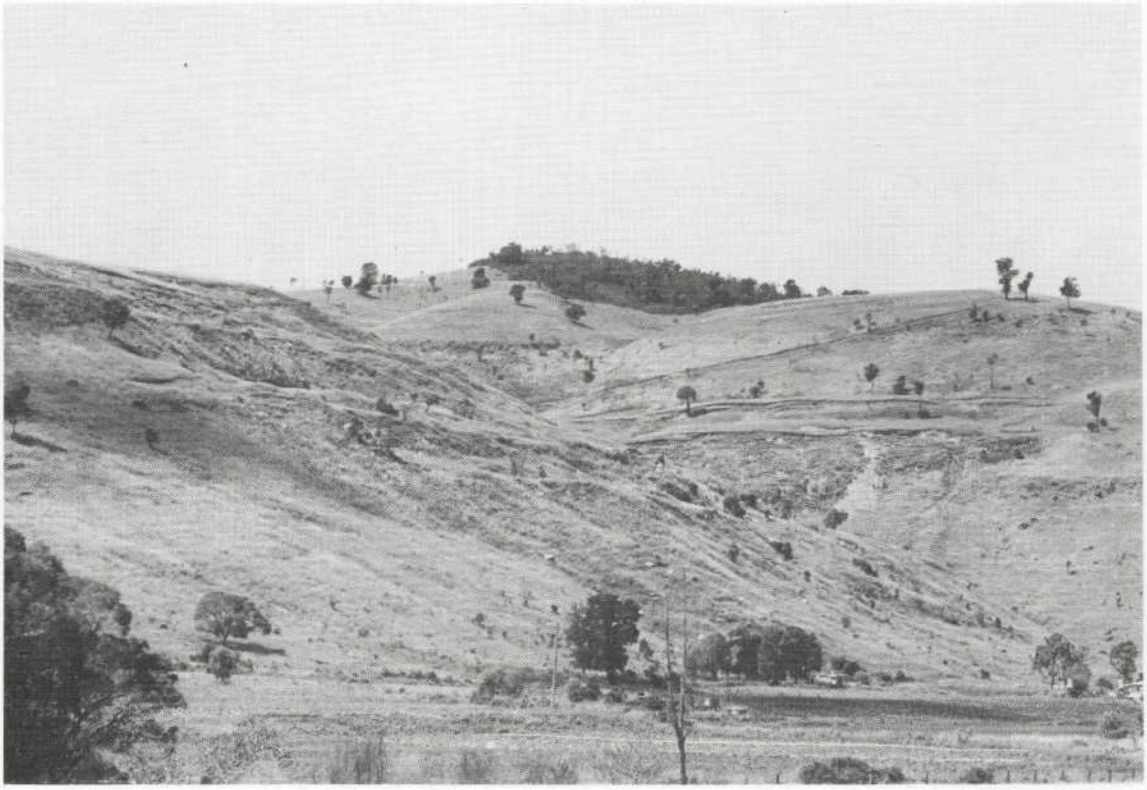
LAND DEGRADATION

IN

THE LOCKYER CATCHMENT

J.H. SHAW



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For information about this report contact *Soils@derm.qld.gov.au*

COVER PHOTOGRAPH:

A large landslip on cleared grazing lands in the Flagstone Creek area. Over 1000 landslips were recorded in this Heifer Creek Sandstone map unit.

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J.H. SHAW

(Formerly Soil Conservation Branch)

DIVISION OF LAND UTILISATION

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FOREWORD:

The Lockyer Valley, as one of the State's most important centres of diversified agriculture, relies on irrigation for its continued prosperity. The occurrence of deep fertile soils in association with surface and underground water supplies has allowed farmers to grow and profitably market a wide range of agricultural and horticultural crops.

A study was undertaken by Mr. Shaw (formerly Soil Conservationist, Department of Primary Industries, Toowoomba), to assess the nature and extent of land degradation which has taken place in the Lockyer Creek Catchment. The study area of 200 000 hectares includes most of the highly productive alluvial plains where irrigation from groundwater is the basis for a diverse range of crop production.

The origin of this study was based on a recommendation in the Moreton Region Non-Urban Land Suitability Study (published as a Bulletin in this series in 1974). The regional study showed that the Bremer and Lockyer Catchments were the most seriously eroded - of all the severe sheet and gully erosion in the region almost two-thirds was in these two catchments. Because of the transmitted effects of degradation in the form of silt and sediment and in the form of the long-term risk to non-renewable resources, it was recommended that more detailed surveys of these catchments be undertaken to determine the nature and full extent of land degradation and indicate the necessary control measures.

This study together with the companion study on the Bremer Catchment (published as Technical Bulletin No. 40) identifies the land degradation situation and highlights the inter-relationships between the form of degradation such as soil erosion, landslip and soil and water salinity. The significance of the upper Lockyer Catchment as a water supply area for the valuable aquifers underlying the alluvials indicates a need for a co-ordinated catchment approach to land management.

Several initiatives have already been made in response to the problems outlined in this Bulletin. For example, the Soil Conservation Branch has adopted a co-ordinated soil and water conservation basis for farm planning and land management in the Lockyer, while various Branches of the Department are developing a research and extension program on salinity. The Geological Survey Branch of the Mines Department is investigating landslips and a comprehensive appraisal of the Water Resources of the Lockyer Valley is being undertaken by the Water Resources Commission at the request of members of the local community.

In the longer term, the success of this study in highlighting the need to conserve the land resources in the Lockyer Valley will depend on its effectiveness in enhancing awareness by land planners, land users, and the public, of the effects of land degradation and the nature of the processes operating.

A. Hegarty

DIRECTOR

DIVISION OF LAND UTILISATION

CONTENTS

ACKNOWLEDGEMENTS:

This study began as part of a combined Bremer-Lockyer investigation and several colleagues have given valuable assistance during the period of the study. The initial planning and collation of existing resource information was undertaken by Mr. P.J.M. Johnston.

Mr. K.K. Hughes provided valuable assistance with the geological mapping undertaken in conjunction with the study and assisted with the compilation of the report. The final editing was undertaken by Dr. B. White.

Mr. C. Ellis gave helpful drafting advice and produced the maps both for field copy and for final publication. Mr. P. Scott also provided much helpful advice.

Mr. C.A.A. Ciesiolka gave valuable assistance on problems of geomorphology and landscape processes and this enabled a greater understanding of the processes operating in the study area to be obtained.

In particular I would like to thank Mr. M. Roberts for his assistance in the mapping of areas of erosive flooding and for his contributions, particularly during discussions, to the progress of the study.

SUMMARY:

A survey has been made to assess the nature and extent of land degradation which has taken place in the Lockyer catchment. The study area of 200 000 ha includes most of the highly productive alluvial plains. Irrigation from groundwater is the basis for a diverse range of enterprises with the emphasis on horticultural production. The northern one-third of the catchment consisting of mainly uncleared lands was excluded from the study.

Degradation in the form of sheet, rill and gully erosion, erosive flooding, landslips and salting was assessed in the field and by air-photo interpretation. Estimates were made on the area affected by each type of degradation. Areas affected were determined in relation to five classes of land use and ten mapping units based on geology and landform. Maps at a scale of 1:100 000 are presented for land degradation, land use, and the mapping units.

Some 17 per cent of 33 000 ha of the study area was assessed as degraded. Sheet erosion mainly on land which is cultivated or has been cultivated was the major form of degradation. Gully erosion with average severity of 18.7 m per ha was most severe on the naturally unstable Hillwash Alluvium and Colluvium mapping unit. Erosive flooding has affected 11 per cent of the alluvial lands. An area of over 500 ha was recorded as severely salt affected. Landslips were concentrated in the cleared areas of the Heifer Creek Sandstone unit and it was estimated that 20 per cent of the unit was affected. There was generally a close correlation between types of degradation, land use, geology and land form.

The pervasive effects of degradation and the significance of the upper catchment was a water supply area for the alluvials were considered in determining a package of recommended control measures to ensure that the land and water resources of the catchment are not used beyond their potential for sustained long-term productivity.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Severe land degradation is occurring in the Lockyer Catchment - 17 per cent of the area studied is noticeably degraded and much land has been used beyond its potential for sustained long-term productivity. The numerous landslips, saline outbreaks, sheet and gully erosion, and the over-development of underground water resources are only the more obvious indicators of land degradation and exploitation in parts of the catchment. The transmitted effects of degradation in terms of sediment deposition in streams and on roads, and on water quality, are more pervasive but are becoming increasingly manifest.

The significance of the upper catchment as a water supply area for the valuable alluvial aquifers demonstrates the need for a co-ordinated catchment approach to the conservation and development of the valley's soil and water resources.

An important aspect of the degradation processes operating in the catchment is the time lag between land clearing and effects such as landslip and increased soil salinity. The role of the 1974 flood rains as a triggering mechanism is demonstrated by the large number of mass movements since then. Increased deposition in streams is reducing their capacity and contributing to increased flooding and damage to lower lands.

Lockyer Creek flows into the Brisbane River above the water treatment plant at Mt. Crosby and contributes quite disproportionately to the costs of treatment. Water treatment costs could be reduced considerably by conservation treatment of key sub-catchments in the Lockyer. The high proportion of colloidal material presents in the water leads to these pollution problems. This is related to the nature of the soils and the erosion in the catchment.

Without action to reverse the processes initiated by clearing unstable lands of the upper catchment, more serious land degradation and effects on water quality are inevitable. The severity of such degradation and its long-term impacts on the soil and water resources of the catchment can only be surmised. without modification of land use and land management practices in key parts of the catchment, the productivity of the valuable alluvial lands will be placed at greater risk - a whole catchment approach is needed.

RECOMMENDATIONS

The following recommendations are presented as the basic means of controlling land degradation. Recognition of the inter-related and catchment nature of the problems is inherent in this set of recommendations, presented for each of the major types of degradation determined in the study.

1. Sheet Erosion - Improved land management practices are required particularly on sloping cultivated lands, to reduce sheet and associated rill erosion.

Over 25 per cent of all cultivated lands have been degraded by sheet and rill erosion - the worst areas are in the sloping cultivated lands, particularly in the Ma Ma Creek Sandstone mapping unit. Stubble mulch farming may achieve sufficient control on lesser slopes but on steeper lands, a pasture rotation or a basic layout of diversion and contour banks linked to stable waterways and water storages is necessary to ensure a stable farming enterprise.

2. Erosive Flooding - Control measures are required to reduce the velocity and concentration of flood flows on the alluvial plains; in particular attention needs to be given to the alignment of roads and paddocks and to co-ordinated drainage.

About 12 per cent of the valuable alluvial plains have been scoured and affected by erosive flooding. Readjustment of the whole drainage network is continuing in response to changes in land use and in the hydrology of the catchment. Control of degradation in the headwaters will also contribute to alleviation of erosive flooding.

3. Landslip - Return to a basically timber cover is required to stabilise those areas prone to landslip.

An estimated 20 per cent of the Heifer Creek Sandstone mapping unit has been subject to landslip. The unit accounts for about 25 per cent of the survey area and 88 per cent of recorded landslips. Sediment from these mass movements is the major contributor to the development of the badly-gullied alluvial and colluvial fans and to poor quality water. Over 90 per cent of landslips are on lands cleared in the recent past; clearing would have raised the water table and also contributed to the transmission of poorer quality water from the sandstone beds to the alluvials. The large number of recent smaller landslips suggest that a lag exists between clearing and landscape adjustment and that the flood rains of 1974 acted as the trigger mechanism.

4. Salinity - The following measures are required to reduce saline outbreaks and the saline conditions in both groundwater and soils, particularly on the margins of the alluvial plains.

- re-establishment of timber cover in the upper catchment, particularly the sandstone units.
- maintenance of ground cover in the basalt areas.
- control of the extraction of water from the alluvial aquifers.

The lowering of hillside water tables is necessary to reverse the increasing occurrence of saline outbreaks. Good quality water is associated with catchments with a high proportion of basalt compared to sandstone. As about one-third of the catchment studied is the basalt unit, it is important to safeguard the efficiency of the basalts as sources of quality recharge water for the alluvial aquifer. The lowering of the alluvial water table, in some areas by as much as 13 m, has contributed to saline outbreaks by reducing lateral flushing of poor quality water, and has also allowed intrusion of poor quality water from adjoining sandstone aquifers.

1. INTRODUCTION

The Lockyer Valley has long been recognized as one of the most productive agricultural areas in South Eastern Queensland. The study area includes most of the Lockyer Catchment containing the highly productive alluvial plains. The Lockyer now produces $30 million worth of agricultural produce annually from a diverse range of enterprises.

The population of the valley is about 15 000, Gatton and Laidley being the major towns.

The Lockyer Valley accounts for about 40 per cent of the lands used for irrigated vegetable production in Queensland and is the major supplier of heavy vegetables, particularly potatoes, onions and pumpkins. Most of the Valley is within 100 km of Brisbane. The economy of the Valley is based in the main on irrigation from the alluvial aquifer.

1.1 THE OBJECTIVES AND SCOPE OF THE STUDY

The Moreton Region Non Urban Land Suitability Study published by the Division of Land Utilisation, Department of Primary Industries in 1974 highlighted the fact that the majority of the soil loss and land degradation occurring in the Moreton Region was occurring in two areas - the Lockyer and Bremer catchments. These catchments, occupying 20 per cent of the region, account for 60 per cent of the estimated severe erosion and also make a disproportionate contribution to sediment load in the Brisbane River. A detailed investigation was considered necessary to ascertain the nature and extent of this land degradation.

This study has been undertaken to evaluate the nature and extent of land degradation which has occurred in the Lockyer Valley.

For the purposes of the study the following forms of degradation were assessed:-

(a) sheet erosion

(b) rill erosion

(c) gully erosion

(d) landslips

(e) salting

(f) erosive flooding

Landslips include rotational slumps, mud flows and other forms of mass movement, excluding soil creep.

Salting includes those areas which have developed from rising water tables, but does not include areas resulting from the use of poor quality irrigation water.

Erosive flooding includes areas where either removal or deposition of silt has been caused by flood waters.

The study area is located east of the Great Dividing Range and includes the major part of the Lockyer catchment south of Murphy's Creek and Lockyer Creek. It is bounded approximately by Toowoomba in the west, Lowood, Marburg and Laidley in the east, Gatton in the north and the junction of the Little Liverpool Range and the Great Dividing Range in the south. The northern part of the catchment which includes large areas of State Forest was excluded from the study area. The study area includes most of the Gatton and Laidley Shires and a small part of the Esk Shire.

1.2 THE HISTORY OF LAND DEVELOPMENT

The history of land development is closely tied to the history of settlement. In a study of land degradation it is useful to know the time span over which degradation has taken place.

The Lockyer Valley was first settled in 1841 with the establishment of sheep and cattle stations at Grantham and Helidon. Franklin Vale station was established near Laidley shortly after. By 1846, the northern part of the valley had been taken up with stations established at Buaraba, Tarampa and Lake Clarendon. During 1846 the remainder of the unsettled land was opened for leasehold occupation. Sheep were grazed in the area until about 1850 and by 1860 cattle grazing had achieved complete dominance.

A move was made, about the time Queensland became a separate colony, to promote closer settlement. In 1868 under the Crown Lands Alienation Act, the Queensland Government commenced resuming land from the large stations to lease as smaller holdings. This move was further augmented by the Homestead Act in 1872.

There was little development of land for cultivation until even closer settlement commenced, in the 1880's. In 1884, the Land Act was passed proposing subdivision of grazing selections into grazing farms. This act failed to achieve its purpose, since enthusiasm for acquiring land for grazing was seriously dampened by the severe drought of 1885. In 1887 this Act was replaced by the Repurchase Act which made provision for Crown Land to be sold to farmers as freehold land.

During the 1880's an influx of German migrants moved into the Valley. Generally, they settled the more outlying areas around Wonga Creek, Hassenburg, Mt. Sylvia, Ma Ma Creek, Flagstone Creek and Hatton Vale. Cultivation of land followed the break up of the larger holdings. The major crops grown were lucerne and maize. With the development of small holdings of freehold land, dairying gained prominence and by the turn of the century the area was producing 10 per cent of the State's total production. By 1905 there were 800 farmers in the Lockyer Valley engaged in dairying.

Cultivation had steadily increased, mainly producing fodder for dairy cattle, and totalled some 17 000 ha by 1905. (This was about 40 per cent of the total area presently cultivated). Irrigation of small areas had commenced by 1902 when eight farmers irrigated some 70 ha of land. Crop diversification in the area followed with irrigation of maize, lucerne, fruit, vegetables, oats and potatoes.

There was much slower growth of cultivation in the area over the next 30 years and the irrigated area only increased to some 160 ha by 1930. Most irrigators pumped from open water along creeks. Irrigation from underground water sources commenced about 1936 but it was not until 1939 that significant expansion occurred. From 1940 onwards there was a rapid increase in the area of cultivated land under irrigation. By 1948 the area increased to 7200 ha and by 1977 the area further increased to about 13 000 ha. The majority of the irrigated land is confined to the alluvial plains with upland areas used for dryland farming.

Cultivation increased as the dairying industry expanded, providing essential winter and early spring feed for stock. Dairying was carried out on the alluvial plains and also on the upland areas. Cultivation of these upland areas has been closely related to the rise and decline of the dairy industry. From 1902 to about 1940 there was a steady increase in the number of dairy cattle and dairy production in the area. Numbers remained fairly steady until about 1955 when a rapid decline occurred. By 1970 the industry had declined to such an extent that dairy factories at Grantham and Laidley closed down. The area of cultivation has remained at about the level achieved in 1955. This has resulted from more intensive permanent cultivation of the alluvial plain and expansion onto adjoining upland areas capable of irrigation, offset by the retirement to pasture of many upland areas previously under cultivation.

These developments have combined to keep the total area of cultivation fairly static. The greater diversification of cropping which occurred has proved more profitable than the lucerne, potatoes, onion and grazing crop pattern which existed in 1955.

The situation now exists where intensive cultivation occurs throughout the alluvial plain. Almost all suitable land is cultivated. In the uplands, intensive cropping is carried out in more favourable locations, particularly where irrigation water is available from adjoining alluvial areas or from on-farm storages. The crop-pasture rotation sequence is often used on dryland areas, with grazing crops and cucurbits predominant in the cultivation stage.

1.3 AGRICULTURAL PRODUCTION

Over one-half of the gross value of agricultural production in the Lockyer Valley is from irrigated vegetables, particularly potatoes and onions. Lucerne for hay production is another major crop. The gross value of production for major product groups in Gatton and Laidley Shires is presented in Table 1.1. The study area excludes northern parts of the Gatton and Laidley Shires and includes a small section of the Esk Shire. For statistical purposes, the Australian Bureau of Statistics (ABS) data for the Shires of Gatton and Laidley give an adequate description of the pattern of agricultural production in the Lockyer Valley and the study area.

In 1977, over one-half of the 838 agricultural establishments were classified as potato and other vegetable enterprises - meaning that this activity accounted for more than half the value of operations. Meat cattle and milk cattle enterprises accounted for 243 holdings. The total cattle population in the two Shires is about 58 000 head, the majority being for beef production.

About two-thirds of the holdings in the two Shires use irrigation. Of the total irrigated area of 13 000 ha, over 80 per cent is from underground sources. Some 600 ha are irrigated from farm dams.

Table 1.1 Annual Gross Value of Agricultural Production
Lockyer District (Gatton, Laidley Shires)

ITEM	ANNUAL GROSS VALUE $m	% OF TOTAL DISTRICT ANNUAL GROSS VALUE
VEGETABLES		
Heavy (Potatoes, Onions, Pumpkins)	12.2	41
Fresh (Cabbages, Cauliflowers, Lettuce, Tomatoes, Melons, Fruit and Nuts)	4.2	14
Processing (Beetroots, Carrots, Beans, Peas, Sweet Corn)	2.1	7
Hay (Mainly Lucerne)	4.2	14
Beef	2.9	10
Oil Seeds (Soybeans, Sunflowers, Cotton)	1.8	6
Dairy	1.5	2
Summer Small Grains (Sorghum, Maize)	0.6	2
Winter Small Grains (Barley, Wheat)	0.3	1
TOTAL	29.8	100

Sources: ABS Statistical Summaries, 1975 - 1977, and Extension Officers, DPI, Gatton.

2. SURVEY TECHNIQUES

2.1 GENERAL METHODS

The survey technique used was identification of land mapping units, land use and land degradation by field work and air photo interpretation. Where possible air photographs were updated to include any current data.

One of the major limitations encountered was the general inaccessibility of many areas particularly in the steeper western and southern sectors where land use is less intensive.

The first stage of the project involved collation and familiarization with previous work relevant to the project area. A good deal of field time was spent in recognizing features and principles highlighted by previous workers, and establishing their mapping boundaries in the field.

The applicability of this work to the present study was then assessed. A number of aspects of previous work has been incorporated into this study. Work by McTaggart (1963) and Zahawi (1975) in particular has been extensively used in determining mapping units.

Because of the high degree of disturbance of the vegetation, mapping units have been based largely on geology and landform. Only where plant species were found to be indicator species has vegetation been used to any great extent. However, these species, while an excellent aid in many areas, were not universal in their distribution throughout a mapping unit, and other factors had to be used to delineate mappable units.

During the mapping program several distinctive physical features were used to differentiate mapping units. These features, such as abrupt changes of slope and drainage patterns, were generally visible on aerial photographs. Soils descriptions were based on the CSIRO map in the Moreton Region Natural Environment Study (Queensland Co-ordinator General's Department, 1971).

Physical data relating to various forms of degradation were collected in the field in conjunction with field checking of mapping units. These data were correlated with air photo patterns, extrapolated by photo-interpretation and then subjected to further field checking.

All data were plotted initially on to 1:25 000 aerial photographs flown in 1971 and 1974 and then transferred to 1:50 000 cadastral base maps. After the information was transferred to the base maps, a copy was made and field checked. Using a similar technique land use and land degradation were transferred to the 1:50 000 cadastral base maps, coloured and field checked.

A number of measurements was then made on the maps to determine the extent of map units, land use categories and degradation, and the relationship between degradation, land use and map units. Measurements were made with a planimeter, with small areas measured using the dot system.

Final map compilation for publication was made at 1:100 000 scale. Air photography comprised black and white photos flown in 1971 and color photos flown in 1974. Land use and land degradation were recorded using these photos, updating where possible to the 1977 situation from ground observations.

2.2 LAND DEGRADATION CATEGORIES

In mapping the various forms of land degradation, several problems were encountered. The assessment of sheet erosion proved very difficult. It was necessary to set boundary parameters since examination of almost the entire valley showed, to some degree, evidence of sheet erosion particularly where the land had been cultivated. The boundary between sheet and rill erosion was likewise difficult. Where gully erosion occurred it was usually confined to the drainage network but in some localities large areas were completely eroded by gullies. A method of representing such areas on a map and maintaining a consistent form of representation proved difficult.

It was decided therefore to use a number of cut-off parameters as defined below to map the various forms of degradation.

2.2.1 Sheet Erosion. Clear evidence of soil movement must be observed. This would be in the form of silt build-up along fence lines, sediment deposition along adjacent drainage lines or the presence of small rills across a paddock.

No attempt was made to judge or measure the severity of sheet erosion which had taken place.

Where areas have been mapped as sheet eroded, sufficient erosion has occurred for this to be easily visible either in the field or on aerial photographs.

2.2.2 Rill Erosion. A working definition of rill erosion is that form of erosion which falls between sheet and gully erosion. In the field it forms a series of small scars spaced at relatively short distances across a slope. These scars are generally not deep and may vary considerably in width.

In the context of this report rill erosion has been used to describe those areas which are so severely sheet eroded that a network of gullies can be seen on an aerial photograph or in the field, or as a gullied area where the density of gullies is such that the separation and measurement of individual gullies was not possible at the scale of mapping used.

The area mapped as 'rill erosion' contains the most seriously eroded parts of the landscape.

2.2.3 Gully Erosion. Gully erosion was mapped almost exclusively from aerial photographs and checked where possible in the field. One of the biggest problems encountered in deciding what should be mapped as a gully was the stage of activity.

In many areas severe gully erosion has occurred in the past leaving an incision in a drainage line. A period of stability has followed where grass has established along the base of the gully and in some cases the gully side walls have battered naturally and stabilized. Most of these gullies have not been mapped. There are, however, many of these partially stabilized gullies which have commenced a further stage of incision with new gully heads formed. Where this situation exists such incisions have been mapped as gullies.

The other problem which existed with the mapping of gullies was the general inaccessibility of a large part of the study area. In these areas total reliance has had to be placed on aerial photograph interpretation.

2.2.4 Erosive Flooding. This form of degradation proved to be the most difficult of all to map. It was fortunate that a complete set of colour photographs was available. They were obtained immediately following the major floods in 1974. The extent of flooding and evidence of soil movement and deposition were clearly visible on the photographs. But, it was very difficult to locate ground truth, most of the land had been cultivated and evidence removed by the time of the survey. Time was too limited to interview all landholders and verify the extent of degradation which had occurred. The knowledge of local field officers and a limited number of landholders was used to verify evidence of both soil removal and deposition caused by flooding.

2.2.5 Landslip. All forms of earth mass movement have been included under this heading, excepting soil creep. Types of movement included in this category include, rotational slumps, earth and mud flows, debris slides and landslides.

In many areas extreme difficulty was experienced in separating individual movements. Whole hillsides have moved and covered extremely large areas and in these situations only the largest movements have been mapped.

Many small movements have been ignored. They were either too small to see on aerial photographs or they were difficult to locate on a map in areas where few landmarks are clearly distinguishable. In the course of the study it was evident that there were many old mass movements in the area. Unless these were currently active they have not been mapped.

A further complication which made the actual mapping of mass movements very difficult was the number of movements which have occurred since the most recent aerial photographs of the area were taken.

The majority of these movements were triggered by the flood rains of January, 1974. However, with each successive wet season many more have appeared. Time was insufficient to field map all post-photography mass movements and only those that were encountered during general field work, which were obviously not visible on the most recent photography, have been mapped.

The extent of mass movement could therefore only be considered to be a reflection of the extent of the situation as at April, 1974. The problem has become considerably worse since that time.

2.2.6 Soil Salinity. Salinity indicated by the presence of salt pans was mapped in this survey. Large patches of salting have been in existence for a long period of time in some areas. It is known, however, that new areas have appeared in recent years and continue to expand. The areas mapped are those which have been affected to the extent that vegetation growth is retarded. The total area affected by soil salinity would be considerably larger as there are many areas supporting salt tolerant pasture.

No attempt was made to map areas which have been affected by the use of poor quality, saline irrigation water. The variability of such occurrences makes this a complex task for which there was insufficient time.

3. GENERAL DESCRIPTION OF LAND RESOURCES

In this section, a brief description is presented of the general land resources of the area. The description provides a basis for the development of the mapping units presented in the following section. Geology and landform are the basic determinants of the mapping units.

The study area of 200 000 ha covers two-thirds of the Lockyer Creek catchment. The excluded northern section includes a small section of the alluvials and large areas of State forest and uncleared lands.

More detailed data on the resources of the study area are contained in "An Investigation of the Land and Water Resources of the Lockyer Valley" (Bureau of Investigation 1949), and Gatton and Laidley Shire Handbooks (Mills, 1972 and 1973).

3.1 CLIMATE

The Lockyer Valley experiences a sub humid, sub tropical climate with long hot summers and relatively short mild winters.

The average annual rainfall for the area is about 820 mm, but some parts in the southern end of the valley receive in excess of 1000mm annually. Rainfall is often characterised by storms of high intensity and short duration.

The rainfall is unevenly distributed throughout the year and shows a marked summer dominance with an average of 68 per cent of the annual rainfall falling between October and March. During the summer months flood rains frequently occur, often associated with the southward movement of tropical low pressure systems or cyclones. Average monthly rainfall figures for selected stations are given in Table 3.1 for the climatic year.

Table 3.1 Average Monthly Rainfall (mm)
(all years of record to 1975)

Station	O	N	D	J	F	M	A	M	J	J	A	S	Year
Laidley	65	79	107	129	113	89	50	40	49	40	29	40	830
QAC Lawes	68	75	100	118	101	86	46	39	47	41	29	38	788
Helidon	63	73	103	122	101	87	48	40	51	40	30	39	797

Source: Bureau of Meteorology

The area experiences warm to hot summers and cool to mild winters. During the summer months, maximum temperatures range from 28 to 33°C although extremes up to 40°C have been recorded. During winter, minimum temperatures range from 6 to 10°C. Cold spells producing frosts also occur particularly during June, July and August, but frosts can be experienced from May to September inclusive. The annual evaporation rate is high - about double the annual average rainfall.

3.2 PHYSIOGRAPHY

The area consists of deeply dissected mountains of the Great Dividing Range and the Little Liverpool Range, low hills and an extensive alluvial flood plain.

The Great Dividing Range with peaks to 1024 m forms the western boundary while the Little Liverpool Range with peaks such as Mt. Castle to 824 m form the southern and eastern boundaries.

The southern part is characterized by plateau remnants of basaltic origin deeply dissected by gorges. An abrupt transition with extensive scarp development occurs between the plateau and the low rolling hills which are characteristic of the central portions of the area. To the north and north east of the area extensive alluvial flood plains have developed.

The alluvial plains have been derived mainly from material eroded from the basaltic plateau area in the south.

3.3 SURFACE HYDROLOGY

The study area is drained by the Lockyer Creek and its tributaries. The major tributaries are Murphys Creek, Rocky Creek, Flagstone Creek, Ma Ma Creek, Tenthill Creek, Laidley Creek, Sandy Creek, Woolshed Creek and Plain Creek. Most of the tributaries flow in a northerly direction to meet Lockyer Creek.

Lockyer Creek itself flows in a general easterly direction for about 100 km from the Great Dividing Range to its confluence with the Brisbane River at Lowood. Mean annual runoff from Lockyer Creek is of the order of 100 000 ML, or approximately 30 mm on an area basis. In extreme years, runoff has been in excess of 200 mm.

Lockyer Creek catchment has an area of about 3 000 km^2, and is about one quarter of the area of the Brisbane River basin above its junction with Lockyer Creek. Although the Lockyer provides about ten per cent of streamflow, it contributes disproportionately to urban water treatment costs at the Brisbane City Council plant at Mt. Crosby, below the junction of the Lockyer. For a three year period, suspended solids in the Lockyer averaged 81 ppm and salinity (TDS) averaged 557 ppm. Maximum salinity recorded was 1026 ppm. (pers. comm., Brisbane City Council). Much lower levels are recorded at Mt. Crosby following dilution with better quality water of the Brisbane River catchment.

The creeks of the Lockyer have well incised channels and along their lower reaches have well developed flood plains. An important feature of the drainage is that most of the streams have well developed meander patterns and some of the more easterly tributaries notably Sandy, Laidley and Plain Creeks, have small secondary channels along the margins of the flood plain. These serve as collector channels for runoff from the sides of the valley, and as overflow channels from the main creek in times of flood.

The streams are all characterised by relatively high bank levees making it difficult for runoff from the valley sides to enter the main channel. The development of the marginal channels is a direct result of the development of these levees.

The development of drainage lines in the upland areas has been directly related to the parent geological formation. Examples of drainage density such as 8.5 km/km^2 for basalt, 4 km/km^2 for Ma Ma Creek Sandstone and 3 km/km^2 for Winwill Conglomerate indicate the importance of the geology on surface drainage of the area through jointing, lithology and associated topography.

3.4 GEOLOGY

The study area forms part of the Moreton Basin, which has been studied and mapped by a number of geologists, the most important investigations being by Hill and Tweedale (1955), McTaggart (1963), Jorgenson and Barton (1965), Cranfield and Schwartzbrock (1971) and Zahawi (1975). The geological sequence in the study area comprises conformable Triassic and Jurassic sediments, overlain in part by outpourings of basalt during the Tertiary Period, with extensive deposits of Quaternary alluviums and colluviums.

3.4.1 Triassic Sediments. These are represented by the Helidon Sandstone of McTaggart (1963). The Helidon Sandstone consists of siliceous sandstones and accessory siltstones, and outcrops in the north west. The main outcrop is situated north of the Lockyer Creek outside the study area.

The exposed Helidon Sandstones consist of medium to coarse feldspathic, labile to quartzose, massive sandstone. The matrix is usually argillaceous, but some of the sandstone is brown with a ferruginous matrix.

3.4.2 Jurassic Sediments. These are represented by the Marburg Formation and the Walloon Coal Measures.

The Marburg Formation (McTaggart 1963) consists of interbedded sandstone, siltstone, mudstone and shale with minor thin coal seams. It overlies the Helidon Sandstone conformably and ranges in thickness from 453 - 776 m.

This formation has been further subdivided into four members the Gatton Sandstone, the Winwill Conglomerate, the Ma Ma Creek Sandstone, and the Heifer Creek Sandstone.

(a) Gatton Sandstone Member - this member consists generally of medium grained sublabile to labile sandstone with minor shale and mudstone beds. The thickness of this member ranges from 120 - 230 m. It lies conformably over the Helidon Sandstone.

This member weathers readily and is often described as "marl" by drillers since it weathers to a white porous mass. The Lockyer Creek for most of its course follows the easily eroded sandstone of this member. (McTaggart 1963).

(b) Winwill Conglomerate - this member consists of coarse to very coarse sublabile sandstones, pebble conglomerates with minor lenses of sandstone, siltstone and shale. It lies conformably on the Gatton Sandstone member. It varies in thickness up to 185 m. Silicified wood is a common feature of this member. The member is described by McTaggart as more resistant to erosion than adjoining members and consequently forms low cliffs and abrupt changes of slope.

(c) Ma Ma Creek Sandstone - this member consists of mudstones, shales, siltstones and fine labile to sublabile sandstones. The thickness is not great when compared to the other members, ranging up to 100 m thick. It weathers readily and forms long undulating slopes. The Ma Ma Creek Sandstone conformably overlies the Winwill Conglomerate.

(d) Heifer Creek Sandstone - this member is the thickest of all the members of the Marburg Formation and ranges up to 250 m thick. It consists of interbedded sandstones, siltstones, mudstones and shales. The sandstones are fine, medium and coarse grained, and sublabile to quartzose, with quartzose sandstones dominant. The sandstone beds of this member form low cliffs up to 30 m high and a number of these beds can be traced across the study area.

The Walloon Coal Measures lie conformably over the Heifer Creek Sandstones. They consist mainly of shale, mudstone, siltstone and fine clayey labile sandstones with some coal beds. Calcareous sandstone, clay and ironstone are commonly interbedded. Whilst in other areas this member often has thicknesses ranging up to 200 m exposures within the study area would be generally less than 70 m thick. This member weathers readily to produce heavy clay soils with a mature topographic surface.

Deposition in the Moreton Basin ceased towards the end of the Jurassic Period. This was followed by erosion of the Walloon sediments until about mid Tertiary time.

3.4.3 <u>Tertiary Deposits</u>. The Tertiary Period was marked by a considerable amount of tectonic activity. Outporings of basalt occurred over western and southern parts of the area. Smaller outpourings extended just south of Lowood and remnants occur along the Little Liverpool Range.

These basalt outpourings were interspersed with considerable periods of volcanic inactivity when landscape denudation was occurring. This is evidenced by the areas of Tertiary sediments which have been identified in the eastern extremity.

These have not been mapped as their occurrence is very minor and does not warrant inclusion. However to the east of the study area significant areas of Tertiary sediments occur.

3.4.4 Quaternary Deposits. These form one of the most extensive areas in the study and comprise mostly clay deposits. A number of river terraces and upper valley floors together with the broad alluvial plains of the Lockyer Creek and its tributaries, have been identified as very recent in origin.

These recent deposits have been divided into two broad categories viz: those with a predominance of coarse material such as sand and gravels, and those with predominantly fine materials such as silt and clay.

3.5 GEOMORPHOLOGY

During the course of the study a number of features relating to the development of the catchment appeared anomalous. These included the relatively large expanse of alluvial flood plains compared to the area of upland, the development of oversteepened slopes and scarps towards the headwaters of all tributaries, and the presence of large numbers of both old and new 'landslips'.

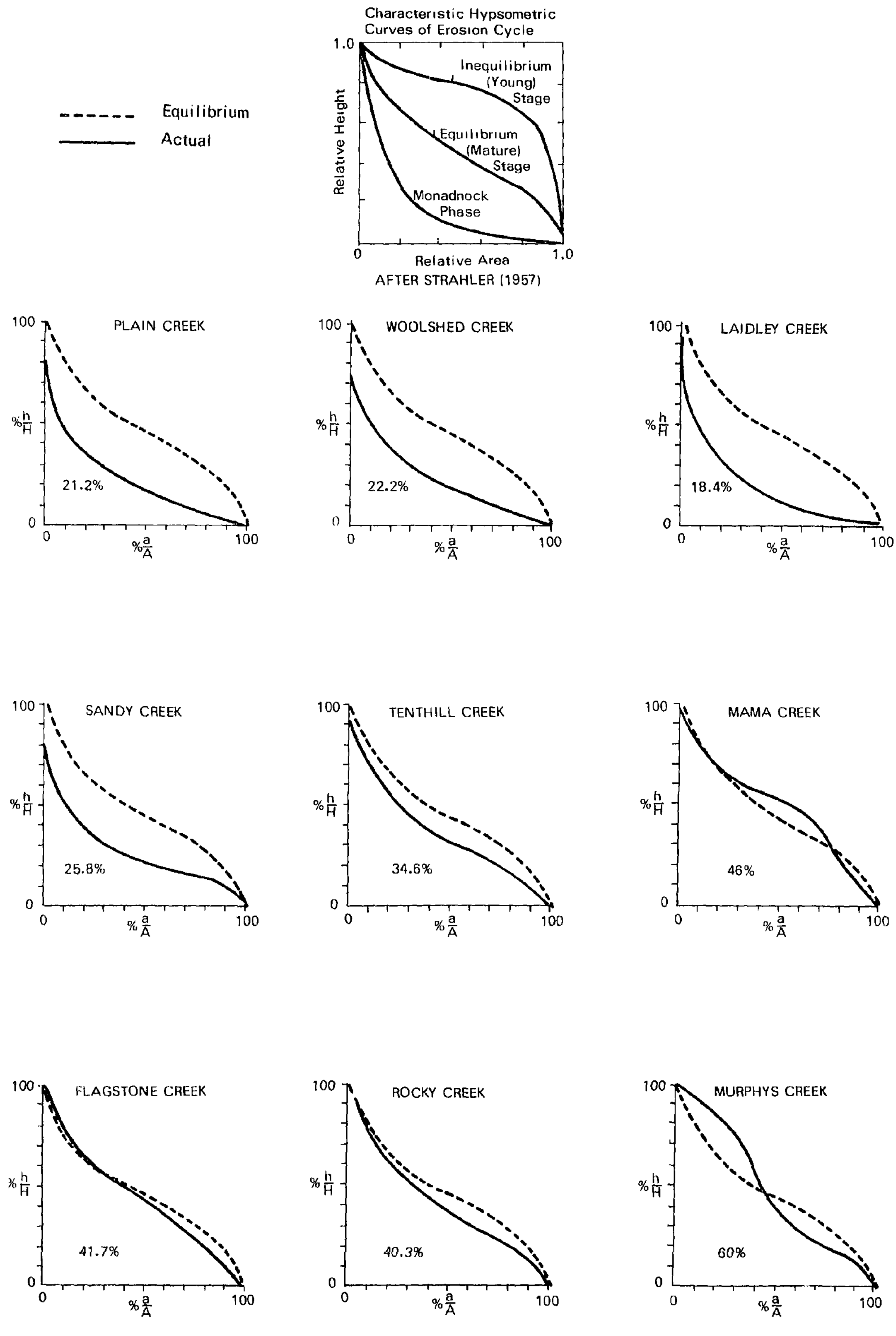
Hypsometric integrals were prepared for tributaries of the Lockyer Creek and are shown in Figure 1. The integrals can be interpreted as profiles of landscape development by erosion processes. For example, the lowest value of 18.4 per cent is for Laidley Creek which has a large alluvial plain; Murphys Creek has the highest value, 60 per cent, indicating a young and inequilibrium stage of development. The integrals indicate that most of the landscape has reached a quite senile stage of development, i.e. the Monadnock phase as described by Strahler (1957). He further attributes the development of this phase to isolated bodies of resistant rock forming prominent hills rising above a generally subdued surface. This resistant rock was provided by the outpouring of basalt during the Tertiary Period.

Scarp development has occurred through differential weathering of the sandstones and basalts. The Gatton and Ma Ma Creek Sandstones are relatively soft, weather rapidly and are easily eroded. The overlying Heifer Creek Member comprises shales and mudstones which weather readily and sandstone beds which are more resistant, forming benches.

The resistant basalt at the top of the sequence maintains a much slower rate of down weathering with a consequent oversteepening of slopes towards the upper reaches of tributary streams.

The majority of landslips occur in the Heifer Creek Member, where alternating beds of coarse sandstone and shale provide conditions conducive to mass movement.

FIG. 1
HYPSOMETRIC CURVES FOR TRIBUTARY STREAMS LOCKYER VALLEY



The development of the relatively large flood plains associated with the Lockyer Creek and its tributaries can be related to late Pleistocene sea level changes. The Brisbane River, the Lockyer Creek and its tributaries have channels deeply incised into bedrock. These channels are up to 30 m deep and have subsequently been filled with alluvium. The downcutting of these channels has been associated with a much lower sea level, some 100 m below the present level, which was associated with glacial eras during the late Pleistocene. With the subsequent rise in sea levels to the present level the decrease in stream gradients has resulted in the filling in of channels and the development of broad alluvial plains. Creeks which have developed large alluvial plains can be seen from the hypsometric integrals shown in Figure 1. These include Plain, Woolshed, Laidley, Sandy and Tenthill Creeks.

3.6 WATER RESOURCES AND IRRIGATION DEVELOPMENT

Reports documenting water resources and water quality in the Lockyer Valley include those by the Bureau of Investigation (1949), Irrigation and Water Supply Commission (1969), and the groundwater investigations by Geological Survey of Queensland (Zahawi 1975). The major water resources of the Lockyer Valley are contained in aquifers within the alluvium associated with the major creek systems in the valley. Sufficient quantities have been located to permit the development of about 13 000 ha of irrigation land, over 80 per cent being from underground sources.

During the 1940's, four weirs with an initial capacity of over 1600 ML were constructed on the Lockyer. Although siltation has seriously reduced storage capacity, the weirs have remained effective in maintaining underground water levels in the vicinity of the stream. More recently, an off-stream storage with a capacity of 31 300 ML was constructed at Atkinson Lagoon to improve suppliers for riparian irrigators in the lower sections of Lockyer Creek and Buaraba Creek.

Parts of the aquifer system have high levels of dissolved salts and have become marginal for irrigation. Poor quality water has entered some of the main aquifers from the surrounding countryside and caused serious deterioration of the water for irrigation purposes.

Water supplies in upland areas are generally of poor quality and yields have generally been low. Most supplies are suitable only as stock water. Surface water in the creeks was the first source of irrigation water. However, with constant siltation of the streams and heavy use, many waterholes have disappeared and supplies have become less reliable.

In 1948, it was estimated that 6 400 ha of land were irrigated and there was a potential for a safe expansion of at least a further 4 000 ha but, this potential may now have been exceeded with some 13 000 ha being irrigated.

Irrigation use of about 50 000 ML is high compared to the estimated mean runoff for the Lockyer catchment of 100 000 ML. Because of the importance of stream flow in maintaining the underground storage, there is little scope for further major water resources development. During the early 1970's three trial weirs with a total storage capacity of about 200 ML were constructed on Ma Ma, Laidley and Flagstone Creeks to determine the effect on recharge of underground supplies. Annual recharge has been estimated at about 700 ML. Recharge with surface water has also reduced salinity levels downstream of the weir.

Considerable interest is now being shown in smaller water conservation schemes including off-stream storages. Several dams have already been built to augment supplies from the underground aquifer or to mix with poor quality underground water for irrigation purposes.

3.7 CURRENT LAND USE

Land use in the Lockyer Valley is very closely related to soil type and topography. The most intensive development has occurred on the alluvial plains. With water available for irrigation and good soils, agriculture has become very intensive, with a wide range of both horticultural and agricultural crops being grown. The majority of cultivated land in the area is on the alluvial soils.

The next most intensively used area is the Ma Ma Creek Sandstone. These beds have developed soils which in the past were considered suitable for cultivation particularly for growing fodder crops for dairy cattle. Oats and sorghum were the most common fodder crops grown.

Most of the area has at some time in the past been cleared of timber for grazing purposes. This has met with variable as many developed areas have been invaded by lantana and wattles.

Currently most of the upland areas of the valley have been retired from continuous cultivation and are now used mainly for grazing. Sown pastures have been introduced into many of these areas in an attempt to improve production. Some favourable upland areas are used for intensive cultivation.

Because of the costs associated with regrowth clearing, many of the steeper areas such as those associated with the Heifer Creek Sandstones and the basalts are being allowed to revegetate naturally. A large area in the south of the valley within the basalts is a State Forest Reserve and is being maintained as a timber production area.

The distribution of land use as determined by this study is presented in Table 3.2.

Table 3.2 Land Use in the Study Area

Land Use	Area (ha)	% of Total Area
uncleared	69 713	35.2
regrowth pasture	51 725	26.1
cleared pasture	33 980	17.2
cultivation	41 817	21.1
urban	725	0.4
Total	197 960	100

4. THE MAPPING UNITS

4.1 INTRODUCTION

The mapping units are based on geology and landform and the geological units described by McTaggart (1963) have been used wherever possible. However strict adherence to lithology has not been possible and modifications to strict lithological boundaries have been made particularly in the Marburg Formation. These have usually been made on the basis of landform. This modification has enabled easy identification of mapping units in the field.

Vegetative indicator species such as bulloak *(Casuarina luehmannii)* have also been used and these will be mentioned in the description of the various units. Additional factors such as position in the landscape, type and degree of drainage development, type and degree of accelerated erosion which has occurred, and distinctive marker horizons within the parent geological unit have also been used to determine mapping unit boundaries (The fold out photograph at end of report illustrates the position in the landscape of the mapping units).

4.2 HELIDON SANDSTONE MAPPING UNIT

This unit consists of Triassic - Jurassic sandstones which underlie the Jurassic sequence throughout the study area.

A small area of this unit, with outcrops of coarse cross bedded sandstones and pebble conglomerates occurs in the northwest of the study area. The main exposure of the Helidon Sandstone is to the north of the present study area.

Within the study area this unit tends to be of low relief but outside the study area the unit is deeply dissected with a well developed drainage network. The soils are generally shallow skeletal or sandy soils. Erosion in the unit, while evident, is of a minor nature. The vegetation growing on the unit is generally narrow-leaved ironbark forest *(Eucalyptus crebra)* with a wattle understorey. Much of the unit has been reserved for timber production as a State Forest.

4.3 GATTON SANDSTONE MAPPING UNIT

This unit is essentially the Gatton Sandstone as described by McTaggart (1963). The major exposures are again outside the study area to the north east. However, this unit can be found striking in an east west direction along the fringe of the alluvial plain of the valley. It is characterized by low relief and where the parent rock outcrops it has often weathered to a white marl-like appearance. Drainage lines are generally broad and flat and have developed few side valleys.

Soils in this mapping unit are generally shallow to moderately deep, neutral to acid, bleached, texture contrast soils - Dy 3.42, Dy 3.31, and Dy 3.41. (Northcote 1965)

Accelerated erosion is often very evident on this unit in the form of extremely badly gullied patches. This occurs particularly where the clay subsoils are exposed,for example, along roadways and stock tracks.

Moreton Bay ash *(Eucalyptus tessellaris)* occurs generally on this unit and the alluvials, and was used as an indicator for the unit during mapping.

4.4 WINWILL CONGLOMERATE MAPPING UNIT

The Winwill Conglomerate which comprises the bulk of this unit is extremely coarse grained. Alternating strata of coarse sandstones and conglomerates have produced a landscape with a series of short steep slopes up to 20 per cent in places and well rounded hills in other areas.

The unit occurs between the Gatton Sandstone Mapping Unit and the Ma Ma Creek Sandstone Mapping Unit particularly to the north west of the study area. However, to the north east and much of the central parts of the area this unit adjoins the alluvial plain. Slopes in the central and north east portion of the unit are much flatter than in the north west and are generally in the range of from 2 to 5 per cent.

Drainage lines are similar in configuration and density to the Gatton Sandstone Mapping Unit but lack the secondary incision so common on that unit.

A characteristic feature of this unit is the presence of gravel on the surface of most soils shed from weathering of conglomerate bands in the unit. Soils found are typically shallow to moderately deep neutral to acid, mottled bleached texture contrast soils Dy 3.42, Dy 3.31 and Dy 3.41. There is potential for gully erosion when these soils are disturbed, but with the limited land use generally applied to this unit there is little problem with erosion.

Bulloak *(Casuarina luehmannii)* grows in association with narrow-leaved ironbark which predominates on this unit and proved useful in mapping the upper level of this unit.

4.5 MA MA CREEK SANDSTONE MAPPING UNIT

This unit is the most distinctive member of the Marburg Sandstones. It is characterized by well rounded hills, long slopes and broad drainage lines. The Ma Ma Creek Sandstones are easily weathered and eroded under natural conditions. Slopes developed generally range from 2 to 4 per cent in the lower parts of the landscape to 10 to 20 per cent in upper parts. A sharp break in slope occurs at the top of this unit where it merges with the Heifer Creek Sandstone Mapping Unit and was used as a distinctive point on which to separate the two units.

A diversity of crops can be grown on the alluvial plains. In the foreground is a crop of cabbage, with an orange orchard in the background. Citrus are widely grown in the Grantham area.

Creeks crossing the alluvial plains have deeply incised channels, but are rapidly becoming choked with vegetation and silt.

The unit is easily recognized by the drainage pattern. The waterways are broad, typically U-shaped and dendritic in nature. The density of drainage shows a marked increase over previous units.

Soils developed on this unit are moderately deep to deep, grey or brown structured earths Gn 3.91 and Gn 3.94. In some localities particularly in the north east of the study area deep, gilgaied, grey or brown cracking clay soils, Ug 5.24 or Ug 5.34, can be found.

Of all units this is the most extensively developed, with the majority of it being cultivated at some time. Much of the unit has now been returned to pasture but the pattern of cultivation is still visible. It is also one of the most eroded units in the study area with sheet and rill erosion being the dominant forms of erosion.

The unit originally carried a softwood scrub vegetation. The western area was characterized by a type of vine scrub but the eastern end was predominantly brigalow - belah scrub.

4.6 HEIFER CREEK SANDSTONE MAPPING UNIT

This unit is relatively easy to identify. An abrupt change of slope occurs generally between this unit and the Ma Ma Creek Sandstone Mapping Unit below. This change of slope coincides with a bed of coarse quartzose sandstone, the lowest of six similar beds which occur within the Heifer Creek Sandstone member. Lithologically this bed is not the base of the Heifer Creek Sandstone but for the purposes of this survey provided a useful mapping boundary.

The top of this unit is capped by the Walloon Coal Measure Mapping Unit over most of the study area. An abrupt change of slope occurs at this boundary also. In areas where the Walloon Coal Measures are absent this unit is usually capped by the Basalt Mapping Unit but areas do occur where this unit forms the highest part of the landscape.

The Heifer Creek Sandstone which forms the bulk of this mapping unit comprises interbedded coarse quartzose sandstones, shales, mudstones and siltstones. Steep slopes in excess of 20 per cent and a deeply dissected landscape are common features.

Drainage in this unit is usually well defined with the network generally parallel in nature.

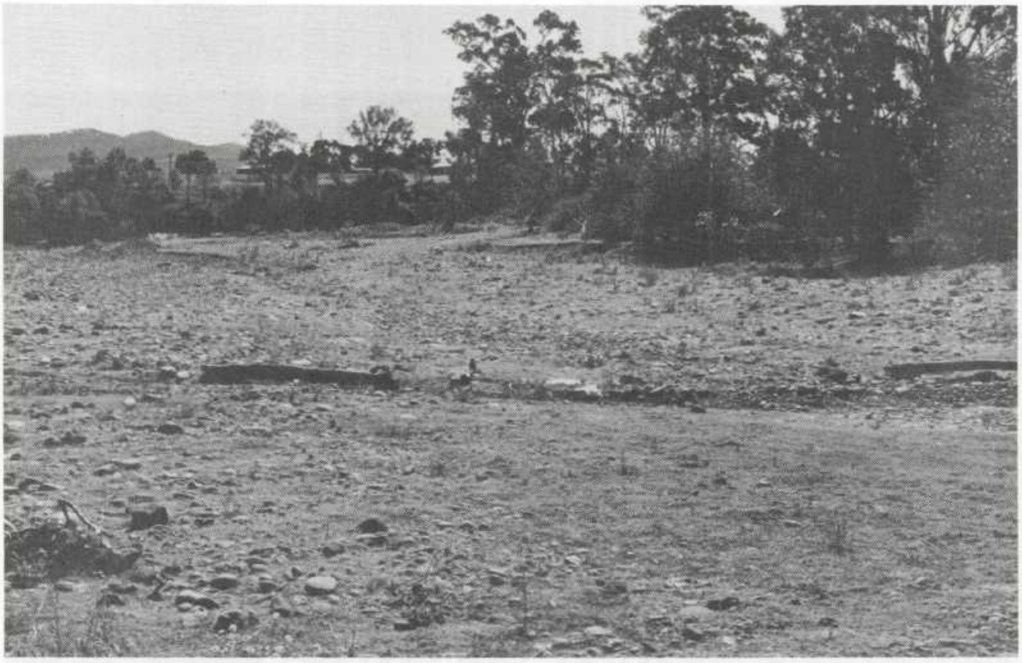
Soils developed on this unit are generally quite heterogenous and exhibit variable characteristics. However, the major soils groups include neutral to acid, yellow to grey, shallow to moderately deep texture contrast soils Dy 2.21, Dy 2.41 and Dy 2.22 as well as structured earths Gn 3.91 and Gn 3.92 and smaller areas of uniform cracking clays Ug 5.24 and Ug 5.34 and mottled texture contrast soils Dy 3.42, Dy 3.31 and Dy 3.41.

The majority of the soil erosion in the study area is occurring in this unit and landslips and gully erosion are extremely serious.

As water quality has deteriorated, crops such as beetroot which are more salt tolerant, have replaced the more traditional potatoes and onions. This has lead to the development of a processing industry based in Laidley.

Contour planted vineyard on the Hillwash Alluvium and Colluvium Mapping Unit. Note the newly constructed water storage dam in the middle of the photo. The water from this storage will be used to trickle irrigate the grapes.

Gravel beds in the upper reaches of creeks provide excellent intake areas for the alluvial aquifers which underlie the alluvial plains.



Where serious degradation has occurred in the upland areas above the gravel intake beds, silt deposition in the stream seriously impedes the flow of water into the aquifer. A serious landslip problem occurs just upstream from this site, and sediment from these slips is being deposited in this area and further downstream.

The vegetation growing is complex but two major subdivisions exist. In the central portion of the study area there is a predominance of fine-grained sediments which have weathered to loams and clays. These areas have in the past supported a vine scrub vegetation. This vegetation can also be found in the north-east of the study area. However, in the north-west and south-east sectors coarser material is dominant. The soils developed in these areas are dominantly texture contrast, and support a forest type vegetation.

4.7 WALLOON COAL MEASURES MAPPING UNIT

In areal extent this unit is one of the smallest. For the most part exposures of Walloon Coal Measures are very narrow, lying between the underlying Heifer Creek Sandstone Mapping Unit and the Basalt Mapping Unit above.

The fine-grained lithic sandstones of this unit weather and erode easily to produce a landscape of low relief. For most of the unit, drainage is ill-defined except in those areas where the drainage is strongly controlled by adjoining larger mapping units such as the Basalt Mapping Unit and the Heifer Creek Sandstone Mapping Unit.

Soils developed on this unit are predominantly moderately deep to shallow dark cracking clay soils Ug 5.13. Sheet and gully erosion are common on soils of this unit and protection against raindrop splash and overland flow is required.

The vegetation found on this unit is generally of a forest type but small areas of scrub occur particularly in the eastern parts of the study area.

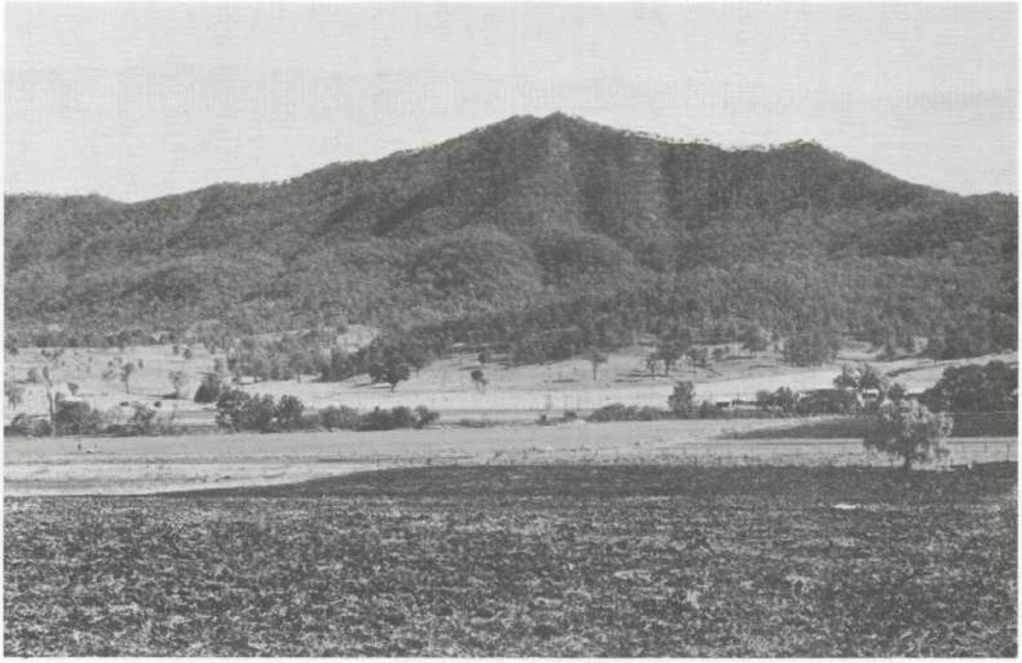
4.8 BASALT MAPPING UNIT

This unit comprises the basalts and other igneous intrusions for example, minor trachyte bands.

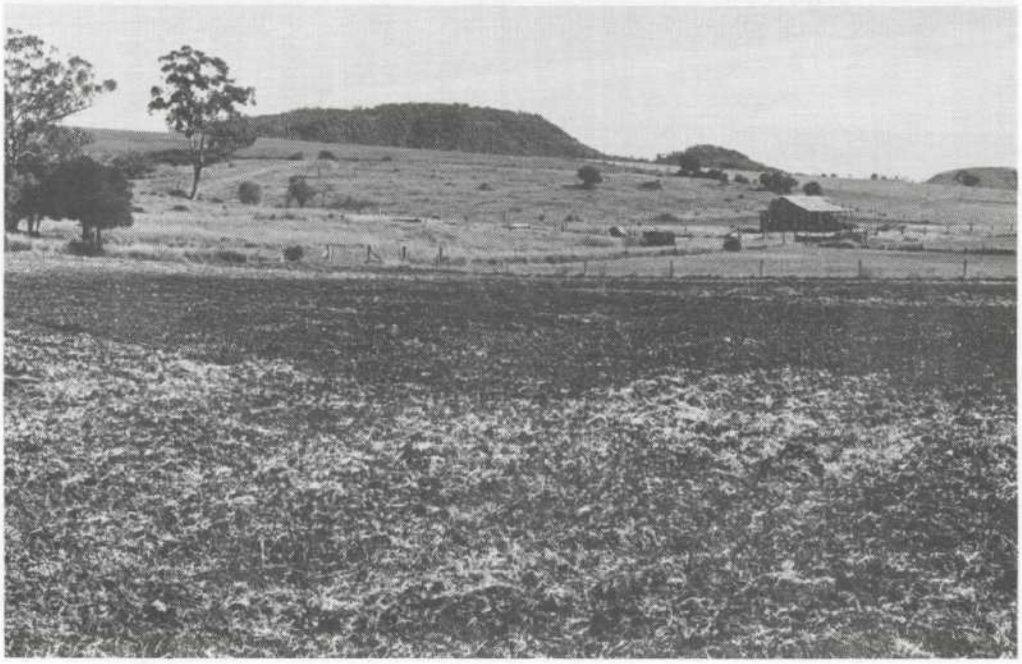
The basalt flows occurred during the Tertiary era and flowed over a mature landscape. As such the boundary between the basalt and the underlying strata occurs at different heights and often shows an uneven distribution. The basalts generally occur on the highest parts of the landscape and are relatively easy to recognize both on aerial photographs and in the field. In the more inaccessible areas, the unit can be recognised by hummocky landforms. Slopes are generally quite steep being in excess of 20 per cent.

The drainage network is well developed with the highest density of drainage of all mapped units. The drainage tends to be parallel in configuration.

Soils developed on the basalts are generally shallow, dark non-cracking clays Uf 6.12, Uf 6.13, Uf 6.31, Uf 6.32. Small areas of shallow, dark, cracking clays also occur Ug 5.12.



Lands typical of the Basalt Mapping Unit. Note the steep upper lands have been left in timber, while the lower hill slopes have been cleared for grazing. The valley floor alluvials in the foreground are the only areas cultivated.



The Walloon Coal Measures Mapping Unit lies topographically below the Basalts. Much of this unit has been cultivated in the past, but because of serious erosion has now been returned to pasture.

Gully erosion is the main degradation in the basalts, and occurs in valley floor and lower slope situations where the unit has been cleared. Some landslipping also occurs on cleared lower slope areas.

The vegetation on this unit is predominantly forest but small areas of vine scrub and rain forest exist in more favourable locations.

4.9 LATERITE MAPPING UNIT

This unit occupies only the highest positions in the landscape generally above 600 metre elevation. The lateritization process took place during the late Tertiary era and only remnants are left. These laterite remnants are easily recognised on aerial photographs by the rain forest vegetation they support and where this is absent by the red soils developed on it.

Slopes are generally low but can be quite steep, particularly on plateau edges where steep scarps have developed in the basalt which underlies this unit.

Drainage is poorly defined because of the high infiltration capacity of the soils of the area.

The soils developed on this unit are generally red, acid structured earths Gn 3.12.

The laterite unit has deep permeable clays and is subject to landslip.

4.10 ALLUVIUM MAPPING UNIT

This unit comprises the stream and flood plain alluvium. These broad plains have developed as a response to changed hydrologic characteristics (see section 4.7) in the Brisbane River and the Lockyer Creek. They are extremely flat with slopes for the most part less than 0.5 per cent. The material deposited to form the plain has, for the most part, been derived from the basalts.

The drainage of the plain consists of a marked creek channel, generally well incised, which meanders irregularly across the plain. Secondary drawdown channels occur at the margins of the plain and these act to drain the plain particularly when the creek capacity has been exceeded.

The streams have well developed levees and the plain generally slopes from these levees to the plain margins. These slopes are, however, still very low.

Soils developed on the alluvial plains are deep, dark grey, grey or brown, cracking clay soils. Gilgai formation is present in many areas particularly in the north-east. Typical soils include Ug 5.15, Ug 5.24 and Ug 5.13.

The alluvium is subject to erosion flooding about drainage lines where the soils have been exposed through cultivation.

The vegetation on the alluvial plains was predominantly Queensland blue gum *(Eucalyptus tereticornis)* but scattered Moreton Bay ash and river red gum *(E. camaldulensis)* can be found. This unit is now extensively cultivated and only poorly drained and swampy areas now remain uncultivated.

4.11 HILLWASH ALLUVIUM AND COLLUVIUM MAPPING UNIT

Within some of the mapping units, notably the Ma Ma Creek Sandstone, Winwill Conglomerate and Gatton Sandstone Mapping Units, broad valley depressions have formed at higher elevations than the alluvial plain. Along the margins of the flood plains drainage lines from the hillslopes have deposited large quantities of debris as colluvial and alluvial fans; and in some localities old river terraces remain along the margins of the flood plain, particularly in the upper reaches of tributary streams.

These three types of deposits have been separated from the units in which they occur and have been bulked together as a separate unit. The soils contain the coarser fragments eroded from the hillsides. They also frequently contain gravel.

The drainage associated with these deposits is generally complex with minor channels developing across the broad depressions and fan deposits. This occurs because of the continual deposition and removal of debris which is occurring in these locations.

Soils developed on this unit are often similar to those developed on the alluvial plains but more often the soils are much coarser in texture with sands and loams predominating.

The vegetation growing on these areas is extremely variable and for the most part has been cleared. Many areas, particularly upland valley floors, have been cultivated. As a consequence, this unit is the most seriously gullied in the study area.

5. LAND DEGRADATION

5.1 GENERAL

Erosion has been mapped under the three categories of sheet, rill and gully erosion. An area basis has been used to determine the extent of sheet and rill erosion. Gully erosion on the other hand was virtually impossible to map and measure as an area affected, and hence has been mapped as a line on the map with the length measured. This length then has been related to the area of map units as gully length (m/ha), to give a basis for comparison between the various map units. It also provides a measure of the severity of the problem throughout the study area.

A summary of the extent of the area affected by these various forms of erosion as related to land units is presented in Table 5.1. (The forms of erosion are as defined in Section 2.2)

Over 10 per cent of the total study area has been degraded by sheet or rill erosion or erosive flooding. The area recorded as affected by salting is over 500 ha. Over 1 000 landslips were identified and the length of gullies was estimated at 949 km, or an average length of about 5 m per ha. From field observation and aerial photographs of the average area involved in each landslip it is estimated that about 6 per cent of the catchment is affected by landslip. For gullies, assuming an average width of five metres and depth of one metre, about 500 ha are involved. The total area subject to degradation is estimated at 33 000 ha or 17 per cent of the study area.

A summary of the extent of the area affected when compared against land use is presented in Table 5.2. Cultivation lands account for 68 per cent of areas degraded by sheet and rill erosion and erosive flooding. Landslips are concentrated on areas which have been recently cleared.

5.2 SHEET EROSION

In total some 14 424 ha of land have been subjected to fairly severe sheet erosion. From the two tables it can be seen that 70 per cent of the area affected occurs on only three of the mapping units - Ma Ma Creek Sandstone, Heifer Creek Sandstone and the Hillwash Alluvium and Colluvium. Also, erosion has been confined generally to those areas of the units which are cultivated, comprising 66 per cent of the units. Of the sheet eroded areas, 85 per cent are on land which is presently being cultivated or has been returned to pasture from a cultivation phase. This highlights the importance of land use in relation to the severity of this form of erosion.

Table 5.1 Land Degradation in Relation to Mapping Units

Mapping Unit	Area of Unit ha	Sheet Erosion		Rill Erosion		Salting		Landslip	Erosive Flooding		Gullying Length	
		Area	% of Unit	Area	% of Unit	Area	% of Unit	No. per Unit	Area	% of Unit	km	m/ha of Unit
Laterite	736	-	-	-	-	-	-	5	-	-	-	-
Basalt	64 715	865	1.3	-	-	-	-	117	-	-	114	1.8
Walloon Coal Measures	7 695	1 380	17.9	6	0.07	-	-	-	-	-	43	5.6
Heifer Creek Sandstone	49 983	2 367	4.7	310	0.6	-	-	1 005	-	-	341	6.8
Ma Ma Creek Sandstone	13 129	5 703	43.4	957	7.3	9	0.06	8	-	-	84	6.4
Winwill Conglomerate	13 152	656	4.9	347	2.6	53	0.4	-	6	0.04	79	6.0
Gatton Sandstone	4 330	297	6.8	210	4.8	13	0.3	-	6	0.13	20	4.6
Helidon Sandstone	249	-	-	-	-	-	-	-	-	-	-	-
Hillwash Alluvium + Colluvium	6 799	2 076	30.5	118	1.7	-	-	-	-	-	127	18.7
Alluvium	37 172	1 080	2.9	160	0.4	442	1.08	-	4 348	11.7	141	3.8
TOTAL ALL UNITS	197 960	14 424	7.3	2 108	1.06	517	0.26	1 135	4 360	2.2	949	4.8

Table 5.2 Land Degradation in Relation to Land Use

Land Use	Area ha	Sheet Erosion		Rill Erosion		Salting		Landslip	Erosive Flooding	
		ha	% of Area	ha	% of Area	ha	% of Area	No.	ha	% of Area
Uncleared	69 713	451	0.6	103	0.15	-	-	115	-	-
Regrowth Pasture	51 725	1 605	3.1	383	0.7	155	0.3	734	27	0.05
Cleared Pasture	33 980	2 797	8.2	694	2.0	143	0.42	286	604	1.8
Cultivation	41 817	9 571	22.9	928	2.2	219	0.52	-	3 729	8.9
Urban	725	-	-	-	-	-	-	-	-	-
TOTAL	197 960	14 424	7.3	2 108	1.1	517	0.26	1 135	4 360	2.2

Sheet erosion, often serious, can also be seen in some areas which have not been cultivated, but where over-grazing has occurred over long periods, for example on the Gatton Sandstones and Winwill Conglomerates.

5.3 RILL EROSION

Rill erosion is most serious on those land units affected by sheet erosion. A total of 66 per cent of the area of rill erosion occurs on the three units previously mentioned.

The Gatton Sandstone with only 2.2 per cent of the total area of the valley has 10 per cent of the area of rill erosion contained in areas of extremely gullied land impracticable to map as individual gullies.

5.4 GULLY EROSION

This has been mapped and measured as a total length of gully and no attempt was made in the field to accurately measure the area of land involved.

Gullying within the various mapping units ranged from 1.8 m of active gully per ha to 18.7 m per ha. The average length of gullying in the study area is 4.8 m per ha. In the Landsborough area of Victoria where extreme gullying exists the average length of gully is 28 m per ha (Milton 1971).

The unit having the worst gully problem is the Hillwash Alluvium and Colluvium Mapping Unit with 18.7 m per ha of gully. This unit is naturally unstable since it covers those areas where deposition and removal are occurring simultaneously and hence gully development is more a natural phenomenon than a problem of incorrect land use on the area affected.

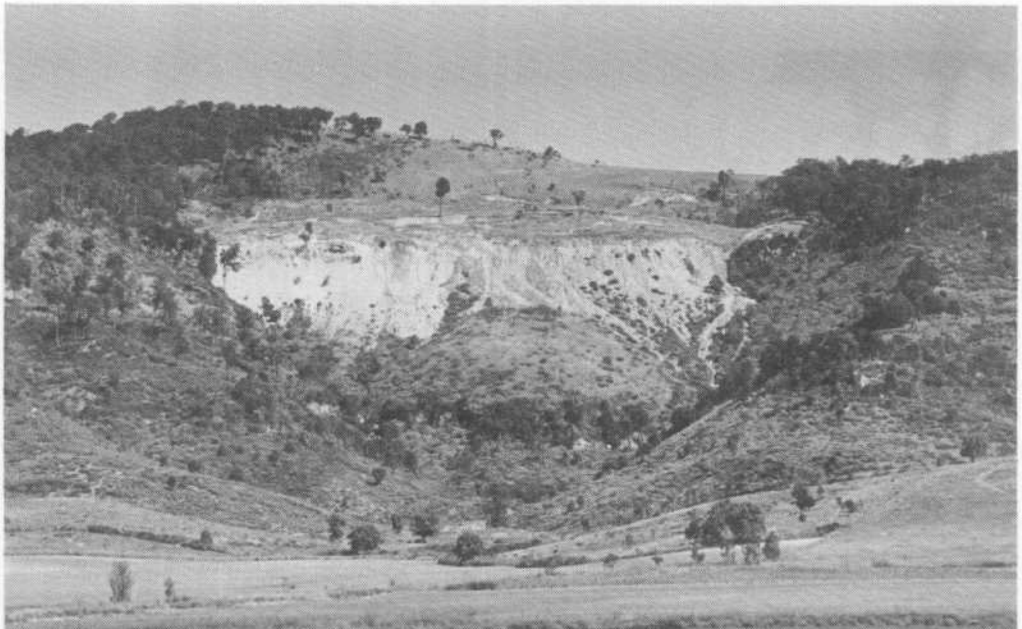
It is also worth noting that on the Gatton Sandstone Mapping Unit, the Winwill Conglomerate Mapping Unit and the Heifer Creek Sandstone Mapping Unit, a serious gully problem exists with over 6 m per ha of gullies.

Because of the complexity of the land use map, it was not possible at the scale of mapping to compare gullying with land use.

5.5 EROSIVE FLOODING

A considerable problem exists with erosive flooding. Laidley, Sandy and Lockyer Creeks in particular do not have sufficient capacity to carry the large volumes of water which they are required to carry. Flooding of the alluvial plain along these creeks is therefore fairly common.

Lands typical of the Heifer Creek Sandstone Mapping Unit. The beds of coarse sandstone forming low cliffs can easily be distinguished. Generally six of these beds occur within this mapping unit.



Landslip - this huge landslip is one of many occurring throughout the study area. The majority of these movements occur on the Heifer Creek Sandstone Mapping Unit. Note that the movement has only occurred where the land has been cleared. The outside face is being eroded away by normal erosion processes.

With the advent of cultivation and a "square pattern" of farming, flood water has often been diverted in unnatural directions. As well as water diversion, soil build-up particularly on the upstream side of fences and roads has been another common feature. These two factors have often combined to produce velocities capable of scouring the flood plain, particularly in areas where the land is cultivated.

In many areas, roads have also played a part in increasing flow velocities by retarding flow, diversion of flows to cross-drainage structures, and concentration of flows at these points.

The problem on the alluvial plain has reached serious proportions with over 11 per cent of the alluvium affected by this form of degradation.

5.6 LANDSLIP

Mass movement is not a new phenomenon in the Lockyer Valley. Many examples exist of large movements occurring in the more distant past. From the evidence, these movements were in general much larger than those which have occurred recently. From the size of the timber growing on these areas and the drainage development which has taken place, most of these larger movements appear to have occurred before European settlement.

Recent movements, the majority of which have occurred since the 1974 flood rains, are of much smaller magnitude. They are also much more widely distributed throughout the valley suggesting that recent changes in the valley have been responsible for the sudden upsurge in the number and extent of mass movements.

As discussed in Section 2, the survey of landslips was based on 1974 aerial photography supplemented by field observations. Numerous slips have occurred since 1974 and many of these have thus not been mapped. The total number identified was 1135. Field observations suggested an area of 10 ha as the average area immediately affected by landslip. Overall, the Heifer Creek Sandstone Unit with an estimated 20 per cent affected, is the most severely degraded by landslip.

A number of facts suggest that the influence of man through clearing has had a major impact on the basic stability of the areas in question. Firstly, greater than 90 per cent of all movements and have occurred on lands which have been cleared in the recent past. Of these movements, 64 per cent have occurred on areas which have been cleared but have since been allowed to revert to a regrowth timbered condition. The regrowth condition includes all those areas which have been seriously invaded by lantana *(Lantana camara)* and African boxthorn *(Lycium ferocissimum)* as well as native tree species which were previously present. Of the 10 per cent of landslips which have occurred on uncleared land the majority were situated immediately above or below areas which have been cleared, suggesting that the initiation of the movement has still been related to the clearing.

Several workers, notably Graf (1977), have stated that a lag phase exists between a major change in the factors promoting stability in an area and a movement towards stability under the changed conditions. It is believed that such a lag has occurred in the valley and that the flood rains of 1974 provided the initiating conditions necessary to cause the movements which have occurred.

As mentioned previously these movements have continued since the 1974 flood rains which suggests that the frequency and severity of the movements will continue to increase until a new level of stability has been achieved or until the previous well-vegetated state has been restored.

Unfortunately the degradation resulting from these mass movements is not confined to those areas on which the movements took place.

Sediment movement becomes greatly accelerated from areas where mass movement has occurred. In many areas these sediments have filled local stock water dams, and have deposited a sheet of coarse sandy material over the alluvial plain in close proximity to the landslip area. Fine sediments have been carried considerably further and have been deposited in the creek systems or removed totally from the valley.

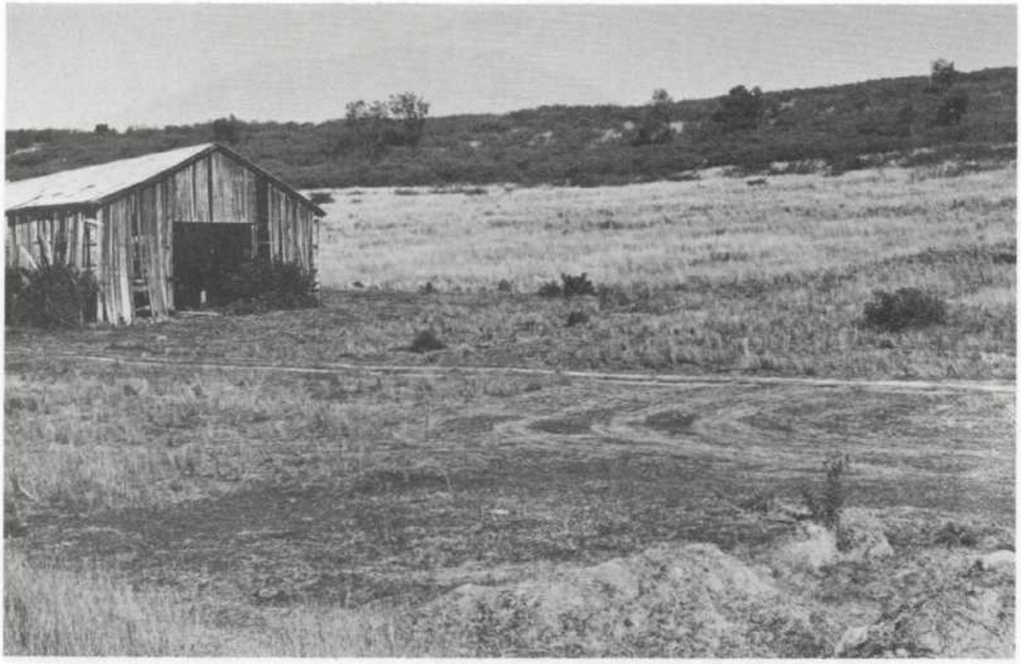
The distribution of landslips in relation to the mapping units can be seen from Table 5.1, 88 per cent of all landslips have occurred on the Heifer Creek Sandstone with the bulk of the remainder occurring on the basalts. The slips occurred most frequently where the stability of the basalt has been greatly reduced by the excessively steep slopes developed on the underlying Heifer Creek Sandstones. This is particularly the case in the upper reaches of Wonga Creek, a tributary of Tenthill Creek.

5.7 SOIL SALINITY

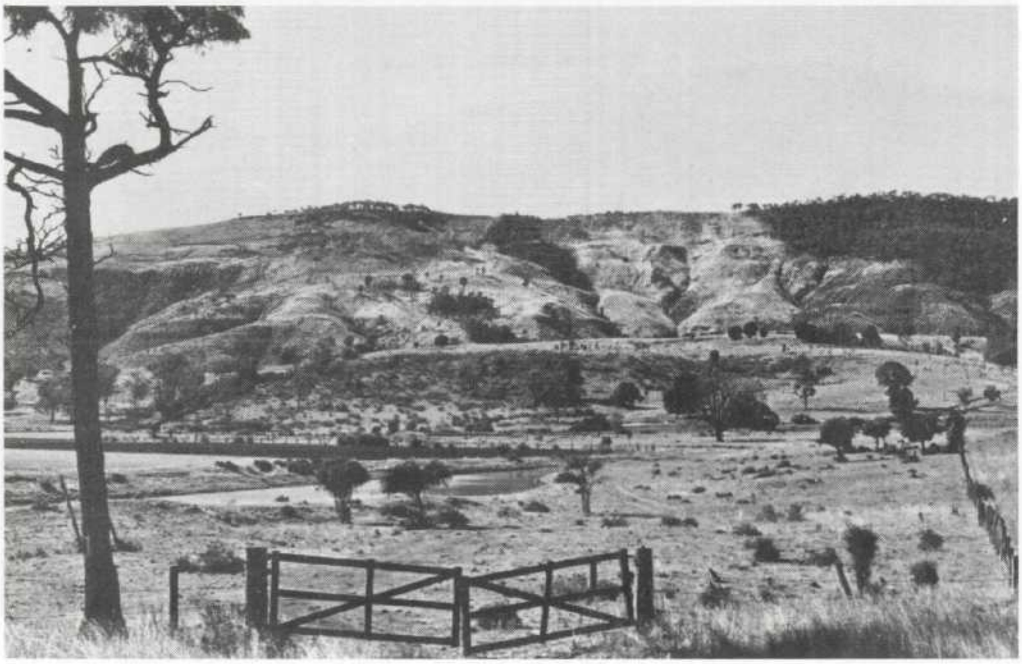
One of the more ominous forms of degradation occurring in the catchment is the development of large saline patches. An area of 517 ha was recorded as severely salt affected. Landholders consider the area is steadily increasing.

Zahawi (1975) has studied the presence of various salts in the groundwaters of the area and Talbot and Dickson (1969) have analysed the quality of stream waters from the Lockyer Valley. An examination of their results in conjunction with the present study highlights a number of pertinent features which give an indication of the source of the problem of saline soil development.

From the previous work it is obvious that there is a direct correlation between the area of basalt (in relation to volume) **which** acts as a runoff/recharge area for stream flow and water quality of streams. Where the area of exposed sandstones is large in comparison to the area of basalt, stream water quality is poor.



Infestation of pasture lands by Lantana is a common feature. This photo shows an infestation of Lantata on Heifer Creek Sandstone Mapping Unit.



Overclearing of steep upper slopes particularly on the Heifer Creek Sandstone mapping unit has led to deep gullying. A landslip can also be seen in the upper left.

There appears to be a threshold area (volume) of basalt required to ensure good water throughput to the streams sufficiently to dilute the poor waters entering from the sandstones. This is the case in Laidley, Tenthill, and the upper reaches of Ma Ma, Heifer and Flagstone Creeks.

The flow from the basalts in the upper reaches of Flagstone, Heifer and Ma Ma Creeks is not sufficient to dilute the water entering from the sandstones in the lower reaches of the creeks. Water quality is generally poor in those creeks where the proportion of basalt to sandstone is low e.g. Deep Gully, Wonga, Monkey Waterholes, Sandy and Rocky Creeks.

From the work of Zahawi, saline groundwaters are being contributed by all the major sandstone members in the area. Differences between members are also apparent. All members above the Gatton Sandstone in the Marburg Formation are high in soluble chlorides. The Gatton Sandstone differs in that it is high in free alkali in the form of sodium ions.

The Winwill Conglomerate is generally the lowest exposed member in the sequence adjoining the alluvial plain and the majority of permanent saline patches occur adjoining this member. It is possible there has been some accumulation of salts into the lower beds by movement of groundwater, through overlying beds. The appearence of small patches in upper areas is more of a seasonal phenomenon associated with periods of high rain fall and higher water tables.

Saline patches have been located in all members below the Heifer Creek Sandstone but many were too small to represent at the scale of mapping used in the present study. It is important to realize however, that they do occur and indicate local appearances of the underground water table at the soil surface.

The appearance of saline soil patches can be directly related to clearing of vegetation from sides and upper slopes of affected valleys. The removal of trees has allowed water tables to rise in these localities increasing the level of salts and developing surface saline areas.

In addition the lowering of water tables within the alluvial aquifer through excessive irrigation is a contributing factor to the development of some saline areas. In some areas this lowering has been as much as 13 m, from a depth of 2.5 m originally, to present depth of 16 m. The lowered water table reduces the flushing effect whereby fresh waters in the alluvials dilute adjoining areas of saline water associated with the sandstones. In many cases it seems the soils have acted as impermeable membranes allowing diffusion of fresh water to dilute saline build ups in toe slope positions. When the water levels in the alluvial aquifer are low,diffusion cannot occur and the salts are held back by the soils, allowing salt build up.

Detailed investigations are required to determine the economic possibility of draining certain areas affected by water table salting, with consideration of disposal of saline drainage waters, water table depth and volume of saline water involved.

No attempt was made to ascertain the degradation occurring through the use of poor quality irrigation water. It is known that within many areas of the alluvial plain landholders are now forced to grow only the most salt tolerant crops such as beetroot and cotton. It is not known at this stage whether this is due entirely to the use of poor quality water or whether salt accumulation in the soil profile is forcing farmers to grow these crops (Talbot *et al* 1971). A detailed investigation of this problem is also needed.

6. CONTROL OF TYPES OF LAND DEGRADATION

6.1 INTRODUCTION

It is apparent from the study that there is a close correlation between land use and the appearance of the many forms of degradation. It is equally apparent that the treatment imposed on one given area will have ramifications for other areas and units. To this extent it is essential that measures taken to overcome the degradation occurring be viewed against a background of its possible effects and repercussions in other areas or units.

The only feasible and practical method of achieving such an aim is catchment planning linking land use and treatment for the whole area, rather than attempt remedial action on a piecemeal basis.

Recommendations have been made in recognition of the fact that inter-relationships exist and that a multi-disciplinary approach will be required to effect solutions to all major forms of degradation occurring in the study area. In this section, treatment needs are discussed for the types of degradation in the catchment. In the final section of the report, recommendations are further developed and presented in terms of the inter-related needs of the land units in the catchment.

6.2 SOIL EROSION

The major forms of soil erosion occurring in the study area are sheet, rill and gully erosion. Sheet and rill erosion are closely associated and are concentrated on lands that are cultivated or have been cultivated.

Sheet erosion results from surface sealing of the soil caused by raindrop splash and overland flow of water removing material dislodged by the effects of raindrop splash. Soil types in units where this form of erosion is particularly prevalent are susceptible to raindrop splash and surface sealing. It will therefore be necessary to implement land management practices to avoid denudation of the soil surface particularly during those periods of the year when high intensity rains will occur.

A system of mulch farming should be introduced on those areas suitable for sustained agricultural production by cultivation. Areas not suitable for cultivation because they are too steep or they have been too seriously eroded in the past, should be returned to permanent improved pasture.

In many areas, length of slope will be an added problem particularly during very intense or prolonged rain periods when runoff will occur irrespective of surface management. Where this situation exists a system of diversion or contour banks will be required to control runoff water.

Where rill erosion cannot be controlled on cultivated lands, pasture improvement measures will be required. On pasture land, stock should be excluded until the area is revegetated. A program of gully stabilization involving the use of diversion banks, gully dams, and head and side wall battering may be necessary in some areas before satisfactory revegetation may be possible.

Gully erosion will be more difficult to control. The majority of the gully erosion is occurring on lands which require a permanent change in land use and this will be dealt with in succeeding sections. However, within one of the units, namely Hillwash Alluvium and Colluvium, a particularly serious problem of gully erosion exists. Much of this problem derives from natural phenomena and little will be achieved by attempts at reclamation. Fencing of some of these areas to permit controlled management will often be successful in reducing the severity of the problem particularly in those areas where improved pastures can be introduced. Changes in land use in upper catchment areas will markedly reduce sediment deposition in these areas and will influence greatly the speed of development of the colluvial and alluvial fans characteristic of this unit. This in itself will reduce the rate of gully erosion.

6.3 LANDSLIP

Clearing of steep upper slopes has been largely responsible for the dramatic increase in the number and extent of landslips which have occurred. Over 90 per cent are on lands cleared in the recent past. The sediment produced from these mass movements has been largely responsible for the development of alluvial and colluvial fans down drainage lines and across lower slopes. It is from these fans that much gully erosion originates.

It is critical to the stabilization of not only the steeper lands subject to landslip but to lower landscape units that these steeper lands, particularly where land slips are concentrated, be returned to forest type vegetation as quickly as possible. Complete destocking during the revegetation phase will also be necessary.

6.4 SALINITY

Since the problem of salinity is not a localized phenomenon but originates from a number of inter-related processes the solution cannot be simple.

Saline outbreaks are about equally common in cultivation, and cleared and regrowth pasture lands. The majority are in the alluvial plains particularly where the Winwill Conglomerate Unit is adjoining. As with the problem of landslip, control of salinity is tied very closely to the revegetation of steep upper slopes by forest type vegetation. Such revegetation, particularly on the sandstones, will effect a lowering of hillside water tables and reduction in the supply of poor quality underground water to saline areas. This will be a necessary prerequisite for any reduction in saline outbreaks, and is particularly the case where the ratio of basalt to sandstone is small and the major intake areas for the underground water table are the sandstones.

One of the more obvious factors relating to outbreaks of salinity is the exploitation of the alluvial aquifers. The reduction in storage in these aquifers has contributed to the development of saline areas by stopping the lateral movement of good quality water from these aquifers to areas containing the more saline groundwater. It will therefore be necessary to control removal of water from the alluvial aquifers to:

(a) provide for long term sustained yield and

(b) to reduce the development of saline conditions in both the groundwater and soils particularly on the margins of the alluvial plains.

6.5 EROSIVE FLOODING

The alluvial plains have developed as a result of the inability of streams to carry the volumes of water they are occasionally required to carry, together with a slowing in velocity due to a levelling of the bed slope or a valley constriction. All factors have combined to produce the flood plains of the Lockyer Valley and a complex drainage network has evolved to carry water across the developed flood plains.

All streams in the study area have well developed levees and the plain margins have developed as secondary drawdown channels. With increased erosion which has occurred since European settlement, siltation of creeks and large waterholes has occurred. Readjustment of the whole drainage network has been taking place to cater for the changes within the catchment. The adjustments are not complete. Deepening of secondary drawdown channels is one of the more obvious effects of this readjustment process. An increase in the general frequency and amount of flooding associated with changes in the upper catchment is another possible effect.

Flooding is a common feature of these plains. Stability was achieved by virtue of the grass cover on the soils. With cultivation this stability has been removed and the retardance effect of the grass is no longer available. Erosive velocities under these changed conditions quickly develop and scouring is inevitable.

The following measures are required to alleviate the effects of flooding:

(a) Judicious grazing should be encouraged along stream bed and banks to reduce the retardance effects on stream flows.

(b) A system of cropping, which aims at maximising ground cover in the form of growing crops and well-anchored plant residue during the flood prone period of the year, should be followed to retard water flow.

(c) The inner levees of streams should be returned to pasture to prevent stream breakout becoming extremely localised by scouring of the levee. Existing localised break out points caused by lowering of the levees by erosion should be restored to natural levels and stabilised with vegetation.

(d) Secondary drawdown channels should be improved and maintained along the margins of the flood plain to carry run off from hillslopes adjacent to the plain and remove trickle flows following general flooding.

(e) Cross road drainage should be planned wherever possible for broad low level overtopping of pavements during flood flows. Residual flow cross drainage structures should be co-ordinated with existing natural drawdown channels, or channels constructed across the plain.

(f) Roads (including internal access tracks) on the flood plain should be constructed with the road crown as close as possible to ground level. The roads should be located so they will not act as major diversionary or impounding structures for flood waters.

7. CONTROL OF DEGRADATION WITHIN MAPPING UNITS

Following the recommendations on control of types of land degradation in the previous section this final section of the report brings together recommendations for each of the mapping units in the catchment area surveyed. As discussed in the previous section, the erosion and hydrological processes operating in the catchment are such that control measures for a specific form of degradation in one part of the catchment can also produce substantial benefits in lower areas. For example, revegetation of the upper lands, in addition to stabilising the treated area, is a prerequisite for control of erosion in the lower catchment and will contribute to the amelioration of salinity problems. The following recommendations have as their basis the interdependency between the mapping units which were derived from geology and landform.

A summary of the units and the assessed degradation in each unit is presented in Table 7.1. The most seriously eroded of the larger units is the Heifer Creek Sandstone in which the landslips are concentrated, in addition to gully and sheet erosion. The Heifer Creek Sandstone unit commonly comprises steep slopes associated with a deeply dissected landscape. An abrupt change of slope delineates the unit from the underlying unit, the Ma Ma Creek Sandstone, which has been extensively developed and cultivated in the past. Over half the area of the Ma Ma Creek Sandstone unit has been assessed as degraded, predominately by sheet erosion.

Table 7.1 Summary of Units and Degradation

Unit	% of Study Area	Area Degraded as % of		Major Forms of Degradation
		(a) Unit	(b) Total Degraded Area	
Basalt	32.7	3.2	6.3	sheet erosion
Walloon Coal Measures	3.9	18.3	4.2	sheet and gully erosion
Heifer Creek Sandstone	25.3	25.8	38.8	landslip, gully & sheet erosion
Ma Ma Creek Sandstone	6.6	51.7	20.4	sheet and rill erosion
Winwill Conglomerate	6.6	8.4	3.3	sheet and gully erosion
Gatton Sandstone	2.2	12.4	1.6	sheet and rill erosion
Hillwash Alluvium + Colluvium	3.4	33.2	6.8	sheet and gully erosion
Alluvium	18.8	16.4	18.4	erosive flooding
Others	0.5	5.1	0.2	
Total or Mean	100.0	16.8	100.0	

7.1 BASALTS

This unit accounts for about one-third of the survey area. The area and volume of basalt within any sub-catchment in the area is crucial to the supply of good quality water to both surface water supplies and underground aquifers. Although the majority of the basalt unit remains uncleared, many valley floors and lower slope situations have been cleared for grazing. It is in these lower areas where the major degradation in the form of gully erosion is occurring. The production of sediment from the basalts poses a particular threat to the underground aquifer intake areas. Because of the importance of these intake areas in supplying good quality water to the rest of the area, every effort must be made to safeguard the efficiency of these intake areas.

Besides providing water from surface runoff the basalts also act as an underground reservoir. The continuous flow of streams in their upper reaches is evidence that water is being released constantly from the basalts, and is being fed into the alluvial aquifers in the upper reaches of streams.

It becomes equally important that intake of water into the basalts should not be impaired. Grazing can severely denude upper slopes, resulting in an increase in surface runoff, and impaired intake of water to the underground aquifers. Consequently grazing of these areas needs to be restricted and some areas should ideally be returned to timber production.

7.2 WALLOON COAL MEASURES

Two small areas of this unit occur in the south west and south east corners of the study area. Elsewhere minor occurrences fringe some of the basalt units.

The areas are suitable for general agricultural pursuits where soils and slopes permit. Sheet and gully erosion are common on the soils of this unit, and consequently protection from raindrop splash and overland flow is required. Stubble mulching and contour banking will be required on those areas used for cultivation. Where the land is too steep for cultivation grazing can be carried out, but care should be taken to ensure that the ground surface is not denuded of vegetation, allowing sheet and gully erosion to commence.

7.3 HEIFER CREEK SANDSTONE

This unit accounts for about 25 per cent of the survey area and 88 per cent of recorded landslips. Topographically, the unit lies below the resistant basalts at the top of the landscape and above the easily weathered and eroded Ma Ma Creek Sandstone. This has resulted in the development of precipitous slopes and has created a naturally unstable area. The bedding of this member with alternating beds of shales and coarse sandstones, predisposes the unit to instability.

This instability has been seriously aggravated by extensive clearing of the natural vegetation. Clearing has caused a rise in the underground water tables through reduced transpiration. The unit has a number of impermeable layers forcing water to move laterally and this water is discharged as springs. During periods of prolonged wet weather, water builds up within the beds increasing internal pore pressures and reducing cohesion until the retaining forces become smaller than the forces acting to move the material, and mass movement results.

The shale beds in the unit develop soils which are extremely susceptible to gully erosion when cleared and denuded of vegetation.

Groundwater dissolves minerals (particularly chlorides) as it moves through the sandstone beds, and the water consequently becomes poor in quality. In contrast, the basalts yield good quality water. The area and volume of basalt in the headwaters of the streams determines the quality of water in the downstream alluvials. Good quality water occurs throughout those alluvials where there has been sufficient water from the basalt to offset the poorer quality water from the sandstones.

It is imperative that every effort should be made to lower groundwater levels in this unit. Because of the very steep slopes involved, this is impracticable to achieve by means other than reversion to permanent timber. Some of the soils of this unit would be suitable for the production of exotic pine timber and could be used for this purpose. Where this is not feasible, or impracticable, the area should be returned to native vegetation.

Returning to timber vegetation would have a threefold effect -

(a) stabilization of areas prone to mass movement.

(b) lowering of underground water tables.

(c) reducing the yield of poor quality water to the valley floor aquifers.

7.4 MA MA CREEK SANDSTONE

Within the uplands of the study area this unit has the greatest potential for agricultural development. Because sheet erosion is extensive, more intensive development will only be possible on those areas where slopes and soils are suitable and suitable sites for irrigation water storage are adjacent. Many small areas fall into this category, but the majority of the unit will be more suitable for mixed farming enterprises with cultivation in rotation with pasture.

To this end a skeleton layout of diversion and contour banks will be required and where possible this should be linked with water storages either for stock water or irrigation.

Stubble mulching as a farming technique on cultivated land will achieve a marked reduction in raindrop splash and sheet erosion. Where cultivation in rotation with pasture is the only conservation measure used, stubble mulching should be sufficient in most areas to reduce soil erosion to acceptable levels. On some steeper, eroded areas, contour banks will also be necessary.

7.5 WINWILL CONGLOMERATE

The nature of this unit and the soil development which has taken place have limited its use. The major current and potential use is grazing. Little degradation has occurred and continued use for grazing can be recommended.

7.6 GATTON SANDSTONE

Soils developed on this unit are texture-contrast soils. Where the sandy A horizon remains, little serious erosion has occurred. Where the A horizon has been removed either mechanically for example, along roadsides, or by erosion as on stock or access tracks and on old cultivations, serious gully erosion has resulted. The clay subsoils, being developed from sandstones high in sodium, are highly dispersable and as such are extremely prone to removal by flowing water.

Every effort must be made to maintain the sandy surface horizon on soils of this unit. This is particularly the case during road construction and surface material should be replaced along roadside drainage whenever feasible.

7.7 HELIDON SANDSTONE

This unit is of very minor importance in the study area. The soils developed and nature of the landscape make it most suitable for timber production, and this has been the land use over most of this unit.

7.8 LATERITE

While laterite has only a minor occurrence in the study area it is strategically important in that it occurs mainly in an area surrounding Toowoomba City. Generally the laterite is subject to landslip and accordingly the unit should not be developed but returned to timber to provide the necessary stability in this part of the landscape.

Ma Ma Creek Sandstone Mapping Unit occurs at the base of the Heifer Creek Sandstone Mapping Unit. The cultivated lands are typical of the Ma Ma Creek Sandstones, with broad U shaped valleys and well rounded hills.

The Winwill Conglomerate Mapping Unit is characterised by relatively low sloping lands typically growing narrow leaved Ironbark and bulloak as shown in this photo.

7.9 HILLWASH ALLUVIUM AND COLLUVIUM

This unit is naturally unstable and has the most serious gully erosion incidence. Where runoff can be satisfactorily controlled by waterways and/or dams intensive agriculture is possible. But, the problem of silt fan development will always be present unless land use changes are made on the steep upper slopes. Saline outbreaks frequently occur in this unit and will restrict land use. The control of this problem will also be linked to the revegetation of upper slopes and lowering of the general water table levels in these areas.

7.10 ALLUVIAL PLAINS

This unit is suitable for intensive agriculture and has been developed to this use. The problem of erosive flooding will become more serious if land use changes and control of degradation in the headwaters are not carried out. As detailed in the previous section, control measures which reduce the velocity and concentration of flood flows are necessary. Alignments of paddocks and roads are key factors determining the extent of erosive flooding.

Gully erosion is a serious problem within a number of the mapping units in the study area. This photo shows gully erosion occurring on the Gatton Sandstone Mapping Unit.

The low sloping lands of the Gatton Sandstone Mapping Unit are typically used for grazing. Gully erosion is often severe on this unit, particular along drainage lines, stock tracks and roadsides.

A salt patch developed in a drainage line in an upland situation. The landholder has ripped the area in an attempt to promote leaching of the salts and establishment of vegetation.

Clearing of upper slopes has led to a rise in the upland watertables. Salts accumulated in this underground water causes saline soil patches to develop where these watertables come to the surface. This photo shows saline conditions where only very salt tolerant plants such as Rhodes Grass are surviving.

REFERENCES

Bureau of Investigation (1949) - An investigation of the land and water resources of the Lockyer Valley. Tech. Bull. No. 2 Dept. Public Lands., Qd.

Cranfield, L.C. and Schwartzbrack, H. (1973) - 1 st Edition, Ipswich, Qld - 1:250 000 Geological Series, Sheet SG56-14, Geol. Surv. Qd.

Graf, W.L. (1977) - The rate law in fluvial geomorphology. *Am. J. Sci.* 277:178-191.

Hill, D. and Tweedale, G.W. (1955) - Geological Map of the Moreton District. Dept. Mines.

Jorgenson, J.T. and Barton, R.H. (1966) - Regional photogeology of the Ipswich Basin - Esk trough Qld. *Aust. Petrol. Explor. Ass. J.* 121 - 125.

McTaggart, N.R. (1963) - The Mesozoic Sequence in the Lockyer - Marburg Area, South-East Queensland. *Proc. R. Soc. Qd.,* 73:93-104.

Mills, W.D. (1972) - Gatton Shire Handbook. Qd. Dep. Prim. Ind.

Mills, W.D. (1973) - Laidley Shire Handbook. Qd. Dep. Prim. Ind.

Milton, L.E. (1971) - A Review of Gully Erosion and its Control. Soils Conservation Authority of Victoria.

Northcote, K.H. (1965) - A factual key for the recongition of Australian Soils. Second Edition. *CSIRO Aust, Div. Soils Divl Rept.* 2/65.

Queensland Co-ordinator General's Department (1972) Moreton Region Natural Environment. Brisbane.

Queensland Department of Primary Industries (1974) - Moreton Region Non-Urban Land Suitability Study. Div. Ld. Util. Bull. No. 11. Brisbane.

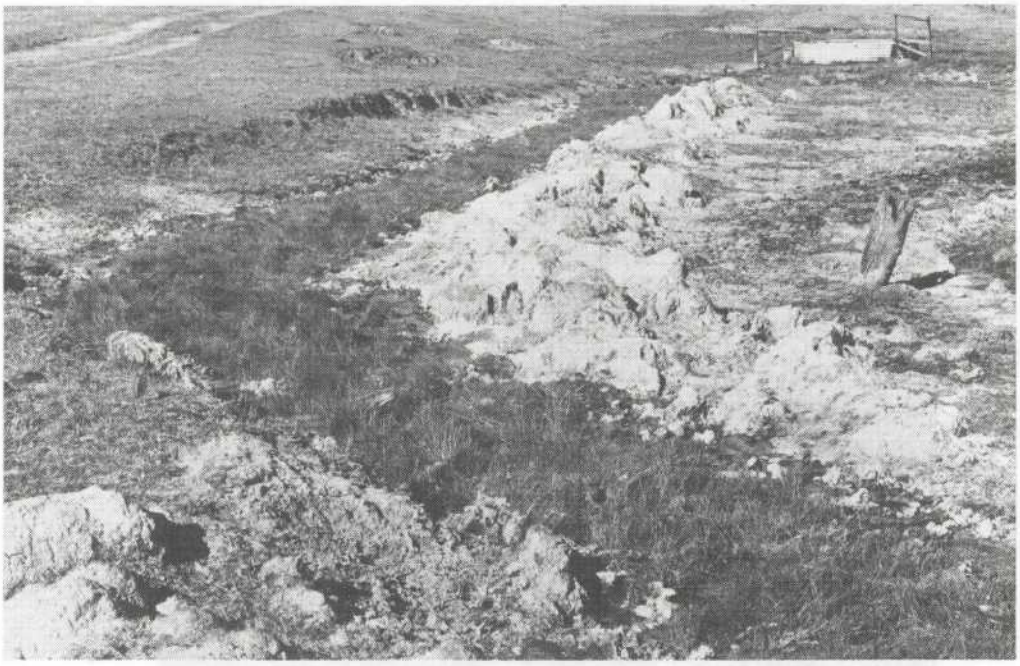
Queensland Irrigation and Water Supply Commission (1969) - Progress Report on Investigation of Water Resources Development, Lockyer Valley. Brisbane.

Strahler, Arthur N. (1957) - Quantitative analysis of Watershed Geomorphology. *Trans., Am. Geophys. Union* 38:913-920.

Talbot, R.J. and Dickson, T. (1969) - Irrigation quality of some stream waters in the Lockyer Valley, South Eastern Queensland. *Qd. J. agric. Anim. Sci.* 26:565-580.

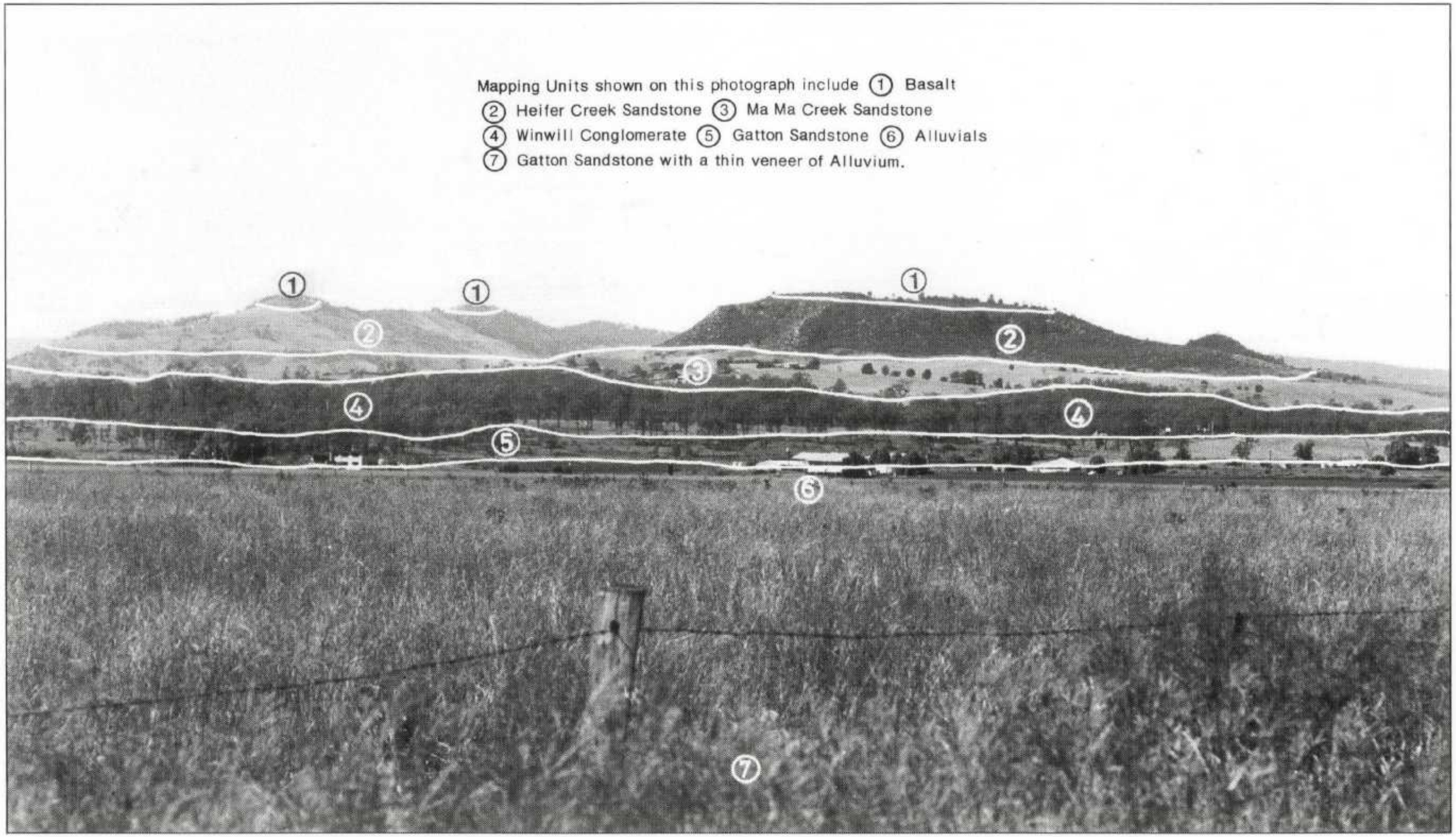
Talbot, R.J., Dickson, T. and Bruce, I.J. (1971) - Long-term effects of saline irrigation water on saturation extract determinations of a clay soil in the Lockyer Valley Queensland. *Qd. J. agric. Anim. Sci. 28:1-11.*

Zahawi, Z. (1975) - Lockyer Valley Groundwater Investigations. Hydrogeological Report, Record 1975/36, Geol. Surv. Qd.



Water from bores drilled into the Gatton Sandstone is generally high in sodium salts. These bores are usually artesian. This photo shows a bore with overflow water running down the hill. Salt incrustations can be seen as white patches alongside the gully.

Offstream storage of water in dams such as this provides a partial solution to the problem of poor quality underground irrigation water on the alluvial plains.



Mapping Units shown on this photograph include (1) Basalt
(2) Heifer Creek Sandstone (3) Ma Ma Creek Sandstone
(4) Winwill Conglomerate (5) Gatton Sandstone (6) Alluvials
(7) Gatton Sandstone with a thin veneer of Alluvium.

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DIVISION OF LAND UTILISATION

TECHNICAL BULLETINS AVAILABLE

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