.51	.47	.66	.67	.76
80 - 90	.62	.47	.78	.74	.73
		Exchangeable Sodium Percentage			
0 - 10	4	1	3	3	6
20 - 30	6	2	9	6	13
50 - 60	10	7	18	14	24
80 - 90	14	11	24	21	27
		Electrical Conductivity m S cm^{-1}			
0 - 10	.10	.09	.07	.07	.12
20 - 30	.36	.20	.50	.24	.44
50 - 60	.88	.42	1.14	.68	1.17
80 - 90	1.48	1.11	1.41	1.55	1.72
		Chlorides %			
0 - 10	.002	.001	.002	.003	.003
20 - 30	.003	.003	.004	.006	.019
50 - 60	.023	.012	.054	.043	.090
80 - 90	.074	.017	.095	.127	.141
110 - 120	.126	.042	.114	.167	.156

* Values are averages of soil analyses from sampling carried out in Hughenden area mid-1983 and comprise KLA (Allaru Mudstone) 6 profiles, KLAt (5 profiles), KLD (Doncaster Member) 6 profiles, KLQ (Ranmoor Member) 9 profiles, QS/KLQ 7 profiles.

This broad level of sampling indicates probable trends only. The data indicate the clay soils derived from the Allaru Mudstone sediments appear less saline, sodic and dispersible than the clay soils derived from the other mudstone sediments. Salinity is not related to the age of soils. Soils on old plateau surfaces do not have higher levels of salts. Some of the younger sedentary soils developed in Cretaceous mudstones have very high salt values derived from the mudstones. The salt values continue to increase to depth of sampling (120 cm) indicating leaching past this depth. Salt profiles beyond 120 cm were not determined in this stage of the investigation. Values are increasing at 120 cm depth, and deeper sampling with analyses of 10 cm sampling intervals would be required to determine the salt bulges. The distribution of salts in these soils is common to many of the clay soils of western Queensland. Gypsum is abundant in the clay soils on the Cretaceous mudstones in the Hughenden area.

4.2 Potential for Salting

Under dryland conditions no seepage salting or springs occur in this semi-arid area. Water movement is into sandstone intake beds of the Great Artesian Basin, with main recharge from creeks in wet seasons. The Cretaceous mudstone beds overlie these sandstone intake beds. The main groundwater level appears to be deep, and unlikely to cause problems from rising groundwater tables under irrigation.

The main salinity hazard is from perched watertables which could develop on the impermeable mudstone beds under irrigation. The soils on the mudstones should allow leaching of salts out of the soil profile. There are very long slopes on the mudstone units, and development of perched watertables containing mobilised salts could result in build up of saline water in subsoils on lower slopes. Under these conditions the very high evaporation rates in this area could result in soil salinisation on lower slopes. At this stage there is a lack of data to assess this risk, and the hazard is considered low and to not affect the overall suitability of selected units for irrigation.

No problems from saline seepages are expected on plateau margins should irrigation of plateau tops be contemplated. On the plateau surface, contacts of earths and lower lying grey clays should be susceptible to water build up and possible salting under irrigation, with salt sources in the grey clays.

4.3 Salinity Hazard Ratings

Salinity hazards alone do not preclude any of this area from irrigation. The hazards are not considered severe enough to form a sole basis for exclusion of lands from irrigation. Combined with other factors (soil characteristics, proximity to water supplies, location and continuity) the ratings can be used for selecting those areas considered most suited for irrigation, namely units P1, P5 and the western part of P3. The mapping units have been grouped into zones with negligible, very low, low and moderate salinity hazard ratings with irrigation. Map 3 indicates the distribution of these zones and the mapping units involved.

Most of the potential irrigation area lies in ratings 2 and 3, classed as very low to low salinity hazard. No analyses beyond 120 cm have been carried out at this stage of the investigations. Indications are that leaching should continue past 120 cm under irrigation in these soils (P1, P5, part P3). The mobilised salts could be moved into a perched watertable on long slopes on mudstones, which could result in seepage salting on lower slopes. This potential problem does not detract from the overall irrigation suitability of these soils, but does warrant a low order of preventative measures e.g. selected piesometers to measure water build up and movement of subsoil water on slopes under irrigation.

If water is found to accumulate in lower slopes, preventative measures against seepage salting would include:

- Irrigation water management over the whole slope.
- Cropping management to utilise subsoil water in lower slope positions.
- Maintaining surface cover crops on lower slopes to reduce any evaporative concentration and capillary rise effects.
- Use of salt tolerant crops on lower slopes if salinity develops.
- Drainage.

5. RESEARCH NEEDS

Irrigation schemes are renown for causing waterlogging, shallow watertables and salinisation. This proposed scheme is unique in having a total lack of basic research to recommend or promote the advantages of the scheme. The following studies are seen as essential before the proposal is accepted and the scheme implemented.

1. Geohydrological surveys or studies are needed to determine potential salinity problems and the effects on watertables. Studies on water quality and the effect on aquifers of the Great Artesian Basin and inland streams are required. The disposal of drainage water is very pertinent for this inland area. Such studies would highlight the irrigation and agronomic practices required to minimise salinisation.

2. This report is based on a reconnaissance survey at 1:250 000 and only provides an assessment of the irrigation potential at the regional level. Additional soil surveys at 1:100 000 with 1:25 000 reference areas of potentially commandable lands are required. Areas which may be considered for further surveys include:

(i) the open downs country west of the proposed dam site between 'Koonkool' and 'Glentor Downs'

(ii) the open downs country south west of Hughenden

(iii) the open downs country of the Jardine Valley east of Hughenden.

3. Pilot farms are required for agronomic and irrigation research in this tropical semi-arid environment. Soil water studies are needed to characterise the water regime of the soils, with regards to irrigation needs and management. These studies would also investigate the consequences of irrigation on salt mobilisation and deep drainage.

4. Environmental studies into pests and diseases and effects on flora and fauna are also needed.

5. Marketing studies are required as any products from this region would be competing directly with other established irrigation areas such as the Burdekin and the Atherton Tablelands. Those other irrigation areas would also enjoy a distinct competitive advantage due to milder climate, established infrastructure and research, and access to markets.

6. The economics of the overall scheme warrant investigation to establish priorities on a State wide basis.

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APPENDIX 1

IRRIGATED LAND CAPABILITY CLASSIFICATION

Limiting Factor	Degree of Limitation	Capability Class (If sole limiting factor)	Sub-Class Symbol
Effective soil	> 100 cm	1	d1
	60 - 100	2	d2
	45 - 60	3	d3
	25 - 45	4	d4
	< 25	5	d5
Soil physical factors affecting plant growth and management	1. B horizon or sub-soil depth. Depth to B horizon with dry extremely hard consistence		
	> 45 cm	1	pb1
	20 - 45	2	pb2
	10 - 20	3	pb3
	< 10	4	pb4
	2. Surface crust. Surface soils likely to set hard if overworked.	2	pc2
	Surface soils set hard.	3	pc3
	3. Distribution of soil profile classes. Soil distribution is such that 2 or more different soil profile classes occur within a 300 m traverse. Soil profile classes are different such that markedly different inputs are required:		
	For specific crops	3	pd3
	For any crop	4	pd4
	4. Texture of surface soils. Sands to sandy loams to:		
	45 - 60 cm	2	pt2
	60 - 90	3	pt3
	> 90	4	pt4

APPENDIX 1 (Continued)

Limiting Factor	Degree of Limitation	Capability Class (If sole limiting factor)	Sub-Class Symbol
Soil salinity or sodicity	Electrical conductivity of 1:5 extract at 25°C is greater than 1 mS cm^{-1} at:		
	30 - 90 cm	3	sa3
	< 30	4	sa4
	Exchangeable sodium percentage greater than 15		
	40 - 90 cm	2	so2
	20 - 40	3	so3
	< 20	4	so4
Topography	Slopes 0.1 - 0.5%	1	t1
	0.5 - 1.0	2	t2
	1.0 - 2.0	3	t3
	2.0 - 4.0	4	t4
	> 4.0	5	t5
Rockiness and stoniness	Tillage restricted - stone picking required.	3	r3
	Tillage difficult - stone picking required.	4	r4
	Tillage impossible.	5	r5
Microrelief	Vertical interval of gilgai		
	< 10 cm	1	g1
	10 - 25	2	g2
	25 - 60	3	g3
	> 60	4	g4
Wetness	Requires accurate levelling and storm drains.	2	w2
	Requires permanent drainage.	3	w3
	Requires subsurface drainage.	4	w4

APPENDIX 1 (Continued)

Limiting Factor	Degree of Limitation	Capability Class (If sole limiting factor)	Sub-Class Symbol
Susceptibility to water erosion	To reduce erosion to an acceptable level, require:		
	Simple practices	2	e2
	Intensive practices	3	e3
	Pasture phase	4	e4
Susceptibility to flooding	Areas subject to fast stream-rise flooding at frequency less than 1 in 10 years.	2	f2
	Areas subjected to major overbank flood at frequency of more than 1 in 10 years.	3	f3

LAND CLASSES

The following are modified versions of land classes as defined by the United States Bureau of Reclamation (1951).

<u>CLASS 1</u> - ARABLE

Lands that are highly suitable for irrigation farming; being capable of producing sustained and relatively high yields of a wide range of climatically adapted crops at reasonable cost. They are smooth lying with gentle slopes. The soils are deep and of medium to fairly fine texture with mellow, open structure allowing easy penetration of roots, air and water and having free drainage yet good available moisture capacity. These soils are free from harmful accumulations of soluble salts or can be readily reclaimed. Both soil and topographic conditions are such that no specific farm drainage requirements are anticipated, minimum erosion will result from irrigation, and land development can be accomplished at relatively low cost.

<u>CLASS 2</u> - ARABLE

Lands of moderate suitability for irrigation being lower than Class 1 in productive capacity. They are not so desirable nor of such high value as lands of Class 1 because of certain correctable or non-correctable limitations. They may have a lower available moisture capacity as indicated by coarse texture or limited soil depth; they may be only slowly permeable to water because of clay layers in the subsoil; or they also may be moderately saline which may limit productivity or involve moderate costs of leaching. Topographic limitations include uneven surface requiring moderate costs for levelling, short slopes requiring shorter length of runs, or steeper slopes necessitating special care and greater costs to irrigate and prevent erosion. Farm drainage may be required at a moderate cost or loose rock or woody vegetation may have to be removed from the surface. Any one of the limitations may be sufficient to reduce the lands from Class 1 to Class 2 but frequently a combination of two or more of them is operating.

CLASS 3 - ARABLE

Lands that are suitable for irrigation development but are of restricted suitability because of greater deficiencies in the soil, topographic, or drainage characteristics than described for Class 2 lands. They may have good topography, but because inferior soils have restricted adaptability, require larger amounts of irrigation water or special irrigation practices and demand greater fertilization or more intensive soil improvement practices. They may have uneven topography, moderate to high concentration of salts or restricted drainage, susceptible to correction but only at relatively high costs. Generally, greater risk may be involved in farming Class 3 lands than better classes of land, but under proper management they are expected to have adequate payment capacity.

CLASS 4 - LIMITED ARABLE OR SPECIAL USE

Lands that have an excessive, specific deficiency or deficiencies susceptible to correction at high cost; or they may have one or more excessive, non-correctible deficiencies thereby limiting their utility to pasture, orchard or other relatively permanent crops. The deficiency may be inadequate drainage, excessive salt content requiring extensive leaching, unfavourable position allowing periodic flooding or making water distribution and removal very difficult, rough topography, excessive quantities of loose rock on the surface or in the plough zone. On these lands special economic and agronomic and/or engineering studies are required to show they are capable of sustained production and capable of supporting a farm family and meeting water charges if operated in units of adequate size or in association with better lands.

CLASS 5 - NON-ARABLE

Lands in this class are non-arable under existing conditions. They have specific soil deficiencies such as being excessively steep, shallow, rocky, rough, badly eroded, have very high salinity or are prone to excessive flooding.