THE KEYLINE PLAN
by P. A. Yeomans

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DEDICATION

My registered cattle brand is a Circled Y. The above sign has been used as a business sign, almost a trade mark, for a number of years, consequently it is regarded with a certain amount of affection by my family. Some years after first using it I was told that it was a very old Northern European or Germanic symbol meaning--the living man -the signal of victory; that it derives from the ancient Sanskrit sign of life-fertility --and well being.

All of these things have their foundation in fertile soil-always the dominating factor.

This book is dedicated to The Fertile Soil.

The health and well being of mankind depends first on the fertility of the soil.

The development and custody of fertile soil is the great responsibility, of the men and women on the land.

Adequate and permanent tree belts are necessary for the full protection of all the land.

BIOGRAPHY

Percival Alfred Yeomans (P.A.) was born in Harden N.S.W. in 1905, eldest son of a family of four. In 1928 he married Rita Irene May Barnes, also of Harden. They had three children; Neville born in 1928, Allan in 1931 and Ken in 1947. Rita Yeomans died 1964 and the two original Keyline properties at North Richmond N.S.W. were sold to pay death duties.

P. A. Yeomans married Jane Radek in 1966 and they had two daughters, Julie and Wendy.

Following this marriage he undertook the design and construction of a different concept in cultivation equipment. He solved the need for better equipment than the chisel plow to deeply loosen soil without bringing up the subsoil. This equipment was the first rigid shanked vibrating sub-soil cultivating ripper for use with farm tractors. It is many times more efficient than a chisel plow, and is able to loosen more soil to a greater depth using less tractor power.

The Prince Philip Design Award officially recognised the breakthrough success of this equipment in 1974 when P. A. Yeomans Pty Ltd received this coveted award for the Bunyip Slipper Imp with Shakaerator.

Manufacture of the Bunyip Slipper Imp eventually passed from P. A. Yeomans Pty Ltd to the Yeomans Plow Company, which is now based at Molendinar in South-east Queensland. This company is owned and directed by Allan J. Yeomans the second son of P. A. Yeomans. The equipment has undergone further developed including some landmark design breakthroughs and has been renamed the Yeomans Keyline Plow.

P. A. Yeoman devoted much of his latter life time to consulting, advising and lecturing on Keyline planning for which he has received requests from many parts of the world.

P. A. Yeomans passed away, aged 79 years, in November 1984.

by

Allan Yeomans

The Late Percival Alfred ("P.A.") Yeomans

A MAN BEFORE HIS TIME

By

ALLAN YEOMANS

Percival Alfred Yeomans or "P.A" as he became known to all alike, changed Australian agriculture. It is doubtful that any man in this country's history has had such a profound influence on the thinking and methods used by the Australian agricultural community.

He was from the country, but grew up in a town. His father, James Yeomans was a train driver, and

close friend of our World War Two Prime Minister, Ben Chifley.

When P.A. started farming he had already achieved considerable success in business. He applied the same thoughtful and common sense approach to agriculture that had proven so successful in his other ventures. He knew what Australian agriculture needed. He created a "sustainable agricultural" system before the term was even coined. A permanent agriculture, he believed, must materially benefit the farmer, it must benefit the land and it must benefit the soil.

His ideas of collecting and storing large quantities of run off water on the farm itself for subsequent irrigation was virtually unheard of, and quite opposed to state soil conservation departments then, and by some even now. His ideas to create within the soil a biological environment to actually increase fertility was unique, and totally opposed to the simplistic approach of the agricultural chemical industry. His ideas that using tyned tillage equipment and a unique concept of pattern cultivation could totally solve the ravages of erosion, was sacrilege in the eyes of extravagant and wasteful soil conservation services. They still are seen as a sacrilege to convention by many, even to this day. A quotation from the great German physicist; Max Planck, (1885 - 1947) seems so relevant to the concepts, the thoughts and the beliefs of P. A. Yeomans:

"A new scientific truth does not triumph by convincing its opponents and making them see the light, but rather because its opponents eventually die".

For how much longer must we say, "So let it be with Keyline"?

In retrospect, Yeomans' entry into the farming world appears almost inevitable. As a young, man after abandoning a possible career in banking, he tried several fields, including the then very new, plastics industry. At one stage he was a highly successful door to door "Fuller Brush Salesman". The wealth and excitement of mining however, fascinated him and during those hard depression years, and with a small family, he completed a correspondence course in mining geology. That course changed the direction of his life. In the wild and charlatan mining days of the 1930's, he established the rare reputation of being a reliable and trustworthy assayer, and valuer of gold and tin mining projects. A reputation he held throughout the mining fields of Eastern Australia and New Guinea.

The family was constantly on the move. It took less than half a day in the town of Snake Valley in south western Victoria to disprove the wild claims of riches of yet another gold strike.

He eventually established himself as an earth moving contractor in the early pre-war years. This business grew, and his company, P. A. Yeomans Pty Ltd became one of the major earth moving contractors supplying open cut coal to the war time Joint Coal Board.

The enormous war time taxes on company and personal income continued for many years after the close of the war. A tax incentive however had been established to encourage the introduction of soil conservation practices, and encourage a possible change to, what we now call, sustainable agriculture. Food production would be enhanced and the terrible dust storms that ravaged the country, mitigated.

Income earned from non agricultural sources could be spent on saving the land. If farm dams, fences and contour drains could be constructed economically, and beneficially, this could result in a considerable capital gain. Capital Gains Tax itself did not exist. It came much later as yet another imposition on initiative. So was born the "Pitt Street Farmer" (or Collins Street, depending on your state capital city).

Consequently, in 1943 Yeomans bought two adjoining blocks of poor unproductive land, totalling a thousand acres, forty miles west of Sydney. The farm manager was his brother in law Jim Barnes. Conventional soil conservation practices then in vogue, were commenced. These practices had been adopted by the newly formed state soil conservation services. They unfortunately originated from

the agriculturally illogical practices, "invented" by the United States Corp of Engineers, guided and advised by U. S. Army construction officers. The doctrines of soil conservation departments, in Australia, have been fairly inflexible on these issues, and department after department adopted and promulgated these extravagant and useless practices. In those years that's all there was and these practices were tried by Yeomans and proved wanting.

A horrific grass fire, fanned by one hundred kilometres an hour winds, raced through the properties. It was the tenth day of December 1944. Jim Barnes was riding the horse "Ginger" that day, but they could not out run the speeding flame front. Only "Ginger survived the ordeal, and was retired to become a family pet. After this tragic accident, it was some time before a family decision finally concluded that, the farms should not be sold.

All the experience gathered in those years of mining and earthmoving Yeomans then brought into play. The twin blocks became "Yobarnie", a combination of Yeomans and Barnes and "Nevallan", from his two sons Neville and Allan. Ken was born later in 1947.

The cheap storage and transportation of water, over long distances, are usually the life blood of a successful gold mine, and Yeomans became convinced it could be the life blood of a successful farm in Australia. Yeomans then became an avid reader and soon realised that conventional agricultural wisdom totally ignored the biological aspects of soil. The concept of totally inverting topsoil by using mouldboard and disc type ploughs was progressively destroying the fertility of world soils.

He applied the wisdom of T. J. Barrett, Edward Faulkner, Bertha Damon, Friend Sykes, Andre Voisin and many others, to Australian broadacre fanning. So for the first time in human history, techniques were developed that could produce rich fertile soil, thousands of times faster than that produced in the unassisted natural environment. This then became, after on farm water storage, the second major facet of Keyline which is also having a significant influence on Australian agriculture.

Being a mining geologist, and understanding the underling geological structures, gave him an appreciation of land form that is almost totally lacking in the farming world. With brilliant insight he combined the concept of the ever repeating weathering patterns of ridges and valleys, with contour cultivation. He was well aware that when cultivating parallel to a contour line, the cultivating pattern rapidly deviated from a true contour. He realised that this "off contour cultivation", could be used to selectively reverse the natural flow and concentration of water into valleys, and drift it out to the adjacent ridges. He discovered that a contour line, that ran through that point of a valley, where the steepness of the valley floor suddenly increased, had unique properties. Starting from this line, and cultivating parallel to it, both, above the line, and below the line, produced off contour furrows, which selectively drifted water out of the erosion vulnerable valley. He named this contour "The Keyline". The entire system became "The Keyline System".

The effects that P. A. Yeomans and The Keyline System have had on Australia and Australian agriculture is profound. His last book "The City Forest" Published in 1971 expanded the application of the principals. In it, the same Keyline concepts are used as a basis for the layout and design of urban and suburban communities. City effluent and waste are considered as valuable commodities. He proposed the creation of tropical, and sub tropical rain forests, within the city boundaries, as park lands , as sources of exotic timbers and as the means of economically utilising city effluent for the benefit of all. The City Forest has now become a textbook for landscape architects and urban designers.

The equipment and the practices of Keyline, have become so well established as part of Australian agriculture, that it surprises many to realise this influence. In no other country in the world, have farm irrigation dams, contour strip forests, chisel ploughs, deep tillage cultivation, water harvesting almost become a nation's "conventional agriculture". P. A. Yeomans was constantly in conflict with bureaucratic orthodoxy. So no stone monuments, nor official recognition, has ever been accorded to his works. The changed and changing face of the Australian landscape however, is his immense and

worthy memorial.

Allan J. Yeomans
Gold Coast City, Queensland
January 1993

Foreword

VISITORS to "Nevallan" and "Yobarnie", our properties near North Richmond, in New South Wales, have, on many occasions, asked me about my husband's interest in the land.

With these queries in mind, this foreword is written.

For a number of years my husband has made an intensive study of land problems. It seems to give a feeling of satisfaction in his life that no other type of work has been able to do. Always an original thinker, with an inventive mind, , he has spent hundreds of hours walking over the land and watching the soil, oblivious to heat, cold and rain. Often he was up in the middle of the night during heavy rain observing its effects on some new cultivation or drain. He has conducted experiments too numerous to mention and built implements to his own design as well as having used any others available.

The growing of grass and tree seeds and the transplanting of young trees were watched and tested. Experiments in the methods of handling water by the "mining man" were tried. In the earlier days of the work these mining methods of water control were commended by visitors, but he was never satisfied. Sometimes he would go on long moonlit walks over the property trying to visualise the ultimate appearance of the land when a particular scheme was completed.

The soil on which all his later work was done was poor, worn-out shale and considered useless for anything except a warm sheltered winter paddock. Knowledgeable land men could only tell him what could not be done with it. However, he persisted in his belief that this type of poor steep country was the most important of all land, and a payable solution to its particular problems was much more important than any of them realised. He is an enthusiast and his faith in the agricultural future of Australia is a tonic.

The property, bought originally as a business proposition, had my brother, James Barnes, as manager. Following the tragic bush fire at the end of 1944, when he was killed, we suddenly found ourselves burdened with an undesired responsibility.

My husband, a city business man with varied interests, was not a farmer, and my knowledge consisted of what slight information was acquired as a girl from a father and brothers who had been on the land. Surely little enough to accept the responsibility of a 1000-acre property, and for some weeks after the fire its fate hung in the balance.

The World War was on, labour problems were tremendous, and the face of the area for the first six weeks was blackened and parched, showing the scars of an Australian heritage, "a bush fire". Fences were gone and the cattle scattered throughout the district. Even the new house was partly burnt. It was by no means an attractive task from any outlook.

However, the decision to carry on was made, and from this unfavourable beginning, assisted by casual local labour, we started the project now known as "Nevallan" and "Yobarnie". The area was subdivided into two for convenience sake.

The agricultural side of my husband's affairs has been a week-end occupation, but the land has gradually assumed increasing importance in his life. He finds Soil Fertility, with its potential

national value, an absorbing subject.

During the years, while travelling through country areas of the different States in connection with mining work, he often commented on the regrettable signs of the dying fertility of much of the land, the growing erosion problem and the indifference of some owners. This indifference was due, not to lack of interest, but to lack of knowledge. The information then available to them was often vague, too technical or economically unsound.

He has been trying to develop a plan or system so that it can be offered as a concrete proposal; one that all farmers could understand and use to their advantage, regardless of each individual problem. The growing favourable comments made by visitors on the appearance of our property and the enthusiasm of those who have had the Keyline Principle explained to them, have strengthened his belief that at last he has found some important answers to major agricultural problems.

My husband has endeavoured in this work to devise a cheaper method, a workable plan that would show results, not only in three or four years time, but next season and next year and every year following. Now, after the years of study and effort, he claims to have produced one.

The' results visible now are certainly intriguing. Where previously existed sparsely grassed paddocks of little value there is now a lush sward of rich pasture carrying many types of grasses, some of which my husband has been told repeatedly would not grow without irrigation in the County of Cumberland.

"Keyline" is the name he has given to his method of land development. It is exciting and carries a message of hope to all owners of land.

It gives them something to think about and apply to their own soil, something within their financial range and a definite plan that can be managed, in each man's sphere of operation.

In the first chapters of the book he described the meaning of "Keyline", and with the understanding of this, the plan is simple. The following instances denote reactions on visitors of sight-seeing and verbal explanations.

One couple, while driving around, came to the "Keyline". Instantly the wife understood it and tried eagerly to explain to her husband. She even drew from her handbag paper and pencil and made a small sketch, but he could not follow the idea at first, and it took some further explanation before he did. To her it was so simple.

Parties of students have covered the same ground; a few grasped the principle immediately and groups would gather quickly around them seeking enlightenment.

I have seen parties of men become so enthusiastic that for the rest of their visit "Keyline" was their main topic of conversation.

If the enthusiasm shown by the "men of the land," who have seen this work and discerned the meaning of Keyline Absorption-fertility is any pointer to its possibilities, then his efforts may have succeeded.

RITA YEOMANS
Sydney, March 1954

CHAPTER 1

Keyline -A New Principle

THE Keyline plan embraces a system of progressive fertile soil development for all crop and pasture lands as well as for the steeper and rougher lands that have never before been capable of fast, economic improvement.

Its primary aim is the development of better soil structure, increased soil fertility and greater actual depth of fertile soil. It includes new cultivation techniques; a method of farm subdivision and layout; planning for timber and scrub clearing and water conservation and irrigation. All are planned to facilitate or assist in the production of fertile soil.

The Keyline plan is based primarily on a particular line or lines called Keylines. These lines and others related to them are used in all land development planning and act as guides for farm working.

The first aim of Keyline is to provide simple means of conserving all the rain that falls on the land into the soil itself, retard its evaporation. rate and use this conserved moisture for the rapid production of soil, fertility over both small and large areas of land.

The simplest form of a Keyline is illustrated in Map 1. This shows a valley formation by means of contour lines. The 180-foot contour line is the Keyline of this simple valley area.

The Keyline conception itself is a little technical, and an explanation of what this basic idea involves is given first.

A Keyline is a level or sloping line extended in both directions from a certain point in a valley, called the "Keypoint". This marks or divides the two types of relationship, always in the same vertical interval, that a valley bears to its adjacent ridges. In one of these relationships, that above the Keyline, the valley will be narrower and steeper generally than the adjacent ridges on either side of it. In the second relationship, existing below the Keyline, the valley will be wider and flatter than its immediately adjacent ridges, or shoulders.

The approximate point of this relationship change in the valley is the Keypoint of this valley. A line, either a true contour in both directions from, this point, or a gently sloping line rising in one direction and falling in the other direction (see later chapter) -- from this Keypoint is the Keyline of this valley area.

Any property that includes in its area a watershed or water divide has one or more Keylines.

In order to understand the full development and uses of this and other Keylines, reference will be made to contour maps and particular contour lines of the maps. Not all readers will have had experience of these maps and their contour lines, but the following description will make the later references clear.

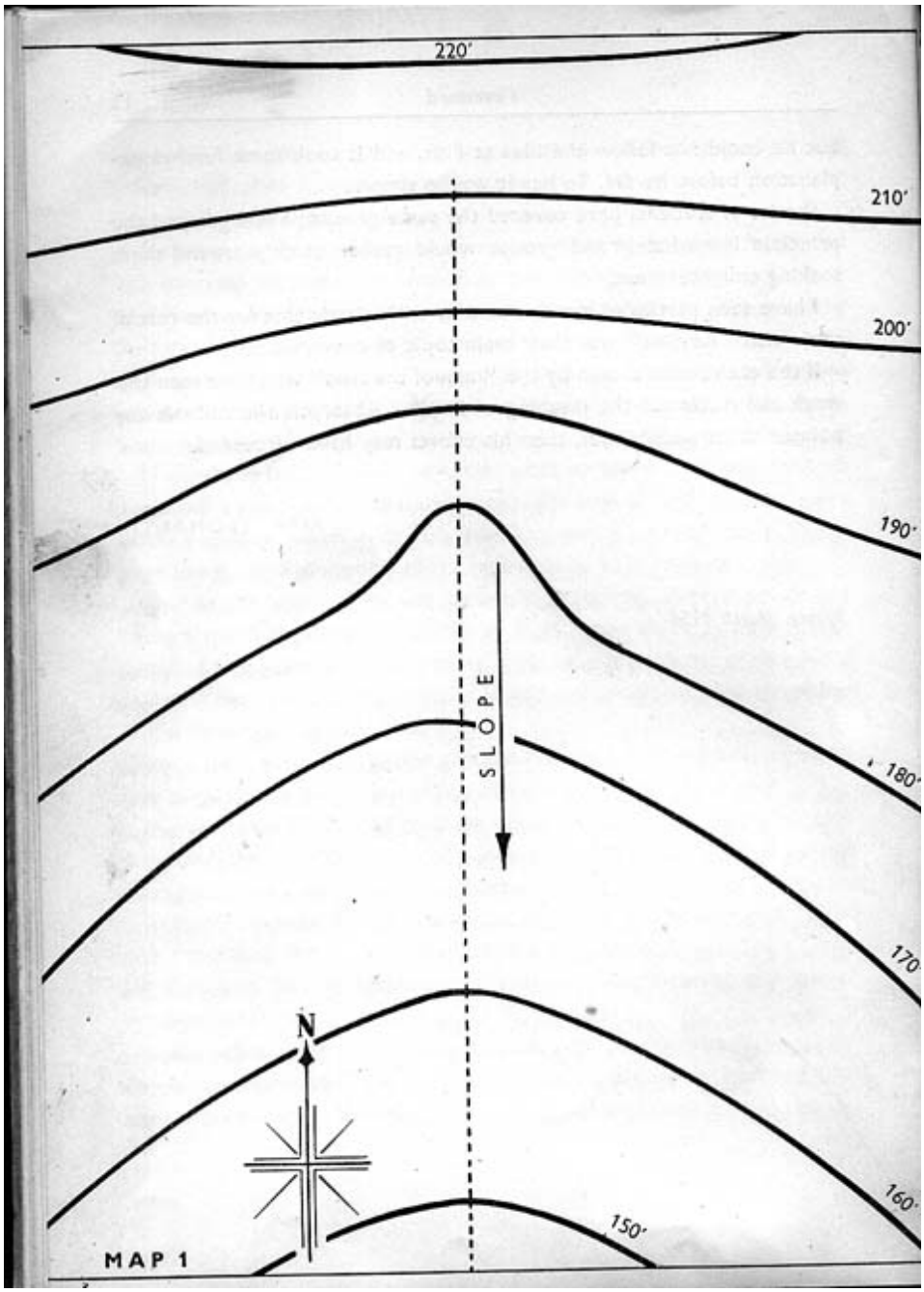
Contour lines, or contours, are lines on maps or marked on the land itself to show particular levels. Map 1 is a simple contour map and the contour lines on the map mark the levels.

All points on the lines marked with the various heights are the same height as indicated by the figures. Thus on the 200-foot contour line all points are 200 feet above "datum". Datum is very often mean sea-level, but may be any other permanent point.

A contour line lies at right angles to the slope of the land; as the slope changes direction the contour lines curve and turn. Contour lines on a contour map are placed at regular vertical heights apart. The distance apart is called the vertical interval. On farm contour maps these range from 25 feet to 2 feet, according to the type of land formation and accuracy desired. On Map 1 they are 10 feet apart vertically. The space or interval between two contour lines is referred to as a contour strip.

A contour map exhibits the formation of land by means of contour lines.

The contour Map 1 exhibits a simple valley formation. The centre line of the valley floor is indicated by a dotted line and the downhill slope by an arrow.



The 220-foot contour is near the top of a watershed or water divide. The valley formation starts between the 210- and 200-foot contours, as indicated by these two contour lines coming closer together near the dotted line of the valley. The actual slope here is steeper than that on either side between the same two contour lines. This is the valley head. The valley steepens a little more between the 200- and 190-foot contours, as indicated by these two lines being closer together than the 210- and 200-foot contours. The slope of the valley then remains constant to the 180-foot contour in the valley. This is indicated on the map by the distances between the 200- and 190-foot contours and between the 190- and 180-foot contour lines at the centre valley point being approximately equal. At this point, where the 180-foot contour line crosses the dotted line of the valley bottom, a change takes place in the character of the valley formation. The valley bottom flattens considerably, as indicated by the greatly increased distance in the valley bottom between contour lines 180 and 170 feet.

The whole relationship of the valley to its adjacent ridges in each contour strip has also changed.

Above the 180-foot contour line the valley bottom is steeper and narrower than its adjacent ridges in the contour strips, but below the 180-foot contour line the valley is flatter and wider, in the contour strips, than its adjacent ridges. The slope relationship between this valley and the adjacent ridges continues through the lower contour strips of the map.

As a general rule, the relationship is constant for the remainder of a valley. The line of this change of relationship between the valley and its adjacent ridges in each contour strip is the Keyline of this valley. The position or point of this change in the valley itself is the Keypoint of the valley.

My own discovery, study and use of this -peculiar significance, relating to the varying valley and ridge forms, is the basis of the Keyline plan. Its use in farming and general land planning and development is discussed throughout this book. A study of the topographical geography of general land formation will show a remarkable consistency and regularity in this changing relationship between valleys and their adjacent ridges.

The crucial point of change in the valley floor slope, the Keypoint, may coincide with the confluence of two or more valleys.

At the Keyline the line of the valley floor and adjacent ridge slope are neutral.

Various types of land formations lend differing forms to their Keylines, but generally the significant valley and ridge relationship is consistent in the widest variations of land formations.

It is important to keep in mind that the valley area in the contour strip above the Keyline is narrower generally than the adjacent ridge area and that the valley area in any contour strip below the Keyline is wider generally than the adjacent ridge area of the same contour strip.

The 180-foot contour line of Map 1 is the simplest form of Keyline -- the Keyline of a single valley. Keylines, as discussed here for farm work, are not located on the very small scale contour maps of large land areas, such as inch-to-the-mile land plans. Maps that have sufficient contours to exhibit accurately every valley on a medium size property will, however, enable the Keylines to be located quite clearly.

Before explaining the full development of Keyline, this simple form is used in the next chapter to illustrate a practical application of the Keyline principle.

CHAPTER 2

Absorption -The First Need

THE use of the Keyline as a guide or design for cultivation is discussed in this chapter. Keyline is a complete planning guide for farm development. it would seem that an overall picture of the plan should come before the details of Keyline techniques. This, however, would involve so much discussion and digression to explain new terms that it is proposed to present the various factors which make up the complete plan in the order that appears best for the sake of clarity. This order may not be in the proper sequence of events as they would be applied in practice.

As the various methods which make up the complete Keyline plan affect and react on each other, some repetition is necessary.

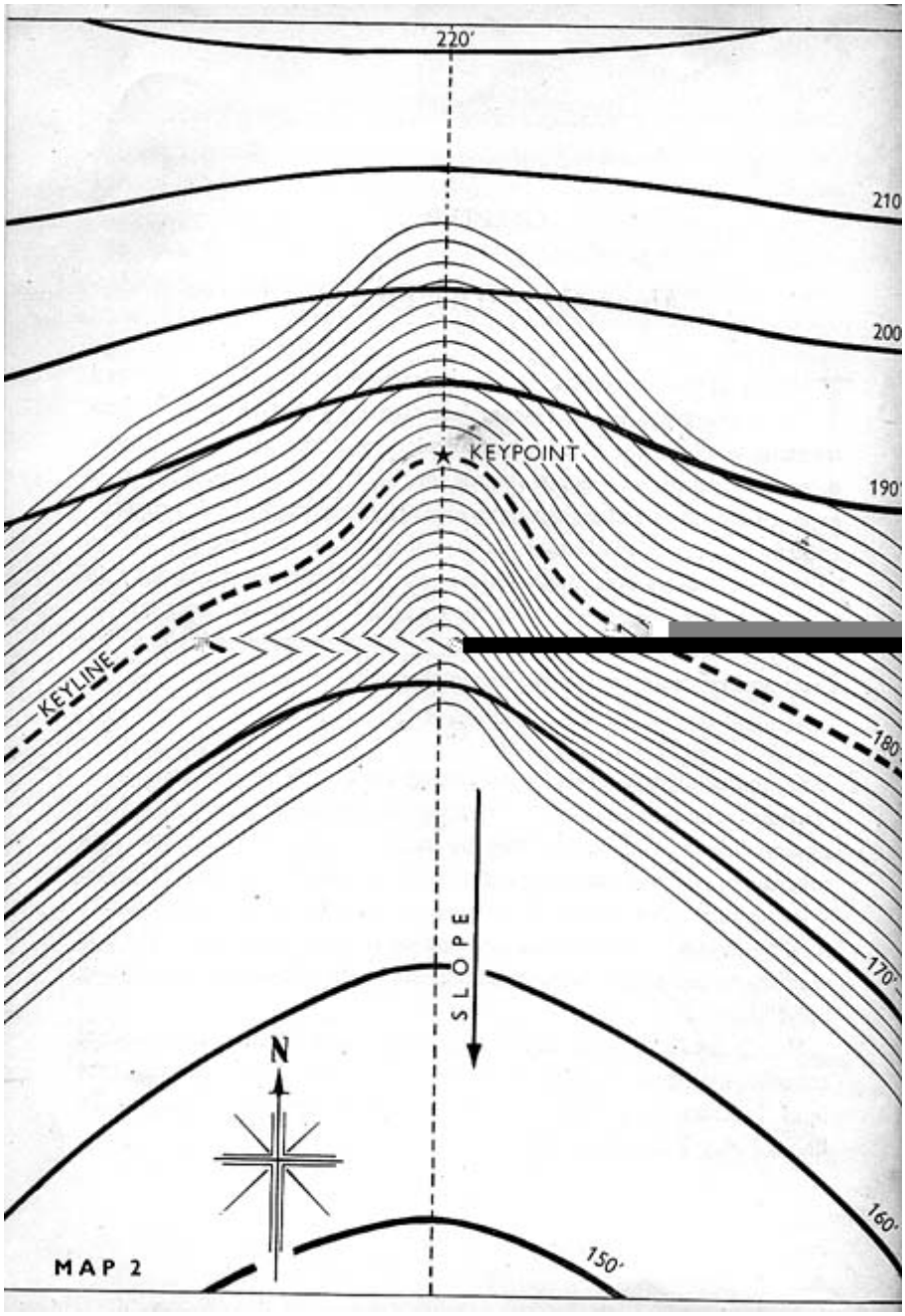
Keyline cultivation is simply cultivating parallel to the Keyline.

In the various methods of cultivation of the soil to prepare land for sowing, several "workings" may be used. A "working" is a complete covering of the land area at one time with whatever implement

is in use.

If one cultivation only is to be done, this single working parallels the Keyline moving away from it. Cultivation that requires more than one working to complete it is done parallel to the Keyline on the last working only.

Map 2 is identical to Map 1 except that the Keyline, the 180-foot contour, has been emphasised and parallel lines have been added. These lines illustrate the parallel furrows of Keyline cultivation. The-parallel lines of Map 2 are drawn paralleling the Keyline.



Above the Keyline these lines parallel the Keyline moving away from the Keyline up the slope of the land.

Below the Keyline they parallel the Keyline moving down the slope of the land.

Study of these parallel lines shows that above the Keyline they do not evenly "cut-out" the valley and ridge slopes in the first contour strip (190ft.-180ft.). The valley section is "cut-out" before the ridge sections on either side of it.

These lines represent parallel Keyline cultivation runs working away from the Keyline up the slope. When the cultivation lines reach the 190-foot contour in the valley they are some distance from and below the same contour lines on the two adjacent ridges. They have reached a greater vertical height in the valley than on the adjacent ridges. The parallel cultivation lines which started on the level or contour at the Keyline are higher in the valley than on the adjacent ridges. They slope downwards from the steeper sloping valley to the flatter sloping ridges on each side.

This parallel cultivation is continued to the upward limit of the area or paddock. When the cultivation reaches this point, there will be parts left unworked. These are cultivated out in any convenient manner without reference to the Keyline or parallel working. Their influence will not alter the effectiveness of Keyline cultivation.

Below the Keyline the parallel lines of Map 2 start at the Keyline and parallel below the Keyline down the slope of the land. The cultivation that they represent does not evenly "cut out" the valley and ridge slopes in the first contour strip, that is from the Keyline to the 170-foot contour line. They reach the 170-foot contour on the ridge slopes first while the run in the valley is some distance from and above the 170-foot contour line in the valley. The cultivation runs are again generally higher in the valley than on the adjacent ridges in the same contour strip. They also have this same downward slope out of the valley to the adjacent ridges, as the cultivation above the Keyline. The slope of the cultivation furrows is now from the flatter sloping valley to the steeper sloping ridges, whereas above the Keyline the slope is from the steeper sloping valley to the flatter sloping ridges.

The cultivation of the area below the Keyline is completed by continuing the parallel cultivation downward to the boundary. When this is reached, areas not completely cut out are cultivated in any convenient manner. Again their influence will not alter the effectiveness of Keyline cultivation.

The significance of Keyline cultivation is apparent when two factors are considered:

(1) Rainfall on or near a valley rapidly concentrates in the valley and flows off the area not only preventing the ridges from absorbing their fair share of the rainfall, but in poor soil, taking with it some of the soil from both valley and ridge.

(2) Keyline cultivation is in effect many hundreds or thousands of very small absorbent drains, preventing rainfall from concentrating in the valley -- thus resisting and offsetting the natural rapid concentration of this water into the valleys.

Very heavy rainfall, after it has completely saturated the soil which has been cultivated in this way, naturally starts to move to its normal concentration lines in the valley. But it is interrupted by the tendency of almost every cultivation furrow to impede it and drift it away from the valley. The flow movement of excess water is widened and its flow is kept very shallow. The necessary time of concentration is increased enormously, thus holding the water on the land longer. The land will have time to absorb the rain that falls on it. Rainfall of maximum intensity is robbed of its destructive violence.

Keyline cultivation is completed in the order already discussed. Cultivation above the Keyline is first completed to enable land, usually the steeper areas, to absorb the maximum or all the rain that falls on it.

This prevents rapid and concentrated run off on to the flatter slope country and so protects all the land from water damage. The general result is even absorption of rainfall over the whole surface of steep land, similar in effect to the absorption of rainfall on flat, fertile, absorbent land.

This part of the significance of Keyline as a cultivation guide has been illustrated on the map with reference to contour lines both above and below the Keyline. The only need for these contour lines is for the sake of simpler presentation. The Keyline is the only line which is necessarily marked on the land area represented by Maps 1 and 2 for the practical application of Keyline cultivation.

On large areas of long slope country where, for some reason, continuance indefinitely downward of the Keyline parallel cultivation is undesirable, a line is used to terminate one cultivation area and form the boundary for another.

This line is called a Guideline and is usually a true contour line, marked at a suitable distance below the Keyline. It may be a quarter mile or much further below. The area below this Guideline is Keyline cultivated from the Guideline paralleling it downward.

Any contour line below the Keyline can be used as a cultivation guide by simply Keyline cultivating from the line downward. The effect of Keyline's cultivation diffusing and even spreading of rainfall is still completely effective.

For Keyline cultivation a special implement is needed, which properly follows the new working lines and for other significant reasons. These are discussed later.

Although the Keyline as illust rated in Map 2 is a contour line, Keyline cultivation is not strictly contour cultivation.

It is rather an "off the contour" type of cultivation, which in no small measure depends for its effectiveness on this planned drift away from the valleys.

Keyline diffuses rainfall evenly over the whole of the land to absorb it in the greatest water conservation storage area -- the land itself.

The field of application of "Keyline" extends in scope greatly from this simple first principle now presented.

Keyline planning can be applied on an area of virgin grassland or forest to develop it into a farming or grazing property. In timbered country it plans the clearing to retain timber in the best places; it positions the house or homestead, all other farm buildings, entrance and farm roads, large and small paddocks, dam sites and irrigation areas. It guides the whole course and sequence of development as well as the details of all cultivation for soil fertility improvement and high yields.

It can be applied as a planning guide to the layout and development of a public park or to the further improvement of a fully developed wheat farm or a fine grazing or dairy property.

Occasionally a very large property may have two sets of Keylines, but generally these wider applications are outside the scope of farming and this book, applying only to such developmental projects as the entire watershed of a river system.

"Keyline" will apply to a single small or large paddock of a farm or to land partly destroyed by erosion.

Although it cures and prevents soil erosion, this is incidental to its purpose -- the development of fertile soil by the factor of absorption.

CHAPTER 3

Fertility -The Dominant Factor

BEFORE extending the application of the Keyline beyond the first simple Keyline of a valley and its uses as a cultivation guide, a discussion of soil and of cultivation methods is undertaken in this chapter. This forms a basis for the presentation of the Keyline methods of progressive soil development.

Prior to the introduction of the mouldboard plough one of the great problems of agriculture arose from farmers' difficulties in controlling the unwanted growth on fertile soil. The rich agricultural land obtained by clearing virgin forest areas or breaking up the natural fertile grasslands were hard to hold from the exuberant growth of vegetation. The growth made it impossible for the farmer to crop large areas.

The mouldboard plough, by turning over the soil and burying the unwanted growth gave the farmer better control. He could then hold and crop larger areas of land.

The advantage of the new power cultivation which was later introduced, lay in the further increased speed to control the unwanted growth. Rubbish was turned under to produce a "clean" soil surface.

After the earlier slow work to control this growth the new implement inspired a fetish for "cleanness" and "fineness" of cultivation. This fine seed-bed, almost universally acclaimed, produced bumper crops year after year and the rich fertile earth showed little evidence of fertility losses over long years.

This type of cultivation and the other farming and grazing methods however, were generally destroying natural fertility much faster than the crops which were profitably extracting some of it.

Eventually, when erosion became a serious menace, some nations undertook an inventory of their soil losses and found that the figures were staggering.

Gigantic efforts were needed to arrest these colossal losses by erosion.

Fertile soil was not being washed away, but only those soils which had already lost or were then rapidly losing their fertility were on the move.

Fertile soil was built originally by processes of absorption, growth and decay, and such soil resists erosion. A change of methods from those that extract fertility from the soil to methods that absorb fertility into the soil is the only way to overcome the erosion problem. A positive change must be made from Extraction Fertility farming to Absorption Fertility farming.

The first requirement, already stated, is the retention of all rainfall in the land for the production of fertility, and not methods to "safely" allow water to leave the property.

It is economically unsound merely to prevent erosion losses of poor soil.

Soil fertility can be built back into the soil in a positive manner so much faster than the natural fertility was lost, that little need be done from the negative standpoint of controlling erosion. The best methods of soil development are the surest means of erosion control. Continuance of these methods will quickly produce as good, if not better, soil than that which originally existed.

While these methods are being followed, even from the first year, better farm yields will result. Absorption, growth and decay make fertile soil, and the factors which produce the maximum growth and decay can be controlled in farming practices. The needs of the farmer are satisfied at the same time.

There is little evidence anywhere in nature to support the "take and put" theory of farming where farmers are taught to "put back" into the soil each year what they "take out" in crops. So much of what is taken out is composed of materials that are available in unlimited supply from the sun, air and moisture -- moisture alone requiring conservation -- that if farmers cease to "mine" the top inches of the soil and farm the land, little if anything else need be put back. Fertilisers should be used when they are necessary, but they are rarely the "first" need. This is true of most of our farming and grazing lands.

Correct cultivation is a means of progressively improving soil structure and soil fertility, thereby developing a greater depth of fertile soil. Better crop production is incidental to the process.

The mechanics of the process of soil development whereby Nature built up the great fertile soil belts of the earth are now reasonably well understood by the farmers. Good writers have made of the process an absorbing and fascinating story. Some see in it a miraculous efficiency and give estimates of the time required to build one inch of fertile soil -- varying from a few hundred years to ten thousand.

If the natural process is efficient and the time estimates of even a few hundred years are correct, there is little that could be done by us in the production of soil. However, nature's methods do not take time into any serious account, whereas to us "time" is all important.

The processes which developed natural fertile soil are capable of control and tremendous acceleration. The dead stalks of plants, slowly laid down by nature loosely on the land surface, decay. This is one fertility process which is capable of acceleration. Each time decaying vegetable matter dries, decay temporarily ceases and fertility processes are slowed down. Processes of decay are increased when moisture is present. This decay, to all intents and purposes, is fertility.

Man and his machines can stimulate decay and growth tremendously.

When vegetation is stirred into the aerated part of the soil, decay continues for a longer period. Moisture remains longer to supply the needs of decay.

Every process and activity in the improvement of soil can be controlled and increased by the farmer, to the continual betterment of his soil. Not all natural soils are fertile -- far from it. Where suitable moisture, heat conditions and minerals exist, fertile soil develops in time. There is a certain progression in the development of soil in nature. The growth and decay of primary and simple forms of plant life -- eventually create conditions suitable for the growth of better crops and grasses.

Through the lack of some essential, this process toward the development of fertile soil will cease, or slow down. Thus poor natural soils exist in many areas.

Vast areas of these poor soils of nature can be made fertile and productive, by supplying the needs to complete their full cycle of development.

Natural shortages of vital minerals often can be remedied economically.

Keyline road and timber strip with pasture areas above and below. This pasture strip, which is now nearly two years old, was formerly the poorest land on "Nevallan". Note that the timber strip swings to the right around the hill. The tops of the trees can be seen through the tree line. The trees have grown spectacularly during the last 18 months from the conserved moisture held by Keyline cultivation above the strip.

Rainfall or other moisture sources can be controlled efficiently, to promote more rapid growth and decay. Great improvement will be made in many of these soils in a year or two. New plants and grasses that will continue and complete a cycle of high fertility can be introduced.

Plants draw their sustenance mostly from the products of decay, from and with moisture contained as a water film in the "pore" space of the soil. Generally, maximum pore space promotes maximum growth by the greater availability of pore space moisture. The pore space is multiplied by increasing the supply of vegetation for decay and for the production of humus.

These vitally important factors are increased also by the correct mechanical mixing of vegetation into the surface soil. Correct aeration of the deeper soil and subsoil will progressively convert these to deeper fertile soil.

Some soil scientists estimate that there are 70 tons of living organisms and other life in an acre of fertile soil. These organism generally work towards man's health and well-being.

The importance of fourteen five-ton truck loads of microbes in an acre is overshadowed completely by a sheep or two to the acre. The sheep or cattle obviously need constant care, but surely this other "livestock" warrants some conscious thought when it is so vital. All the elements of growth are made available to us by the various processes of the life cycles of this "life in the soil". Soil management can reduce this dynamic force to a low ebb, or tremendously stimulate its activities.

Fertile topsoil and even very poor soil can be treated as a yeast. Fed and cared for, it increases. Starved and asphyxiated, it dies.

Processes of decay are the multiplication of soil life. These processes initiate or commence in the presence of moisture, air and heat. All three are necessary. This suggests that a starting point in soil development should be a critical examination of farming practices as to their effect on these factors.

Past cultivation habits have destroyed soil fertility to the stage where vast quantities of once valuable soil have been lost by destructive erosion.

Pounding and pulverising, turning and slicing implements have all interfered with and reduced pore space in fertile soil. Soil suffered too much cultivation each time it was worked.

Extremely fine "seed-beds" are still produced on some farms, almost as if the crop in its growth was expected to devour every fine soil particle.

Too fine a cultivation destroys the soil's structure, smothers and reduces soil life, thus degenerating the art of soil management into a bandit-life process of fertility extraction.

Soil fertility need not be "extracted" or destroyed to produce good crops. Crop production is properly a part of an important method in the development of better soil.

Cultivation can be either the mammoth destroyer of soil fertility or the greatest single means of improving and even the creating of more fertile soil.

An understanding of the structure and condition of naturally fertile soil and an appreciation of just what is happening, or has already happened, on some major soil areas will indicate logical means of improvement.

Fertile soil is loose, absorbent and pleasant smelling. It is dark in colour caused by decay in the production of humus. It receives rain quickly and allows it to penetrate deeply. It holds moisture in pore spaces which are found in and around every particle of decaying material and in humus as well as around the mineral particles of the soil. Moisture dries out of fertile soil slowly from the effect of the highly insulating structure of its surface. Deep soil and subsoil moisture is protected from the drying effects of sun and winds.

There are no definite horizons to the top soil, deep soil and subsoil; one merges gradually into the other and all are subject to a gentle stirring action from the larger forms of soil life and from the action of deep roots which bring nutrients to the surface. There is no sharply defined plant root zone in natural fertile soil. Shallow, medium and deep root growths mingle. Root decay acts to aerate the soil to an appreciable depth via the cavities left by the roots after decay.

The fluids, acids and gases of the fertile soil act continuously on the deeper mineral particles of the subsoil and rock below, converting these to forms which are later available to plants, and so improve and deepen the soil.

Soil life flourishes according to the varying condition of food supply -- moisture, air, minerals and

decaying. plant life. The whole body of the fertile soil is teeming with dynamic energy -- growth and decay is continuous and simultaneous.

Cultivation that is highly successful mechanically in controlling soil for crops also has had the effect of separating the body of the soil into sections and horizons. Only the topsoil has been used to yield crops by these extraction fertility methods.

Replenishment of the very small amount of minerals required from the subsoil has been rendered ineffective. Eventually this manifests itself in top soil and crop deficiencies no matter how fertile the soil originally. These soil deficiencies reach man and affect his health through impoverished foods.

Plow soles or hard pans have been formed at the cultivation depth by implements that exert a positive pressure on the soil at this depth to enable them to operate effectively. Plow soles resist the penetration of moisture and air. Surface soil above these plow soles becomes waterlogged in wet seasons. Deeper soil and subsoil dies from asphyxiation.

When this happens plant roots have nothing to gain by penetrating this dead soil. These are all vital factors in maintaining and building soil fertility.

Vegetation is controlled by such soil turning implements by simply burying the vegetation in a sandwich. This layer of turned-under vegetation acts to separate the soil further. It may remain dry, resisting decay and. insulating the top soil from the deeper soil moisture, thus making crops more and more dependent on well-distributed rainfall. Partial crop failure becomes more common. Full decay and growth are both interrupted. A too fine surface working of such primary cultivation further reduces the effect of rainfall by self-sealing tendencies. This will retard the infiltration rate of rainfall to such an extent that water will often be eroding some of this soil before all of it is wet to a depth of three inches. Finely cultivated heavy clay soil will very quickly form a sealed surface .during heavy rains.

If mouldboard plows are used for deeper cultivation total crop failures often result. By deeply burying the surface soil, the soil life is destroyed. Soil of poor structure and fertility is turned up to the surface. Considerable time is required to make it again productive.

Surface chopping and slicing implements, if over-cultivation is avoided, are much less destructive to soil fertility. Good management and such implements can start a cycle of soil improvement. They do tend, however, to separate the soil into sections by their even bottom-depth cultivation, and the danger, already mentioned, of destroying the completeness of the soil is ever present.

With all the other abundant ingredients of fertile soil, what depth of the land is available to the farmer to supply the very small amount of minerals necessary? It is certainly not the alleged six or nine inches of top soil, vast quantities of which have been removed by erosion. The depth of soil available to supply the small mineral requirements extends to at least the full depth penetrated by the roots of the large trees.

The whole deep root system of trees, occupying as they do usually a much greater area below the ground than the trunk and branches above, are continuously bringing in all the necessary minerals to the trunk, branches and leaves.

Some of these minerals gathered by the roots and contained in the ever-falling leaves, twigs and small branches are available continually to improve the soil. Trees are a part of the fertility of the soil. Some need to be "left", or grown in a logically planned manner, to serve the soil and protect the land.

Originally, large areas of land when only partly cleared, maintained healthy stock. Now, some years after complete timber destruction, it is unable to support healthy growth without added trace

elements such as copper, zinc, cobalt, etc. No doubt these were once supplied to the surface by the growth of timber as described.

Deep-rooted plants and grasses will all root deeper if the soil is developed fully, and will bring minerals toward the surface.

The importance of preserving this complete process to the full depth of the soil -- which includes top, deep and subsoil -- has generally been entirely overlooked. Implements that tend to separate the whole body of the soil into defined sections are destructive to soil fertility. The all-over, even-bottom depth cultivation, whether shallow or deeper, destroys this soil completeness.

However, it takes an appreciable time to destroy fertile soil. By wrong cultivation methods, farmers have been able to produce vast quantities of grain for generations during the process of fertility extraction.

Now this soil has lost its former structure and its capacity to absorb fertility. Its destruction is much more rapid. Usually only three inches or a little more of the earth was used, while the basic materials for the improvement of fertility existed both above and below in limitless quantities.

There is a general belief that the supply of food will be -- almost is -- the limiting factor in the ultimate population of the earth. It is likely -- because of the tremendous supply of food potential in and above the earth and oceans -- that some factor, other than food supply will first impose the limit.

There has been available sufficient knowledge of soil to produce small areas and amounts of highly fertile soil for a long time. What is of particular importance now, in the further development of agricultural Australia, is a means of inducing or producing fertile soil over large areas of land quickly and profitably. It is only necessary to maintain the soil in a condition to absorb all the vast fertility potential of the sun, air and rainfall. If the rainfall is absorbed into the earth, the store of minerals, chemicals and gases it carries always is filtered out of it and retained in the soil. While oxygen -- and rainfall is practically a saturated solution of oxygen -- is probably needed by our soils more than any fertiliser the farmer uses at present, there is a considerable variety of other fertility factors taken out of the air by rainfall. Some plants that actually grow without contact with the earth have been found to contain a comparatively large amount of element in their ash-element of the "trace" variety -- which they must, somehow, extract from air and rainfall.

CHAPTER 4

Keyline Absorption-fertility

KEYLINE Absorption-fertility cultivation techniques are so different in their effects on the land cultivated from those generally employed that their introduction on farming land will be considered as a "conversion" of land to these new principles. The first year in which these new principles operate is called "Conversion Year".

The "conversion" cultivation has as its object the maximum possible improvement in soil structure, soil fertility and increased soil depth which can be obtained from this conversion. For this reason the first application of the technique will be different in some respects from the continuous later process. The conversion stage is to be profitable, much more so than extraction fertility methods. The continuous processes of progressive soil development are profitable both from the increase in quality and quantity of production and in the capital value of the improving land.

Soil erosion is not considered as a problem in the process, simply because it is cured incidentally. There is no problem of erosion when its cure or solution is made profitable to those directly concerned.

Ordinary crop land is discussed first.

The considerations of the last chapter indicate quite clearly some important details of the type of cultivation that is desired.

The first requirement is minimum surface cultivation, mixing whatever vegetation is available into the few top inches of the soil. Some subsoil or deep soil is to be broken to provide capacity for rapid moisture absorption. With oxygen and the other vital elements absorbed, some of the subsoil is converted to live soil. This deeper soil is only broken, and none of it is brought to the surface. The deeper cultivation is to leave an uneven bottom, not all cut out clean at the maximum depth of cultivation. The cultivation is to again unite the soil into a complete structure -- not a topsoil divorced from the deep soil by a compacted layer.

The surface of this cultivation is rough, rather than fine, in order to resist the sealing effect of heavy rain and to allow the rainfall to penetrate quickly and deeply.

The finer materials of this surface cultivation lie below the level of this rough surface. Surface wind velocity is thus reduced -- moisture losses by evaporation are lowered.

The deeper cultivation conforms to the Keyline cultivation, which holds excessive rain longer on the land and permits more complete absorption.

Rainfall is quickly absorbed into cultivated poor land, making it wet and heavy on the rough, uneven bottom of the cultivation. The heavy wet soil is effectively knitted to the land and resists substantial water flow if it occurs.

New Keyline Absorption-fertility cultivation is practically erosion Proof; within a year or two of the resulting improvement to the soil, it is certainly so.

The maximum depth of this conversion year cultivation requires some serious consideration.

In so-called shallow or thin soils, this cultivation is restricted to a depth that can be converted successfully to an improved structure by the aid of the fertility in the top soil. Considering the top fertile soil as a yeast, it is likely that too deep a cultivation could restrict the rate of soil development. This happens if a large amount of vegetation is not available for stirring into the surface cultivation. This type of soil rarely has a large amount of vegetation available.

The too deep cultivation of sticky clay subsoil is waste of time and money. It will seal immediately rain falls. There is generally little purpose and no profit in cultivating to depths that cannot be held by definite soil improvement.

A good general depth guide for conversion year cultivation is double the depth of previous ploughing for crop productions, that is, approximately eight inches deep and in the poorer soils seven inches deep.

The means and the implements available for conversion year cultivation are restricted greatly by two factors. The lines of Keyline cultivation cannot be followed satisfactorily by mouldboards or disc plows, nor are these implements suitable for the deeper cultivation that must keep the subsoil under the cultivated surface soil. They also produce the destructive even-bottom cultivation.

They can both be made to do the surface cultivation reasonably well, while another implement of the tine type, with wider spaced rows than the usual farm implements, could complete the deeper cultivation immediately following. Some tine shapes will keep the subsoil down.

Mouldboard plows, with the boards removed, give a satisfactory cultivation, if the final deep run is done with some shears removed to keep these furrows wider apart.

Scarifiers or tillers both give a satisfactory surface cultivation to 4 inches, but the tine spacing and design render them unsatisfactory for the final full depth run.

Rippers will follow the lines of Keyline cultivation for the final working. It is unnecessary in surface cultivation to do this. The resulting cultivation is satisfactory but the cost with any rigid implement is much higher than it need be.

The Graham Chisel-type Plow is the ideal implement for conversion year cultivation. The following details of Keyline Absorption-fertility cultivation both for conversion year and the cultivations in following years, are given for use with this implement.

Conversion Year

The standard shank row spacings of the Graham Plow are 12 inches apart, approximately double the spacing of other farm cultivating implements. The Graham Plow is equipped with tines, spikes or chisels two inches wide, which are set at 12-inch row spacings.

With a suitably power matched tractor and Graham, set the plow's depth to enable the tractor to operate without labouring at a good speed. Five miles per hour is recommended if the surface is suitable for this speed. When stumps are encountered, reduce the speed to 3 miles per hour. The "first working" should be 3 to 4-1/2 inches deep. Large clods may result from a first cultivation which is too deep and could necessitate some special extra work to break them down. Plow three or four parallel runs completely around the area, marking out the area for cultivation clearly.

The paddock area is then "cut out" on this first run by plowing backwards and forwards, turning in the series of parallel runs first made without necessarily reducing speed on the turns. The Graham will follow as fast as the tractor can turn.

Plow a second complete run immediately at a long angle to the first with the plow now set deeper and travelling at the same speed. It is more economical usually to regulate the increased depth to suit the speed and not the speed to suit the depth.

This second plowing will sometimes give a suitable surface "break-out" and the necessary depth of seven to eight inches. If this is so, the second cultivation run will follow the Keyline cultivation principle of Chapter 2.

Usually three fast cultivation runs using two-inch chisels at twelve-inch spacing are, necessary for perfect conversion year cultivation in poor compacted soils. In this case the depth of the last run is set at seven or eight inches, as already discussed.

This simple Keyline conversion year cultivation will commence a cycle of soil fertility that can be carried forward to greater soil improvement and will produce a better than usual crop at the same time. It will also be effective in holding the soil against erosion.

This fast and low cost cultivation will start to improve soil immediately adequate rainfall is supplied. The natural processes of decay will, at once, go into action.

Poor heavy soil, that is soil low in humus content, should be watched closely after heavy rain against a possible surface sealing. If this is apparent the area is given a one-run Keyline cultivation immediately the soil is sufficiently dry. The soil will improve only with adequate air. This first year is one of destiny for this soil.

If a crop has already been sown, it is still often advisable to aerate the sealed surface soil when it is dry enough by this one-run cultivation. The spikes should be spaced at 24-inch intervals for this aeration cultivation.

The health of the soil, the progressive development of structure, fertility and soil depth, is of infinitely greater importance to the farmer than any one crop. This outlook will, however, result in better crops all the time. Even a crop newly out of the ground and partly destroyed by a cultivation to aerate the sealed soil will usually yield better for this treatment.

Conversion year cultivation of poor soil is completed by not more than three fast workings, each becoming progressively deeper. The last working, which is seven or eight inches deep, is the only one which follows the Keyline cultivation principle. Spikes are two inches wide and the spacings between the rows are 12 inches.

The increased moisture of conversion cultivation will continue decay processes longer and thus obviate one of the difficulties of stubble mulch farming with disc implements, that of having too little moisture available for rapid and continuous stubble decomposition.

The changes which will take place in this soil which has been converted to Keyline Absorption-fertility should be watched by the farmer. Only absence of rain will restrict the working of the yeast-like process of soil development.

Examination of the underneath cultivation by removing a couple of square feet of the plowed soil will disclose the deeper chisel final furrows that knit the soil to the earth.

Make an examination a few weeks after the first good rain has fallen -- see the change -- smell the soil.

Again when a crop is well grown - -examine the deeper broken subsoil -- note its further changed condition. Fertility development in the surface inches will be apparent and the deeper broken subsoil will be changing into good soil.

When the crop is stripped, examine the condition of the subsoil again to get a cue to the depth of cultivation to be followed for the next crop.

If a change from the subsoil to a soil is definite, second year work should be a little deeper. The increase should be an inch or two at most. This broken subsoil is to be converted to soil, a little each year -- progressively.

In subsequent years, following a successful Keyline conversion year, a single run on the Keyline

cultivation will complete the plowing. Now spikes or chisels with weed knives attached are used. These weed knives operate three inches below the surface, mixing growth and trash correctly into the soil for rapid decay. At the same time the chisels operate at the full cultivation depth, properly aerating the whole body of soil.

These weed knives, which are adjustable in relation to the 2-inch chisel depth, permit a progressively deeper year-by-year cultivation, with the knives operating at a fixed depth below the surface. The uneven furrowed type bottom and the "completeness' of all the soil is preserved.

The rate at which beneficial decay will take place in the soil will vary with soils and climatic conditions. The rate of decay accelerates as a positive new soil fertility develops. Decay of the incorporated vegetation of conversion year cultivation will be rapid given sufficient moisture. Decay in subsequent years will be much faster as the active life in the soil has been built up enormously as a result of this conversion to absorption-fertility.

For a short time decay does tend to rob growth of some of its requirements. Both decay and growth require among other elements, moisture, air and nitrogen. A crop sown immediately in conversion cultivated land may first grow weak and yellowed from the lack of nitrogen which has been absorbed temporarily in the processes of decay. With adequate moisture, air and heat, nitrogen will be available to the crop in a few weeks. The. crop will respond with a rapid growth of healthy green foliage.

A rapid fertility gain and almost weedless farming on this crop land can be secured by cultivating immediately the crop has been stripped and again each time a growth of grass and weeds reaches its "full green" stage prior to. the weeds seeding. The use of the chisel and weed knives combination tends to germinate all seeds together, while "soil turning" methods of cultivation do not. The "soil turning" implements bury some seeds in a dry layer of vegetation, which prevents their germination until a later cultivation, thereby assisting the continuance of weed growth.

Weedless farming. may disclose that the present row spacing of seeders, which are close together to enable crops to partly choke weed growth, is too close for best yields.

There is a growing well-informed body of opinion among practical Australian farmers, that wider apart seeder row-spacings will give better grain yields when weeds are not a factor.

The sowing of seed into conversion-year cultivation requires some little changes from the old orthodox habits.

It is of particular significance that sowing be done in such a way that this new condition of the soil is preserved as much as possible. If an ordinary grain combine is used, the cultivating tines, both the front and rear rows are removed permanently, use being made only of the two planting rows. The soil will continue to be in a suitable condition for the rapid absorption of rainfall. The use of all the tine rows on a combine may so "fine-up" the soil that it will cause puddling and washing. The use of the combine with all the cultivating tines removed will permit rougher and trashier ground to be seeded.

Planting depth for grain will vary also, but generally seed should be planted into the moisture zone and not shallow-sown with complete dependence on later rain for germination.

Soils of good structure and fertility may be cultivated directly with the chisel and weed knife combination. If surface cultivation ever appears to be too fine, use the chisels only.

Cultivation of soil in very low rainfall areas should be accomplished by a shallow surface cultivation followed by a final Keyline cultivation with the chisels two feet apart. An overall cultivation that is too deep on these soils will tend to lower the moisture zone too much for best yields. As the fertility of the soil increases humus will protect the moisture and hold it at a more

consistent level.

Once a normal rainfall season follows, or good rain out of season has fallen on Keyline converted land, the moisture horizon will be more dependable. Continued year by year, Keyline Absorption-fertility cultivation will keep adequate crop moisture available for longer and longer periods into dryer times. No doubt later, on this "Keyland", one good season's rain will produce two years good crops.

The low cost and fast operation of this method of cultivation is apparent.

Conversion-year cultivation will usually cost less in time and money than extraction-fertility methods. Following conversion -year, costs are about one-third only of old cultivation habits.

Deep fertile soil, then, is built up for crop land first by conversion year cultivation with an, increase in the depth of the chisel penetration each subsequent year. The weed knives operate at approximately three inches below the surface. In from three to five years soil depth to the limit of the Graham's 16-inch is formed.

When this depth is reached, a further "wave of fertility" may be induced in this soil by reducing the penetration depth of the chisel back to approximately nine inches and adjusting the weed knives to operate deeper under the surface.

Instead of three inches, as used in the first cycle of increasing depths, they are used five or six inches below the surface. For the following two to four years increase the operating depth of the chisels one to three inches each year, but adjust the weed knives to keep them five or six inches below the surface.

The effect of this second series of increasing depth cultivations and increased weed knife depth is expected to add a greater depth of intensely fertile soil. By incorporating or mixing vegetation into a greater depth of top soil this should be achieved. The soil should now be in a condition to "take" this somewhat deeper mixing of vegetation, whereas in the first years it would have been largely lost as a fertility gain. At the end of this second cycle -- originally poor soils in reasonable rainfall areas may rival the most fertile soils left on the face of the earth. I say "may" - -I do not know -- yet.

CHAPTER 5

Soil Improvement on Pasture Lands

0N grazing properties generally, compaction of the soil has developed from the tramping of stock. This tends to limit the pore space and the free movement of oxygen in the soil. These soils change as distinct zones are formed by compacted horizons below the shallow grass root depth. The natural movements throughout the whole of the soil becomes more restricted, less deep mineral material finds its way to the topsoil to replenish it, and the soil gradually becomes impoverished of both humus and minerals. An unnatural division of the soil into layers is made. Only the shallow top soil, with its rapidly diminishing minerals, is available.

Good grass species tend to run out, as the whole pasture deteriorates; less rain is absorbed; soil losses may occur; valleys become too moist and sour or they erode; hills become dryer and less productive.

This pasture now needs two things that it has lost and which can be supplied by proper cultivation, enabling its processes to be stimulated again. They are air and water; or simply absorption capacity which will enable the soil to absorb and hold the rain that falls on it. Although the soil cannot be put back in perfect condition in one operation, it can be progressively improved to a condition usually

better than it was originally.

Single working Keyline cultivation with a depth of penetration just through the top soil into the compacted zone is a logical first means to supply both the air and moisture required. Excellent results will follow this work completed in the autumn. Another suitable time is probably a few weeks before each locality's best rainfall season.

Spike or chisel furrows 12 inches apart and at the depth previously suggested, break or crack the continuous horizon of compacted material that now divides the full depth of this soil. With aeration and quick moisture penetration the wholeness or completeness of all the soil's depths is brought back progressively. The decay of dead and dying root growth again adds rapidly to soil fertility by the formation of humus below the pasture.

Some pasture grass is destroyed in this process by being uprooted, and further pasture becomes temporarily unavailable to stock by being partly clod and sod covered. Within a very short period a much improved pasture, both in quality and quantity, is again available. The soil is coming to life again.

It may be appropriate at this time also to introduce new species of clover or grasses to assist the development further. The use of lime or fertiliser is often of considerable advantage in commencing a new cycle of fertility in the poor soils.

It is often highly profitable to conduct a two- or three-year plan for the improvement of a very poor soil paddock.

First Year -- One Keyline cultivation working approximately 4-1/2 inches deep with spike spacing 12 inches apart is given in the autumn.

Second Year -- Another Keyline cultivation working five to seven inches deep with spike spacing 24 inches apart.

Third Year -- A further Keyline cultivation working seven to ten inches deep with spike spacing 36 inches apart.

Stock is moved off the area immediately prior to each Keyline cultivation working and not returned until some weeks after the first rain has fallen on the area.

The clods quickly become improved in structure and are partly distributed by the stock over the surface, thus forming a valuable top-dressing to promote further absorption, decay and fertility. Careful stocking of this treated pasture can make it still more effective. Soils so treated are in a perfect condition, especially if frosts have operated on the clods, for rapid response to all other means of increasing soil fertility and yield.

Rotational grazing, strip grazing and smear harrow treatment, by greatly increasing the effectiveness of the use of the fertility potential of the animal droppings, are outstanding in their fertility effect on this treated soil.

By this means poor shallow soils will not only become more fertile, but will be converted profitably into areas of considerably increased soil depth.

If the depth of fertile soil is doubled, the profit margin is increased many times.

The aim of progressive development by progressive increase in penetration depths for maximum absorption-fertility is of outstanding importance.

February pasture on Nevallan" (not irrigated). In the picture with me is Ginger, one of our pets.

Ginger was badly burned in the bush fire on "Yobarnie" in 1944. Pasture -- lucerne, rhodes, clovers, cocksfood -- is under two years old.

The drastic deep ripping or subsoiling of pastures on the poorer thin soils, while probably increasing first year yield, will all too often be disappointing in yield for following years. Deep ripping with rigid implements is very costly and throws up clods which are too big. Heavy soil will not remain open to this depth but will reseal with the first good rain. There is no profit in taking depth that cannot be held. The topsoil fertility will fail to produce a rapid soil change in the subsoil if it is given too much depth of subsoil to "convert". Again consider the topsoil as a yeast and do not subject it to too great a dilution--as may take place in the case of overall deep ripping or subsoiling.

The present methods of subsoiling crop land, where deep sub-soilers rip the soil to 24 inches deep, and surface cultivating implements follow, is wrong. The fine surface cultivation of deep subsoiling largely offsets the benefits of the moisture and air absorption capacity of the subsoiling. All the benefits of subsoiling, without its usual disadvantages and high cost, are obtained in the final deeper run of Keyline cultivation. Extra depth can be obtained by increasing the cultivating row spaces.

The object of Keyline cultivating below the soil into the subsoil is always the improvement of soil fertility and the conversion of this subsoil into more fertile soil. It can be done most profitably and economically only as a progressive process.

Compacted soils of all types have lost the natural fertility potential that is available to all soils of good structure. The continuous decay and humus formation from the considerable amount of grass roots material which dies each year is almost entirely wasted.

Poor compacted pasture land usually has available to it every ingredient for a rapid fertility increase except oxygen and water, and these two are prevented from operating fully.

Minerals of all necessary kinds are usually only inches below the poor pasture. The urine and dung of the animals are available in sufficient quantity. Materials for aerobic decay and humus formation exist in the grass roots, all of which have not been completely lost.

One low cost fast run with spikes or chisels on the Keyline principle makes available all the ingredients for a new fertility. Within a few weeks after rain on this cultivation, the return of life to the soil and pasture can be seen in the rapidly changing structure of the soil.

Whenever pasture land shows sign of surface sealing or compaction it should be treated in this way. If and when the second cultivation is required it is made deeper. The same high speed and low cost is obtained by increasing the spike or chisel row spacings. Actual soil depth is increased this way.

On the slopes below "Nevallan" Homestead. "Keyline Cultivation" for soil and pasteure improtement a few days after the first shower of rain. The area shown in the lower half of the picture was originally pasture sown on shallow disking. After this one Keyline cultivation, pasture growth improved fourfold.

As soil becomes more and more fertile, less and less aeration by cultivation is necessary. Reasonably well managed highly fertile soil will look after itself. It will absorb all the available factors of fertility and aerate itself. It will preserve its own "life", including the beneficial earthworms.

Fertile soil and pasture absorb moisture rapidly, store it deeply and the soil aerates itself.

Other plant nutrient as well as oxygen and water reach the earth in the rainfall. These are largely absorbed into the soil and held if the soil is properly treated.

When poor pasture land is to be completely cultivated to kill all growth for the replanting of a new

pasture, it is treated as described for conversion year cultivation.

Grass seeds are sown into this cultivation with outstanding results by seeding with an ordinary grain combine with the cultivating tines removed. For even sowing and better germination, a flow medium of some kind mixed with the grass seed is a great advantage. Sow into the moisture zone some time after rain has fallen.

If the soil is of poor structure -- low in humus -- watch it against possible surface sealing after heavy rain. If it seals give it one working when it is dry enough. Follow the Keyline cultivation with spike spacings 24 inches apart.

If pasture tends to run out something is definitely wrong. Apart from overstocking or indifferent stocking management, the cause will be moisture wastage -- shortage of oxygen -- or both. If pasture land is assisted by correct cultivation to absorb moisture and air it will continue to improve in fertility and productiveness and will not run out.

To-day most pastures tend to deteriorate, and these declining pastures are ploughed up, a crop or two taken and re-sown again to grass and legumes. The poorest pasture paddock is usually selected to be used in this way.

If crops are to be taken on pasture land only good pastures should be used.

Any farmer would be reluctant now to take this course, but if all his pastures were good, he may select his best pasture paddock for cropping. Any three-year-old pasture should be good, and improving. The newly sown pasture will probably be the lowest yielding, but will be improving rapidly with the soil fertility. The farmer will select his best soil and pasture for his crops and so allow time for his newer and poorer pasture to improve with the soil before they in turn come up for cropping.

Some pastures may need Keyline cultivation for fertility by absorption each year for two years, and need the treatment again in three years, then five or more years later.

As both the soil and pasture improve, better grasses may be introduced with any Keyline cultivation.

An improving soil will more truly indicate its requirements in minerals or trace elements -- should these be necessary -- than a soil that is being forced to yield by one or more of the popular methods of extraction fertility.

There are numerous methods and techniques for pasture improvement, some good, some very bad.

Pasture improvement can be obtained -- temporarily at least -- by more efficient methods of extracting the remaining fertility of the soil. It can be secured properly and permanently only by methods that primarily improve soil structure, fertility and depth. It is wrong to use chemical fertilisers only to improve pastures. A fertiliser, if used, should be used in such a way as directly to improve the soil. This improved soil will give an improved pasture, thus commencing a cycle of soil fertility, permanently improving pastures.

If fertilisers cannot be used on soil apparently requiring them to assist directly in "triggering-off" this new cycle of soil fertility, the soil is much better off without the fertiliser.

Soils that do require the use of fertiliser also usually need, and much more urgently, the application of the principles of absorption-fertility.

If the soil is very low in humus, the first full green growth on this soil should be plowed into it. This will start the cycles of fertility and increasing yields. Fertilise to improve soil and depend on

improved soil only for increased yields.

The recent enthusiasm for pasture improvement in Australia has unfortunately emphasised the wrong word. "Soil improvement" is the only real basis for long-term pasture improvement.

It is more than likely, indeed almost certain, that the introduction of new grasses and fertiliser to increase rapidly the stock-carrying capacity of poor soil, is providing the farmer with another method of extracting the fertility of the soil. The soil must always be considered first. Increase absorption, manufacture -- humus under the pasture, improve the structure of the soil, increase soil "life", then the improved grasses will readily assist in the full development of soil fertility and produce abundant pastures.

It is fully recognised, however, that some methods and techniques have produced outstanding pastures.

Disc implements have on occasions been used exclusively, and have improved soil and pasture on soil that had lost its condition and some of its fertility. The shallow disc plowing into the soil of crops of weeds and later sowing pasture grasses by the methods of broadcasting or "direct-drop" and then harrowing, may give an outstanding pasture for a few years.

By improving top soil fertility, actual improvement of soil depth may take place very slowly, but the pastures tend to "run-out".

Such pasture treated by the Keyline method for soil and pasture improvement will produce rapid and permanent soil and pasture improvement.

Very fertile soils on occasions require Keyline cultivation.

After big floods recede from farming and grazing land there is usually striking evidence of the damage caused to the soil by waterlogging. The soil has been partly killed by too much water. It is literally "dying-for-air". Pastures which grow out of this soil are not healthy stock food, although the grass may be growing well. It is the type of food suitable for the hordes of pests that feed on the products of infertile or "sour" soils. These pests locate this food and devour it as they breed in countless millions. They may "foul" the soil to such an extent that stock will not graze what may remain. With the infestation, weeds often grow in profusion.

This soil needs Keyline aeration cultivation immediately it is dry enough. The "sickness' is then cured and the soil will be almost immune to these pests. A fast working of the land with tines spaced at 12 or 24 inches apart at a depth of four to five inches is all that may be necessary to bring this soil back to a healthy state. Deeper cultivation depth on the wider spacing could be considered.

Disc implements and mouldboard plows are not recommended because they are unsuitable for following the lines of Keyline cultivation. They do not promote rapid soil improvement and are incapable of the correct deeper cultivation.

Mixed growths of vine and rough grass may be given one shallow run with a disc implement and immediately followed with the spiked implements. Keyline cultivation must always be followed.

An outstanding pair of implements for soil improvement particularly where the growth is heavy and matted, is the Mulch Mower and the Graham Plow.

The Mulch Mower can be used also to the great benefit of the soil any time pasture growth is high and not required for immediate stocking or fodder conservation.

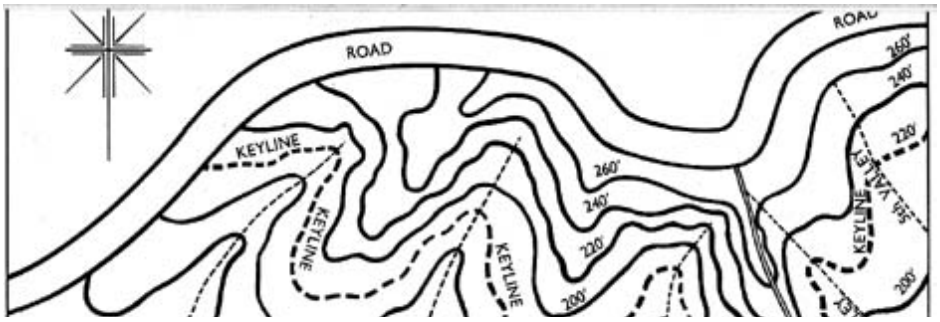
CHAPTER 6

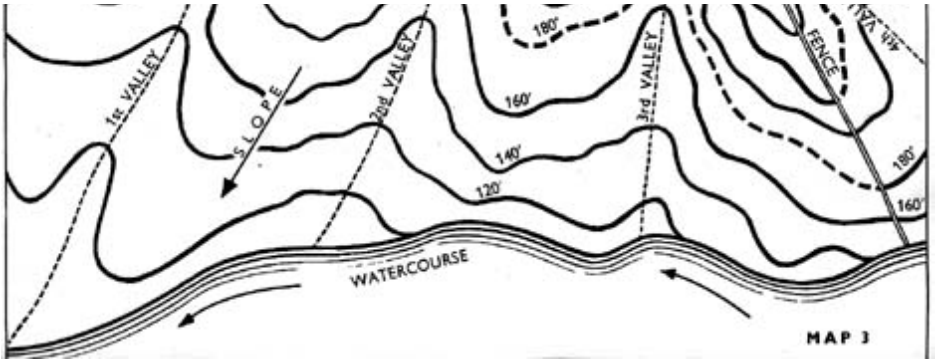
Common Keylines and Keyline Land Units

FROM the limited application of the Keyline of one valley as illustrated on Maps 1 and 2 and discussed in Chapters 1 and 2, we now consider the next step -- the extensions of the Keyline.

Each valley will have its Keypoint and Keyline. Where, by the extensions of the Keyline levels -- either on a true contour or with a slight fall -- the one Keyline serves two or more valleys, this line becomes a "Common Keyline". It is simply one line of levels that forms the Keyline of each valley it crosses.

Map 3 illustrates an area of steep country with five major valleys draining towards a rocky creek.





An examination of the first valley indicates that the 180-foot contour -- the broken line - -is the Keyline of this valley. The same contour also serves as the Keyline of the second and third valleys but crosses the fourth valley in a location obviously not the Keyline of this valley. The 180-foot contour is the Common Keyline of the first, second and third valleys, while the 220-foot contour line is the Common Keyline of the fourth and fifth valleys.

For purposes of cultivation and development these two Common Keylines control two separate areas. A fence line up the centre of the ridge between the third and fourth valleys divides the areas according to Common Keylines. These two sections are Keyline areas, or complete Keyline cultivation and development units. They include the areas both above and below the Keyline.

A Keyline area, then, is an area controlled by a Keyline or a Common Keyline and may include any number of valley areas. The Keyline areas of Map 3 may be further subdivided into any number of paddocks.

Conversion-year cultivation in the case of crop land or Keyline soil development for pasture improvement is first completed in the area above the Keyline and parallels the Keyline up the slope of the land.

If the Keyline is not to form a gently falling water race--it often does, see "Water Storage", Chapter 7--some other means. of permanently marking and preserving the Keyline is necessary.

A row of stakes first marks the Keyline. Leave a narrow strip unploughed on each side of the Keyline stakes. On this, brush or trees will grow along the line during the time the area is closed to stock for cropping. This line need only be a few feet wide and it will serve as a permanent marker for the Keyline.

Without the tree growth on the unploughed Keyline strip, a marker can be satisfactorily preserved by carefully following the lines of the previous cultivation.

Another means of permanently marking the Keyline is to use it as a farm roadway.

CHAPTER 7

Water Storage

IT has already been stated that the greatest available water storage capacity exists in the soil itself. The association of Keyline cultivation and this water storage capacity has already been explained.

If all rain which falls on crop and pasture land could be absorbed into the soil, there would still be areas remaining that do shed most of the rain that falls on them. Farm roads and yards, the homestead and other farm buildings and sheds, and often main roads, shed considerable quantities of rain. Conservation of this water for farm use is of the utmost importance.

Whether a farmer realises it or not, he is dealing with forces that need the full use of engineering planning. A sudden storm may send 100,000 tons or 500,000 tons of water on to a 1,000-acre area in an hour or two. This huge weight of water can be controlled and conserved by the farmer to the great benefit of the land and himself, or it can run largely to waste, leaving a trail of destruction in its path.

Levels are important factors in any water control and conservation project. These need to be used to advantage by the farmer. Contours and other level considerations are basic land engineering factors. The farmer must know how and when to use them.

The application of Keyline methods requires very little levelling work, but those levels that it does require are of great importance.

On undulating country, dams can usually be located which will enable the farmer to enlist the forces of gravity to provide him with water under pressure. This will give him a better farm, easier work and higher yields. Other things being equal, the value to a farmer of conserved water is in direct proportion to the height of the storage. The dams of potentially greatest value are those in his high country.

New pasture being irrigated by gravity pressure on "Nevallan". Guideline timber strip forms a permanent market for Keyline cultivation. The truck in the centre background is travelling along our Keyline road.

The Keylines, by crossing the valleys at their first main point of slope flattening, will invariably position the highest suitable valley storage area for water.

In any plan of general land development, the control of water is one of the first considerations. At the same time, it is to be kept in mind that Keyline Absorption-fertility is going to reduce run-off water very considerably. It may even completely stop run-off water from farm and pasture paddocks, except in the rare, but under present conditions, very dangerous period of general heavy flood rains. With the absorption of what previously would have been heavy run-off, consideration has to be given to conserving water from every available source.

With the Keyline positioning the highest suitable dam sites, it becomes important to locate potential water-shedding areas above the Keyline.

The Keylines have been illustrated as contour lines in the discussion on cultivation for the sake of simplicity.

For purposes in connection with the conservation of water in the Keyline dam, the Keyline itself is a gently falling line to form a drain or water race to carry water to the dam. The use of the Keyline, which is now a drain, is still fully effective as a guide for Keyline cultivation.

It is usually convenient and good practice from most other viewpoints, to locate the homestead and all farm buildings and the yards and their attendant roads in the higher country. From the point of view of full Keyline development, it becomes a part of planning to do so, in order to secure abundant run-off water to fill the Keyline dams from these sources.

Wherever it is possible and practical, dams are constructed on the Keyline in the valleys, and the Keyline itself is pegged and constructed as a gently falling drain to carry water to the Keyline Dams.

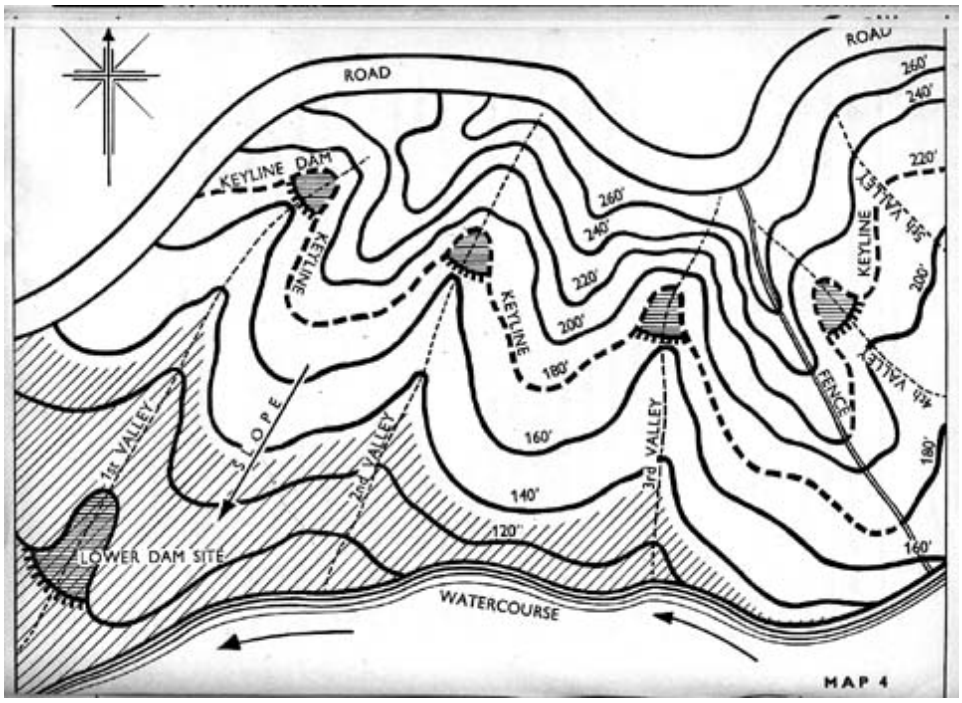
Keyline dams are constructed with a pipeline through the wall or through the floor to one side of the centre line of the valley, so that the full gravity pressure of the conserved water is available for spray irrigation and other farm purposes.

Where areas of land exist that are 50 feet or more vertically lower than the Keyline, the water from the Keyline dam will supply effective pressure for irrigation without pumping. This "line of effective water pressure" suitably forms the top boundary for the irrigation paddocks. A 4-inch pipe through the wall, controlled by a 4-inch gate valve, in these circumstances will control gravity pressure which, often from a single dam, will effectively operate a comprehensive spray irrigation and stock-watering system.

Spray irrigation without pumping. The Keyline dam which provides the water is situated in the hills below the small cloud in the centre of the picture. The bare area on the right is located on the site of an old disused road. All land below the timber line can be spray-irrigated wit4hout pumping costs.

With the use of a 4-inch pipeline, the vertical drop from the water level to a nearby irrigation area multiplied by 0.4 will give the approximate pounds pressure available in the spray line. A vertical fall of 50 feet multiplied by 0.4 gives a twenty pounds per square inch pressure, which is suitable for operating most types of spray lines. As the spray line is moved downhill a little on each "move", there is, of course, an increase in available pressure.

Referring to Map 4, which exhibits the same land area as Map 3, the Keyline crossings of the valleys are to be considered as possible dam sites. The sites marked in four of the valleys could be considered good dam sites. The site of the Keyline crossing of the fifth valley is not as suitable as the others.



The most valuable water storage site for a Keyline dam is located in the first valley, as this site has the greatest area of land below It which Is suitable for irrigation by gravity sprays. This fact indicates a rule or general formula for determining the direction of flow of the Keyline when it is formed by a drain. If the creek or drainage line below a series of valleys -- as in Map 4 -- has a general fall greater than five feet per thousand feet -- the fall recommended for the Keyline drain -- the direction of the Keyline fall follows that of the creek. When the creek has a flatter fall than required by the Keyline drain, the drain falls in the direction opposite that of the creek. This is illustrated by the shaded area on the map.

The construction of a Keyline dam will often cost considerably less than a pump and engine installed for spray irrigation. The Keyline dam, its pipe and valve outlet, will operate the same sprays with no pumping cost.

This low cost water is used in the general programme of progressive soil development, and higher

yields will be incidental and automatic to the Keyline Absorption-fertility programme.

The following construction comments should be considered.

Most undulating country is suitable for dam construction if correct preparation and compaction of the material in the wall is secured. Fine clay, which is usually considered the best material for dam bank construction, has its own particular problem. This material in the wall of the dam will tend to "jell-up" below the waterline to such an extent that the weight of the wall above this wet unstable material may squeeze the material outwards from the wall, thus causing a central subsidence of the wall which extends down below the water line. This would result in the water overflowing at this point and would completely destroy the bank.

In shale country the mixture of shale and clay will give the best possible material for bank construction.

Before laying in a dam bank, the foundation area of the bank must be treated first according to the type of country. In shale country it is necessary to remove only the darker topsoil material to one side-this can be used later to cover the bank to obtain a quick growth of grass. This cleared area is then ripped before the wall filling material is placed on it. The material for the wall should be placed on in layers of from 6 to 12 inches thick, so that suitable compaction of the soil takes place during construction. Bulldozers will give sufficient compaction usually without the need of further special compacting implements.

The back of the wall of the dam, that is the side away from the water, should not be specially compacted. If water seeps through the compacted front of the wall into the centre, it must be allowed to get out through the back of the wall, otherwise it may build up hydrostatic pressure inside the wall. This could destroy the wall by forcing or breaking the material from the back of it.

Clean water seeping through a dam wall is usually quite safe, but a seepage that is discoloured by the wall material should be considered a danger to the wall itself. Raking or harrowing of the side of the wall in the water of the dam is usually the best means of sealing this type of seepage.

In the construction of this type of dam by bulldozers, the excavation of the sides of the dam, if the land will stand firm, should be made on as steep a slope as the implement will dig. The water-side of the wall, as formed by the action of the bulldozer pushing the material upwards, should be flatter than the excavated sides. Usually the limitations of the implement to push material up the slope of the wall will form a wall of suitable slope.

The laying of a pipeline through the wall of the dam, or through the earth below the wall of the dam, requires some special attention.

The danger to be avoided here lies in the fact that water will tend to flow along the outside of the smooth pipe, creating an ever-widening and larger hole, which may eventually let all the water go and so destroy the wall.

The following method of laying these pipes has been found completely satisfactory.

After the wall site has been prepared by clearing away the topsoil material and the subsoil ripping, a trench to receive the pipeline is dug

Across the wall area a little to one side of the centre line of the valley fall. This trench is to be at least three times the diameter of the pipeline in width and depth.

A 12 x 12-inch trench is required for a 4-inch pipe. The pipeline is laid in this trench with three or four large loose flanges 12 to 16 inches diameter. These are placed around the pipe from the inside of the wall to about its centre line.

At each flange along the pipeline trench, two or three bucketfulls of wall material mixed with about 20 per cent. of some lightweight material is placed around the pipe. The trench is then filled in with adequate tamping of the material up to the surface level of the trench. It is important that this material should have the same moisture content as the wall material.

The special mixture at each flange of the pipes will tend to seal the leak .if water does commence to flow along the outside of the pipeline. Some of this lightweight material will move to the small openings and will automatically re-seal them.

In granite country it may be necessary to excavate a considerable portion below the wall site down to the depth of the firmer decomposed rock to prevent complete loss of water through the material below the wall..

If this work is done properly and the bank consolidated in layers of six to nine inches deep, dams in this country will hold water effectively. Without this work these dams will often not hold any water.

The High Contour dam is the highest dam of the Keyline plan. It is located in the areas above the Keylines.

Gently sloping country usually exists above the steeper slopes which lie above the Keyline. The valley heads will actually start at the low edge of this flatter country where the steep slope country commences. The High Contour dam is constructed here. The area selected for the dam site can be the side of a hill or ridge. A slope as steep as 1 in 10 is suitable.

The race or drain to transport water to fill this dam is located above the valley heads. It also serves to protect further these valleys by preventing any flow into them. The drain requires a fall of approximately 5 feet per 1000 feet. The site of the drain and dam must be studied and planned together.

A sketch and cross section of a High Contour dam built on the steep slope mentioned is illustrated below. Each cubic yard of earth moved conserves two cubic yards of water. This ratio is not as favourable as that in the construction of Keyline and other valley dams which may be round the ratio of six of water to one of excavated material. However, the value of the conserved water in this High Contour dam more than warrants its construction where the topography is suitable.

The High Contour dam may be constructed anywhere along a ridge where a suitable slope exists and where run-off water can be brought to the dam by a drain from one or both directions.

Because of these circumstances, the dam is usually long and narrow and always along the contour.

A bulldozer is used for construction and the earth is moved from the topside straight across the dam to form the wall. In this way the haul is lessened and the cost of earth moving is in direct proportion to the distance the earth is moved, so this distance is kept to the minimum.

The drain to fill the dam is located and pegged when the dam is marked out. The construction of the dam is completed before the drain is built. There is then no danger whatever of losing from heavy rains any part of the dam during its construction. The back wall of the dam is constructed first. Then the 4-inch pipe outlets are laid at one, or both, ends. After this, the end walls are closed and the drain made.

A spillway is not constructed, because surplus water is allowed to overflow from the drain at some distance from the dam when it is full.

It is only necessary to see that the overflow does not occur at the same place more than once during the first year or two, so that no water wash is started. Once the drain is grassed, blocks can be made at any suitable place in the drain to overflow the water there.

Water transporting drains can become less effective, or sometimes completely ineffective, by becoming overgrown with vegetation. The best means of controlling this growth is by seeding the drain to good grass species and manuring the drain heavier than the adjacent pasture. This encourages the stock to graze the drain area more closely than the rest of the paddock. It is also advantageous to mow regularly the long excavated slope of the drain so that the water transporting capacity of the drain is unimpaired.

If a road is to traverse the area of the drain it can be placed parallel to and above the drain. The water run-off from the road is caught by the drain and conserved.

The Keyline dam, constructed on the Keyline, and the High Contour dam, above the Keyline, are the two highest dams used in Keyline planning. For this reason they are the most important dams of all water-conservation schemes.

The water conserved in these dams is available under pressure for instant use. It is the lowest cost irrigation of all conserved water and is, therefore, used when the first dry spell makes its use profitable and advisable. No dam should ever be completely emptied except for reconstruction or enlargement. A few feet of water is always left in these dams, and this will go a long way toward protecting a bank from dangerous dry cracking.

There are many farms that do not have their own Keylines. The development of these farms is mentioned in a later chapter. The con servation of water below the Keyline and on these properties of lesser slopes is discussed here.

The first of these dams is called the Guideline dam, and is, like the Keyline dam, a valley dam. The wall material is excavated from the area of the valley which will be below water level when the dam is filled. All earlier comments about the Keyline dam, including the pipe outlet, are common to this dam. Its particular location is apparent from the chapter "Flatter Lands".

The next dam in Keyline Planning has its counterpart in the ordinary valley dam. These are to be seen on farms and grazing properties all over the countryside. The main consideration in locating the usual farm valley dam has been to conserve the greatest amount of water for the earth moved.

With the absorption into the soil and the conservation in Keyline, High Contour and Guideline dams, of practically all the rainfall, a large capacity lower dam has to be located where it can be filled despite these other storages. By locating it in a lower valley, such as the site indicated on Map 4, it is in a favourable position to receive the combined seepages from all the higher country. Apart from seepages, this dam will receive water from very heavy storms and in the periods of general heavy flood rains when most water conservation storages may overflow.

These dams can be made large to act as a buffer or safety against prolonged drought. They should be as deep as practical, so that evaporation losses are reduced. Losses by evaporation are in proportion to the surface area of the water. A dam six feet deep could lose all its water in a hot dry year, while a deeper dam would lose only the same depth and have water storage when the other is empty.

The construction of dams by blocking a stream or creek is usually controlled by the Government Water Conservation and Irrigation Authority. Plans for these usually need the approval of this authority, which will also often assist with advice on the preparation of the construction plans.

Apart from other constructional details, the provision of adequate and safe spillways for overflow is of maximum importance in these stream dams.

Contour dams, of which the High Contour dam is the one placed in the highest location, can be constructed in almost any type of country to provide low cost large capacity water storage. They are not located in valleys and, as with the High Contour dam, require drains to provide the water.

On the land below the Keylines they can be filled from a flowing stream or one that flows intermittently.

The location of a Contour dam is decided by first, the means to fill the dam, and second, a suitable area for the use of the conserved water. The water may be used for spray irrigation and other purposes. The main excavation and bank of the contour dam is always along the contour. The total cross sectional area of the excavation and bank are approximately the same whether the dam is very large or of medium size.

In the construction of the Contour dam a bulldozer is used and earth is moved straight down the slope at a right angle to the contour. The distance of the "haul" is kept to 100 feet approximately, to provide for the most efficient bulldozer operation.

A similar construction to that of the High Contour dam is followed. In flatter country the end walls -- which are the same length as the width in the High Contour dam -- become longer. In the High Contour dam all water is conserved by holding it in the excavated area by the wall. The Contour dam, on the other hand, holds much of its capacity over unexcavated land.

In flatter country, where the contour dam then assumes the shape of a "broken ring", the end walls are turned in toward each other. The water race feeds the water into the dam between the converging end walls.

On still flatter sites it assumes the shape of a "complete ring" and the major storage capacity in larger dams is then over the unexcavated central area.

A pipe outlet is placed through the end wall of the Contour dam at the lowest ground level, and water conserved above this height can be released by gravity.

Gravity pressure is used for irrigation if the conserved water is high enough.

The outlet pipe through the wall of these dams can lead directly to a centrifugal pump outside the wall. This maintains the pump under a positive water head, so that instantaneous water pumping is available without pump priming.

A Complete Ring dam should be constructed on a flat area of land below a ridge to which water can be brought by the drain. In deciding the location of the Complete Ring dam consideration is first given to the filling of the dam by flow from a watercourse. It may be practical to lead water from a watercourse along a water race to a rise close to and above the site, and from this point flow the water over the wall through fluming.

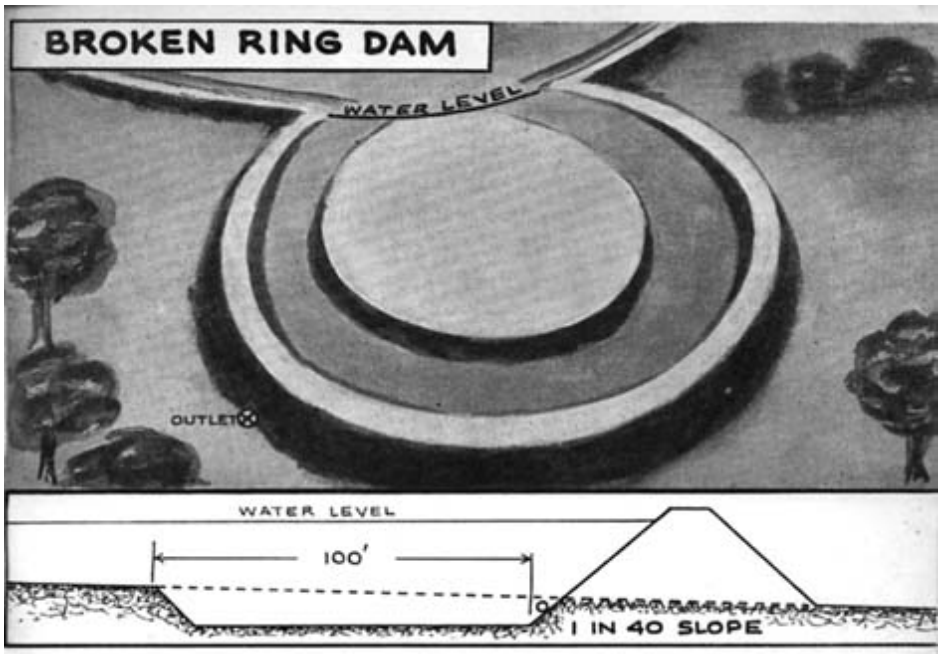
The filling operation is controlled by a low weir wall constructed across the supply stream bed. A suitable notch outlet is provided to control the water. This wall, constructed of logs, grouted stone or cement, need be only 2 feet to 3 feet high.

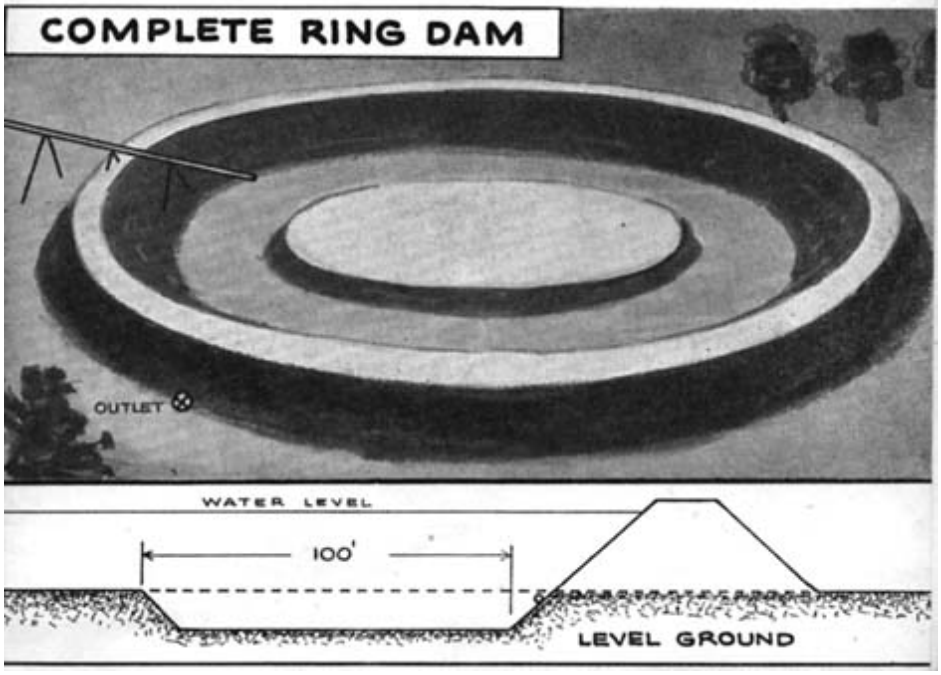
The fluming for the Complete Ring dam may be made of a variety of materials, but its shape is always that of a long trough. Wood or iron fluming is most suitable and the fluming is supported by a trellis of bush timber.

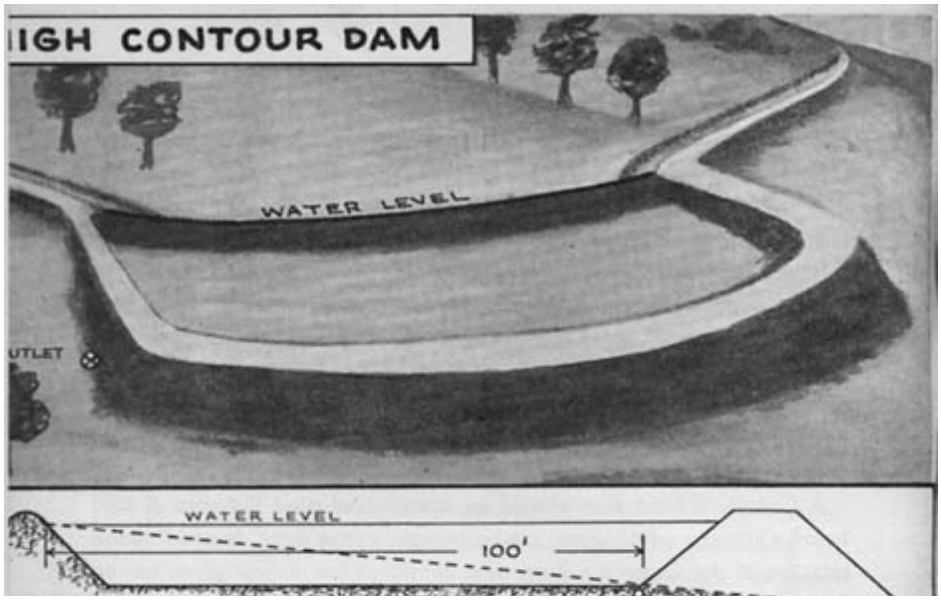
These dams, ranging from the High Contour to the Complete Ring dam are suitable for easy construction and very profitable use in a wide variety of farming land. Small bulldozers may be used. All the land that can be spray irrigated from such dams will develop rapidly in fertility, productiveness and value. Keyline progressive soil development, greatly stimulated by the correct use of spray irrigation, will bring this land very close to the value class of fertile irrigable river flats.

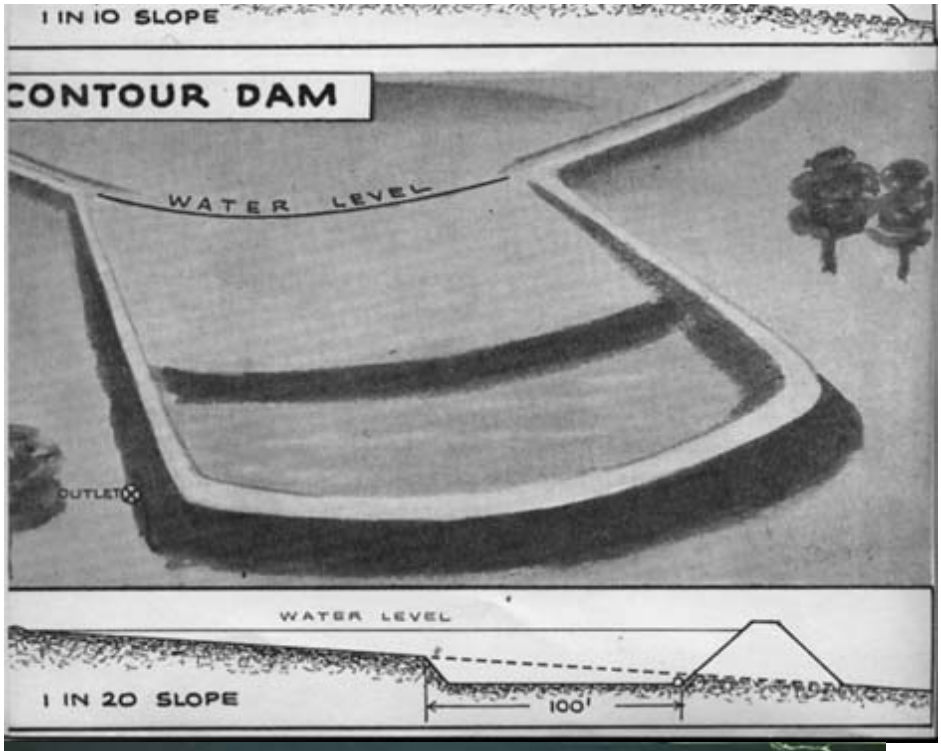
The overall costs of spray irrigation will be less than those pertaining to river flats and the pumping of water from the river. River water will have to be "lifted", whereas the water of these dams is at

least "assisted" by gravity.








1 IN 10 SLOPE
CONTOUR DAM
WATER LEVEL
OUTLET
WATER LEVEL
1 IN 20 SLOPE
100'

CHAPTER 8

Trees

TREES that were on land originally timbered were part of the natural soil development. In no circumstances is the complete destruction of all this timber necessary or desirable for farming and grazing pursuits.

There is probably no other land development work that has been so completely unplanned and haphazard as that of timber killing and clearing and no factor of fertility so completely ignored.

In order to grow crops and satisfactory pasture on forested country, clearing of timber is necessary. Gradually more and more timber is cleared because of the disadvantageous effect of trees on crop land.

However, like cultivation, clearing has been overdone, with the result that soil fertility eventually suffered and crop and pasture yields were affected.

Grasses and timber do not usually grow well together. A large tree will all too often affect quite a sizeable area of crop or pasture land and the tendency is to get rid of the tree.

On some farming lands trees are left scattered about. These trees, no longer living in forest conditions, tend to die out. It is often observed that the upper and outer branches are dead; the trees are slowly dying together. On some farms they are already dead.

Properties which contain some steep country are often cleared to allow all the flatter country to be cropped. The steep land is left timbered and used as grazing areas.

The general practice of leaving all steep country in timber to protect it from erosion has not been successful, nor has this practice improved the timber. Steep country, left fully timbered, is often the greatest bushfire hazard and the worst area for pests. A fire in a timbered area, followed by heavy rain, is one of the causes of widespread land erosion.

To derive the greatest benefit from timber for soil fertility and better farm working and living conditions, trees must be left to serve the whole of the property.

Properly located trees cool a property for stock in summer and warm it in winter. They protect the land from winds and in their widest aspect may be capable of some overall improvement in climate.

Keyline timber clearing is planned to derive the greatest benefit from trees for the whole of the farm.

First, trees are left in strips or belts wide enough to keep some semblance of forest conditions in the timber for its normal healthy growth.

Steep country is not left in full timber, but partially cleared and timber strips are left to serve as wind protection for the property.

The Keyline is again the planning guide for clearing. The first timber strip half to one chain wide is left just below the Keyline and forms a Keyline Timber Strip.

In most areas the lower side of this timber strip is suitable for a farm road being drier generally than the land above the timber strip. Crop or pasture suffers more from the effects of moisture lost to the trees on the lower side of a timber strip. However, when a road follows along the lower side of the strip the little extra water run-off from the road causes both grass and crop to grow well right up to

the road.

The timber strip or the road along the timber strip forms a permanent guide for Keyline cultivation.

The "first" Keyline road and Keyline timber strip. The road and strip continue for another half mile beyond the point shown in picture. Pasture consists of cocksfoot, lucerne, rhodes and clovers. The area is above the "line of effective water pressure" and does not receive irrigation water. Pasture grows right up to the road. The trees protect the land.

From the Keyline both up the slope and down the slope of the land, timber strips are left (or planted) on the contour at regular vertical intervals apart. The important guide for determining this vertical interval between timber strips is related to the height of the trees. If trees are 45 feet high the timber strips could be 40 feet apart vertically. This provides some overall wind protection for all the land and locates the timber strips closer together in the steep country and farther apart as the country flattens.

Even in very flat country of low scrub or mallee only 10 to 15 feet high this formula for clearing will provide greatly improved farm conditions. The only trees that are necessary other than those on this pattern are the ones left around the boundary of a Keyline paddock area.

Timber strips left as described are a valuable aid to soil fertility, apart from the supply of the deep minerals which they bring to the surface. In wet weather cattle will only stay on soft pasture ground long enough to feed and then return to the firmer ground in the undisturbed soil of the timber belt.

The two most efficient land compacting implements are the sheep-foot roller and the multiple pneumatic wheel roller. The farmer has to contend with his own efficient compactors, which are his stock and wheeled farm implements. The comfortable conditions of the timber strips will keep his stock off wet, soft ground to a large extent. The farmer, of course, should leave his wheel machinery in the machine shed when the land is wet. Thus compaction of the soil, one of the great destroyers of soil fertility, is minimised.

By clearing the steep country on this pattern, more and better grass areas are available and better timber will grow in the timber strips.

Very short steep slope country is always of greater value when cleared and Keyline developed. Suitable timber strips are left on the flatter top country above.

Keyline Absorption-fertility methods above the timber strips do, by the greatly increased moisture-holding capacity of this land, provide the timber with better moisture. Timber growth is considerably accelerated.

Timber strips will prevent land slips on country that would tend normally to slip when fully cleared and saturated in heavy rains. The timber strip is a definite and effective anchor, holding the land together.

Land that has been Keyline cleared, when subsequently subdivided into paddocks will have some shelter timber in all paddocks. Every paddock, whether in the steeper slopes or the flat country, can be rotated to grasses and crops in turn.

The only way to ensure perpetual timber is by providing conditions that allow trees of all ages to grow together.

If each paddock in turn is closed to stock and cropped for two years or more in each ten or twelve years, young trees develop in the timber strips and permanency of timber belts is secured.

To sum up the simple plan of Keyline timber clearing:

Decide on the location of the largest paddock areas -- see further comment in the chapter headed "The Plan" -- and locate the Keyline or Common Keyline of this section. Then peg or suitably mark a strip or belt from 30 feet to 60 feet wide parallel to the Keyline below it. This belt is to remain in timber.

Next mark out the first timber strip above the Keyline by pegging or marking a contour line at a vertical height above the Keyline approximately ten per cent. less than the height of the Keyline trees. Mark another contour line above this one 30 to 60 feet wide. This pegged area is the timber strip which is to be left there.

Continue this contour marking, both above and below the Keyline.

The contour marking of the tree strips leaves the strips themselves of uneven width.

If tree strips of even width are desirable, then a contour line forms the lower line of the strips above the Keyline. A line, parallel to this, forms the upper line. Below the Keyline the upper line of the strip is on a contour and the lower line is parallel to it.

A strip of trees may also be left around the boundary of the area.

When the country is cleared on this pattern, the timber strips form permanent markers for all Keyline cultivation.

No land could be more spectacularly beautiful than the timbered undulating country of Australia which has been cleared and developed by Keyline planning.

However, large areas of land that will come up for Keyline development have had too much of their timber removed without plan, and the growing of timber strips will be a necessary part of the best Keyline development.

Generally a small Australian native tree will cost a little over one shilling to plant, but may cost over one pound to maintain for a year. While the cost of planting is not so serious and can be reduced by growing the young trees on the farm, the cost of growing timber strips of thousands of trees is impracticable unless some cheaper and easier methods are devised.

Keyline planning and development will permit the closing of paddocks from stock for two or three years while crops are grown. This time will allow a planted or "induced" timber belt to develop to a stage where the trees will survive without attention.

In large or small paddocks without trees that are to be Keyline conversion-cultivated a timber strip 4 to 10 tree rows wide can be planned. After the paddock has been completely cultivated tree rows are marked; the first row by a deep single rip cultivation parallel to the Keyline or Guideline. The distances apart of the further rows of trees are gauged by the tractor that will later cultivate between these rows. The following procedure has been found suitable.

After completing the full Keyline conversion cultivation of the paddock, mark out by a single rip the first tree row position. A single shank is allowed to penetrate deeply through the plowed soil. On the return run with the tractor, place the higher side rear wheel in the lower wheel track of the first run and travel the tractor back without ripping. Turn and again with the uphill side rear wheel in the lower track of the last run, mark out, by ripping deeply, the second tree row. Repeat to the number of tree rows to be planted. This row spacing will allow the tractor later to cultivate satisfactorily between the tree rows. One or two cultivations are advisable during the first year.

This work is done some months prior to the time for planting the young trees, so as to collect as much deep moisture into the earth as possible. The object is to improve the soil and to provide sufficient moisture in the soil before the planting of the young trees, so as to avoid entirely the

necessity for watering later.

Australian native trees should be planted when a few inches high and a few months old, and planted directly from the tubes as used by the Forestry Nurseries. Plant the young trees well into the moisture zone without breaking the tubed soil in which the tree was raised. Press the soil down very firmly around the trees.

Trees can be planted very quickly into this deep moist soil with very few losses and without the addition of any water. The distance apart of the trees in the row may be closer than is intended for the developed trees. Spacings of eight feet are suitable for a variety of tree species. Planting time varies in different districts.

If watering and hand cultivation can be avoided, the chief cost of growing the trees is also avoided.

A tree strip on a Keyline may sometimes be satisfactorily grown by planting the tree seeds directly into the paddock.

Trees can be induced to grow by a variety of means without the actual planting of young trees or tree seeds, by merely leaving a strip of country out of plowing when the paddock is closed for cropping. Tree growth will often flourish on the untouched strip and form a valuable tree strip.

Two interesting incidents are recorded here to show that other low cost means of growing valuable timber strips are available to the farmer:

1 . During the construction some years ago of several water races, the completed drains, all except one, were harrowed and fertilised. A directive was given that this one drain was not to be treated or touched in any way, in order to see just what would grow on it. A variety of rubbish grew quickly on this exposed subsoil. Three years later a row of trees 20 feet high, all of one species, covered the drain.

2. During a very dry period several runs with a heavy road plow were made to form a fire break. Later the dry grass of this fire break strip was burned off. The paddock was not stocked heavily during the following two or three years. At the end of this time the fire break strip alone was then well overgrown with trees all of one species. The trees here were a different species entirely from those which were growing in the drain less than a mile away.

From these happenings it can be seen that whenever a treeless paddock is to be closed up for cropping for two years or more, a suitably marked and planned strip of land should be left untouched, or perhaps given some special attention so as to allow a timber strip to develop of its own accord. Once the trees are two or three years old the majority will survive stock damage."

CHAPTER 9

Steep Country and Valleys

CLIMATIC features have a profound influence on soil development. Gently failing rains are better for natural absorption-fertility than sudden heavy downpours. The gentle rains are absorbed into the ground with all their fertility factors. Ground moisture lasts longer and beneficent decay continues while moisture is present. The surplus water percolates underground after the majority of fertility factors are filtered from the rainfall. All the gases contained in the rain become available in sufficient or maximum quantities to aid optimum fertility development. Many kinds of basic minerals, organic elements and chemicals are contained in the air.

There is every reason to assume that a wide variety of elements are brought into the soil when rain is absorbed and held long enough to enable the humus of the soil to filter these into itself.

In the harsher climatic conditions generally affecting most of the Australian farming lands, natural absorption fertility does not operate to the extent it does in countries of milder climatic conditions. Moisture losses continuously retard decay. Methods of extraction fertility farming act more rapidly to reduce soil fertility to the stage of active soil erosion. Australia, of course, is not alone in this. America and Africa have similar conditions. The causes of erosion are precisely the same in these and many other countries.

Just as obviously absorption-fertility farming on these lands will be more strikingly effective than in the countries of benevolent climatic conditions. If, by every practical means, rainfall is absorbed into the earth and all its fertility elements held, and if evaporation losses of moisture are retarded greatly and processes of decay continue longer, then these countries of the harsher climates may develop more rapidly in fertility than the others. In such development, the most important type of country of all is unquestionably the steeper mountain and hill lands.

The effective control and rapid soil developments of these lands will do much to mitigate the calamitous effects of the worst feature of our climate,. The worst effect of droughts and flood can be fought and conquered by absorption-fertility methods of farming and grazing if applied quickly to these steeper lands.

At the present time the rapid run off from these lands directly causes uncontrollable and destructive floods, with losses of life, alarming destruction to property and stock, and the choking of rivers and harbours with silt. The trail of havoc extends from the mountains to the sea.

In dry, hot weather the steep undeveloped and uncontrolled lands are a constant menace with their bushfire hazard. Extermination of rabbits and other pests is more difficult in these lands.

Present recommended orthodox practice is to fence well, stock conservatively and leave the timber on these steep lands in order to protect them from erosion.

The trees of the steep grazing lands of Australia do not of themselves prevent erosion. Only good management does that. Timbered areas require better management to protect them than do grasslands.

Generally, the present condition of this steeper country is such that it will not grow both good grass and good timber.

A Keyline principle is that planning and development above the Keyline comes first. This

development must be sufficient at least to protect the lower lands.

The full development of steep country can only be accomplished rapidly and effectively if it can be made to pay. The profit must be almost immediate and definite -- not something in the dim and distant future.

The first approach is simply to enable the steep country to absorb the rain that falls on it and keep it in this condition. Then follow the Keyline method of soil improvement for pasture lands.

The clearing of this country on the Keyline clearing plan leaves permanent timber strips that form a guide for Keyline Absorption-fertility cultivation.

The full control that this gives will enable the effective control of bush fires. The parts of this steep country that may be adjacent to an outside fire risk area can be managed to protect the whole property. It can be heavily grazed or cultivated to form a completely effective fire break.

Considerable acreages of this steep country, often regarded as of lesser or almost insignificant value, will be found to develop better pastures than the land now considered as the best on the farm.

At present, when a farmer leaves his steep country in timber it is usually because he feels he must do so. Sometimes it is left because he really wants to run it as a forest for profit or for general farm purposes. He thinks then that the steep country is the only place for such a forest. In the Keyline development of steep country the farmer has the choice. He can develop high quality soil and pasture, or if he wants a forest area he can have this in the steep country or anywhere else.

Australia is, geologically, a very old continent. There are no very high mountains and practically no steep country of long, unbroken slope. By steep slope country is meant slopes of 100 per cent., or a rise or fall of one foot for each horizontal foot. Many slopes of 100 per cent. do exist, but they are nearly all short slopes rarely 150 feet long horizontally. These short steep slopes generally exist as the sudden dip-overs that form the valley heads -- the start of the valleys. If the farmer wants some good growing timber he will rarely grow it on this short steep country. Much better timber will grow on the flatter country above and below.

The clearing of timber on sloping country is dealt with in "Keyline Timber Clearing". Slopes of up to one foot rise in three feet are Keyline developed as described in earlier chapters. Most wheeled tractors will do this safely and well. The three-point hitch and other tractors on which implements are mounted, especially those of about 30 horse power, are particularly effective.

For short slopes steeper than one in three and up to one in one, a rawler tractor and a trailed Graham will provide means for full development of soil for pasture growth.

Keyline cultivation of the type required, up to three workings, is first completed above the slope to 30 feet from the steep dip over. The slope is then plowed directly down hill. The tractor and "plow" make the turn in the flatter area below and then travel squarely up the steep slope in the same width of plowing of the downhill work. Turn in the flatter area above and plow directly downhill beside the plowed ground of the first downhill plowing width. Continue plowing directly down hill in new ground and uphill in the plowed land of the previous downhill width. By "breaking ground" only on the downhill work and travelling uphill In the plowed ground, the load on the tractor of the uphill work is reduced to such an extent that the tractor will handle the implement on the uphill travel without continuous implement depth adjustment. The whole of the steeper country receives two cultivations by this means, and this completes the steep country plowing.

The next step is to start from the Keyline and plow the area above the Keyline to the bottom of the steep country plowed area. Follow Keyline cultivation parallel to the Keyline on the last run.

This land may in a short time grow some of the best pasture on the farm.

Unless it is solid rock, there is probably no country too steep for improvement if stock will climb it for food. Country that carries some soil, even if it is very steep, will display significant improvement by Keyline full development undertaken in the area immediately above it. It will probably be much richer in the minerals of fertility than land that has been heavily cropped and grazed by methods that have not only been extracting fertility but destroying more fertility than they extract in crop and stock production.

Our droughts and flooding rains are factors of prime importance in the loss of fertility and later in soil losses by erosion.

The effects of both are capable of profit producing control, by the absorption of fertility into the soil of the hill lands.

Valleys start or head where a portion of a slope near the top of a watershed or divide becomes steeper than the general slope on either side. Thus the first part of a valley formation is steeper than the ridges or shoulders on each side that form the valley. At some point down the valley -- the Keypoint -- the valley slope flattens to such an extent that it becomes flatter than the ridges or shoulders on each side in the same vertical interval.

These factors, as already stated, locate our Keylines. The valley itself and the ridges that form the valley are the two points that require special care once the steeper land above has been controlled by Keyline Absorption-fertility. The valley floor has been a danger point for erosion and may have gullies which require repair. The shoulders of the valley are usually the driest areas.

While the valleys of the usual farming and grazing property, if not eroded, carry more moisture than other areas, they continue to extract ridge moisture even when the valleys are too wet for healthy growth. This "dog in the manger" aspect of the valleys is quickly offset by Keyline cultivation. The ridge areas then receive and retain their fair share of moisture for longer and longer periods.

If the valley is eroded the erosion holes will continue to bleed moisture to the atmosphere until little remains. The effect of this process can be observed where every tree of a forest is dying in an eroded valley area.

Sufficient has been said in earlier chapters to illustrate the effectiveness of Keyline cultivation in the control and development of absorption fertility in valleys. Where significant gully erosion exists this can also be controlled by correct Keyline methods.

Keyline development first controls the usual water run off into valleys from the higher land, by tremendously increasing the absorption capacity of this area and diffusing the excess water, thus greatly retarding and delaying its concentration time.

With the high country in this condition effective gully control and repair in the valley below is simplified. If the hole or gully is not large, repair is best done without the use of bulldozers. Repairs with these implements, where the valley soil is not deep, too often result in the topsoil finishing in the hole and a relatively large area of slow-to-improve subsoil remains. This will spoil the look and value of the repaired valley.

A much better procedure is to use the Graham Plow for the repair work.

Plow up each side of the valley, allowing one end of the "plow" to drop over into the hole. Spikes with heel sweeps quickly move sufficient soil and subsoil from the banks into the hole and allow the "plow" to cross in all directions. Only sufficient filling or levelling of the hole is necessary to ensure that the deeper part of the hole is not lower than the valley immediately below. In this way ponding is prevented.

This repaired valley does not then expose all subsoil. The soil and subsoil will be mixed and the

effect of a bare infertile patch in the valley will more quickly disappear.

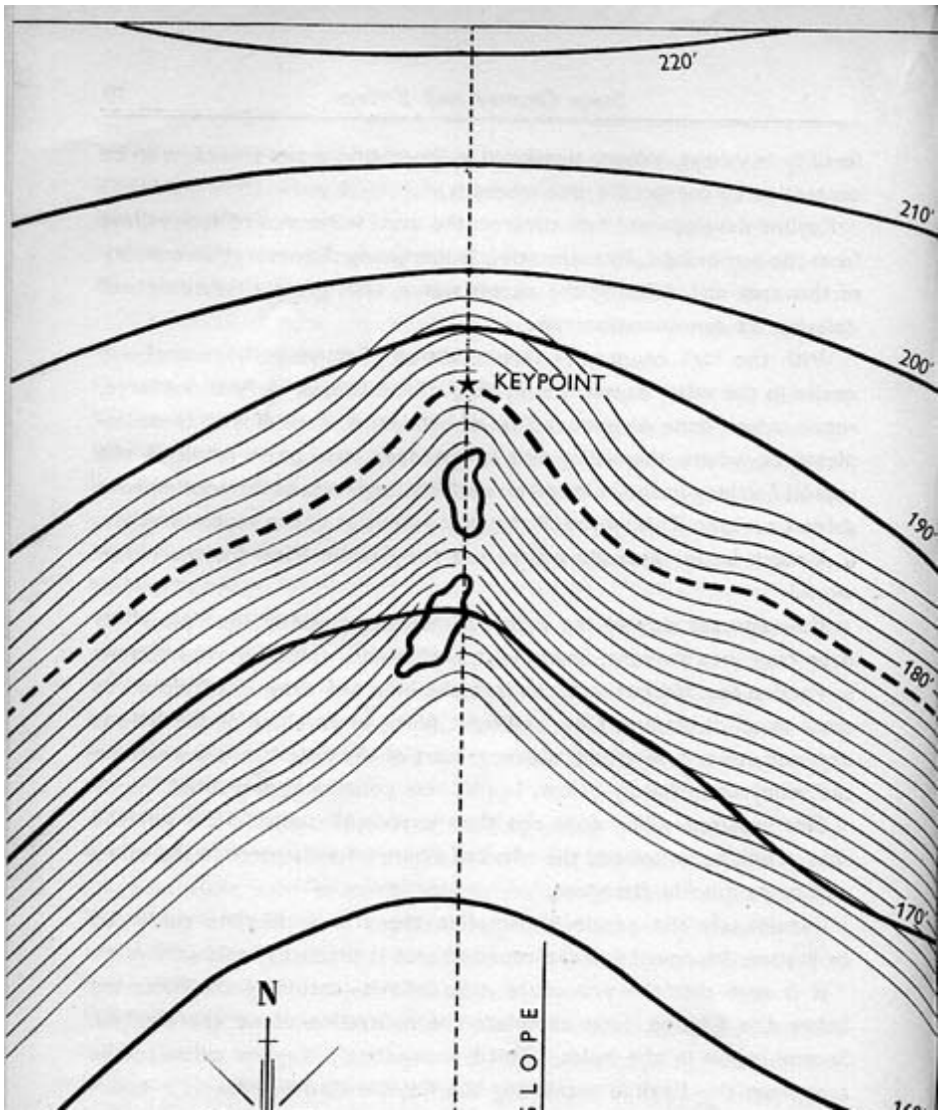
Immediately the repair is complete the area is Keyline cultivated or pasture improved and the repaired area is practically safe.

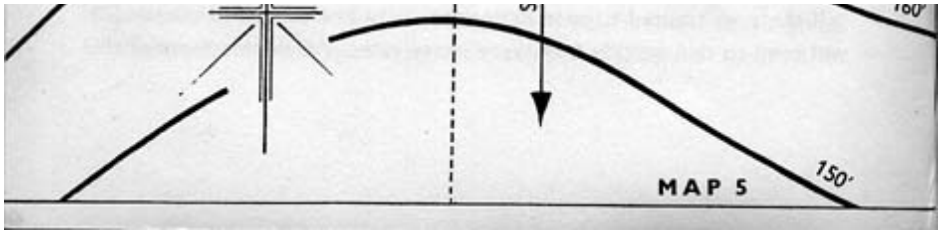
It is seen that the procedure is as follows -- assuming the holes are below the Keyline. First complete the cultivation above the Keyline. Second, plow in the holes. Third, immediately Keyline cultivate the area from the Keyline paralleling the Keyline downward.

If the area treated is poor heavy soil, very low in humus content, it will tend to seal quickly from very heavy rains. When this happens the area is treated again both above and below the Keyline on the procedure already discussed for soil improvement of pasture lands. This is necessary to provide oxygen so that improvement will continue. Without oxygen both decay and growth will tend to cease. As the soil improves less cultivation will be necessary to provide aeration and absorption. The improved soil will provide these itself.

The great advantage of Keyline aeration cultivation on soil that is sealed is sufficient to warrant its use even if a recently sown pasture is still new and weak. In these circumstances the cultivation still follows the Keyline procedure. Spikes are to be used and spaced 24 inches apart. One fast run completes the necessary Keyline aeration cultivation and soil improvement will continue without check.

If the erosion holes and gullies in a valley to be Keyline improved are merely to be "killed" or prevented from getting worse, the procedure is the same except that the Keyline cultivation -- that is the final cultivation run -- is divided or split to suit these circumstances. See Map 5.





Parallel the Keyline progressively crossing and re-crossing the valley until the first erosion gully is encountered. Then complete the parallel runs downward, working to the gully and back on one side until this side cultivation reaches the end of the hole. Continue the cultivation on the other side of the hole to the bottom -- downstream end -- of the hole. The next cultivation run will then be a complete one parallel to the others and again crossing the valley but now below the hole.

All this cultivation running from the erosion hole out and away from it will have the Keyline drift away from the hole. Only with very heavy rain will water again run in the gully, and if any further erosion takes place it will be on a greatly reduced scale. With continued Keyline soil improvement it will cease altogether.

In times of severe drought the only noticeable green tinge on a grazing property will often be the narrow moist strip in a valley. One of the first very noticeable effects of Keyline development if followed by severe drought conditions is the greatly widened area of longer-lasting valley greenness.

Keyline soon multiplies the effects of the average rainfall.

Practically no valleys are safe from erosion under "extraction-fertility" methods of farming and grazing, while under methods of Keyline Absorption-fertility all valleys, including those of the steeper land, are safe from soil losses and consequently erosion. Not only are they safe, which is a negative matter, but they will improve progressively with all other land in fertility, productiveness and beauty.

The use of trees in Keyline planning is discussed elsewhere in this book, but a special reference to trees and their effect on valleys can be considered here.

In the Keyline development of land, trees are not generally left in valleys except as part of a Keyline or Guideline timber strip. The eddying of water caused by a tree in the path of the water flowing down a valley will often commence an erosion gully. The breaking of the soil round a tree from root movement and growth can also be a contributing factor.

Stock sheltering beneath a tree tends to powder the soil around it, thus causing soil movement when water flows down the valley.

The effect of both these erosion hazards will be quickly offset by Keyline improvement. It is still advisable to clear the valley timber except when a Keyline or Guideline timber strip crosses the valley. Stock will not damage this timber which is left in a valley as part of a timber strip crossIng the valley.

The Keyline development of valleys is simpler and more rapidly effective if there are no odd trees to consider.

It has been noted that a mob of cattle in a large paddock containing three timber strips at different levels invariably all camp in the one timber strip and spread themselves well along the line of this belt. A night or two later they will be together maybe in a higher or lower timber strip.

CHAPTER 10

Flatter Lands

IT has been previously stated that Keyline cultivation parallels from the Keyline up the slope of the land and from the Keyline down the slope of the land. However, there are very many properties that do not contain Keylines or a single Keyline, and so a means of the simple application of Keyline cultivation on such lands needs a Guideline on which to work.

These areas or farms are treated in the same way as are all areas below the Keyline. Cultivate the land parallel to the highest suitable Guideline, always working parallel down the slope of the land.

The line that forms the overall or planning guide on these properties is called a General Guideline, and, as with the Keylines, may be either a selected true contour line or a line with a very gentle slope. The slope would be for the purpose of a water race connected to a water storage.

The special or significant feature of all land lying below the Keylines is that the valley slopes are generally flatter and wider than the adjacent ridge slopes that form the valleys. This was fully explained in Chapter 2. The aim of Keyline cultivation is the equalising of the moisture between the wettest and the driest parts, that is between the valley and the adjacent ridges. To do this most effectively a Guideline is located in the highest position, where it can serve as a guide for Keyline cultivation.

If the slope is long, another Guideline at a lower level is located. It lies at a convenient distance below to serve as a boundary to the upper area. This is a Lower Guideline and it is usually a true contour line. It is marked by any suitable means, preferably one that permanently locates it.

The control and development of these areas is approached first from a consideration of water which flows down to the valleys from the higher country outside. The entry of this run-off water is usually at the lowest point along the highest boundary fence. This may also locate the Guidepoint from which a level or sloping line in both directions suitably forms the General Guideline.

If a large area of land lies above the selected General Guideline it will be necessary to locate an upper Guideline to control the Keyline improvement of the higher area. If so, the upper Guideline is located and marked as high in the area above the General Guideline as possible. Care should be taken to see that it is of sufficient length to serve its purpose.

Outside run-off water may now be a problem. Perhaps the main factor in determining the General Guideline will be the position of a suitable conservation dam site for the storage of this extremely valuable water. This site is looked for in the highest third of the area, and when located the General Guideline becomes a suitable water race to the dam site.

All the details of farm planning above the Keyline also apply above the General Guideline of the land below the Keyline.

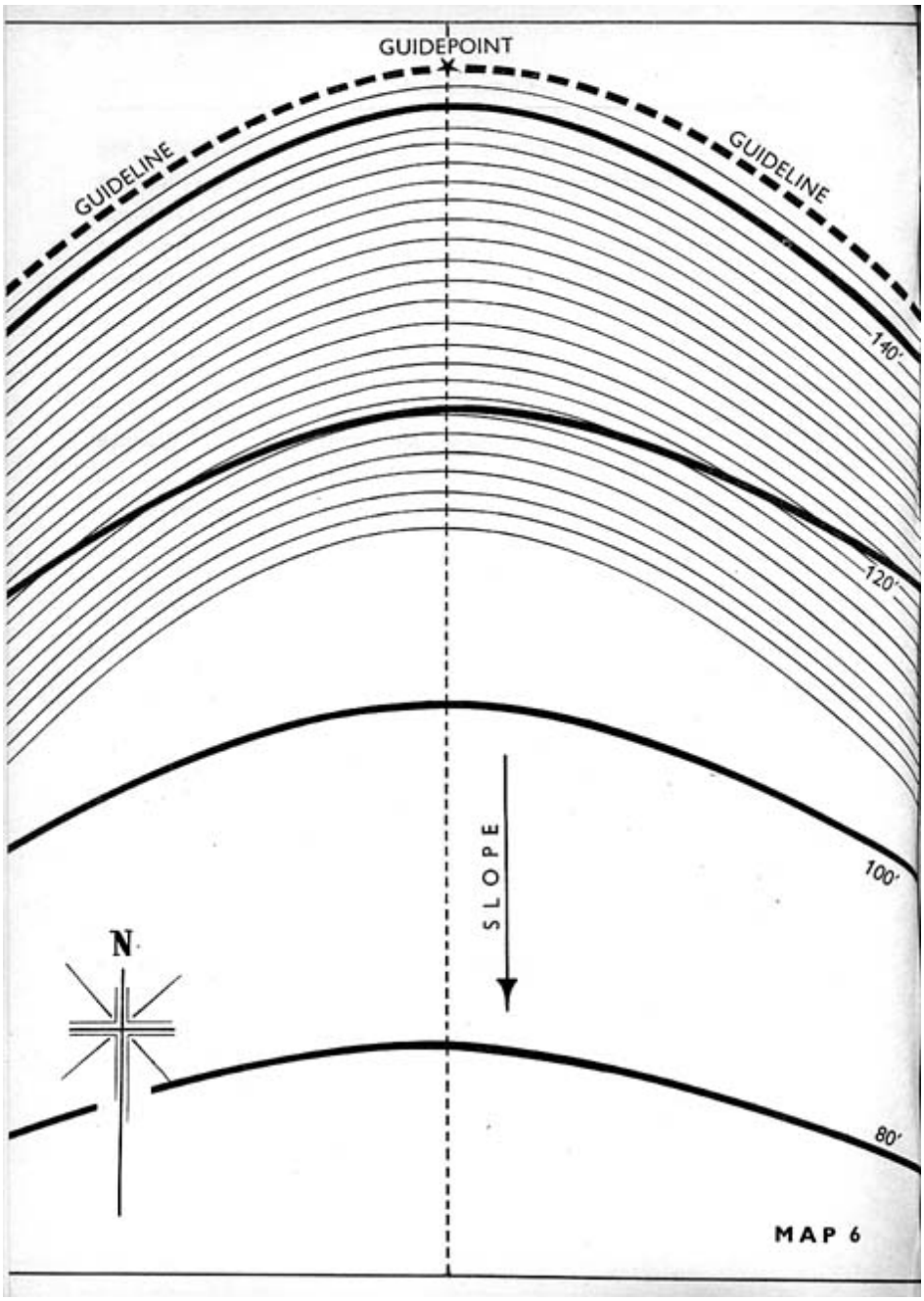
The main grazing or large cultivation area is below the General Guideline. A Lower Guideline located at a suitable distance below forms the top boundary of another group of smaller paddocks. If their vertical distance below the conserved water is sufficient, gravity spray irrigation is always planned. Five per cent. of a grazing property that is suitably planned and supplied with water for gravity spray irrigation may add fifty per cent. or much more to the capital value of the whole property.

In the development of timbered areas of this type of country, clearing is done to leave suitable timber strips along the General Guideline and all Guidelines.

The formula mentioned in Chapter 8, which relates the vertical distance apart of these tree strips to

the general height of the trees, is again the planning guide.

Map 6 illustrates in simple form a valley area below the Keyline and the location of the Guidepoint and General Guideline. The parallel lines on the map which start from the General Guideline and parallel it downward illustrate the drift of water out of the valley. This compensates the natural water concentration in the valley. Keyline cultivation is again completely effective.



In selecting the Guidepoint -- in place of the Keypoint of properties containing their own Keyline -- it may be advisable to locate it just away from the fence at the lowest point along the highest boundary. A distance of 20 feet from the fence would allow a farm road to cross the paddock above the General Guideline.

Soil erosion by water is simply and profitably cured on flatter lands by the methods of this book.

There is, however, a type of erosion that appears to defy man's efforts to cure it when these efforts are confined to "maximum soil improvement". This is the serious periodic erosion by wind, which occurs alike on poor soils and fertile soils of our marginal lands.

Following a period of three or four years of much drier than usual conditions on this country when

it has a normally sparse rainfall, this serious wind erosion manifests itself. If the latter end of a dry period coincides with that of a severe drought, followed by high wind, these soils will move in vast quantities.

The dry period or the severe drought cannot be controlled and the only possible solution to this problem lies in measures designed to retard the ground velocity of the winds. A rough cloddy surface will reduce a 60 m.p.h. wind to a velocity that will not raise any appreciable dust from this soil, but at the end of such a period of weather conditions as described the surface condition alone will not have sufficient effect.

The growing of sufficient tree strips is the only possible means of reducing the high velocity of these winds to such an extent that the soil will not blow. The problem is one of great magnitude and the solution in the planting of trees must be of like proportions.

Indigenous trees can be induced to grow by leaving protected strips of land in the right pattern. This is the lowest cost means of growing the tree strips on a large scale. If the country is treeless, then tree species will have to be introduced which will not only grow well in this country but survive the period of very dry conditions.

Nothing can be done during the time of the actual blows that will give results commensurate with the money expended. The planning of the work can be satisfactorily done at this time so that when better rainfall conditions follow the drought the land will be in a position to make quick rejuvenation. Four years later this land could be safe from wind, erosion.

CHAPTER 11

Other Applications

KEYLINE discussions so far have been concerned with the land areas that contain valleys. The prime purpose of the lines of cultivation on the Keyline principle is to counteract the natural rapid concentration of rainfall into the valleys by an induced drift out of the valleys. At the same time the particular type of cultivation discussed in Chapter 4 enormously increases the absorption of rainfall into the soil and effectively uses this rainfall for progressive soil development.

It is a practical impossibility to plow accurately on the contour unless every travel line of the plow is level pegged as a true contour line. This would require hundreds of lines of instrument levelling in every small paddock. When contour cultivation is attempted it must drift mainly off the contour. Contour lines are rarely parallel to each other. They are never parallel in undulating country.

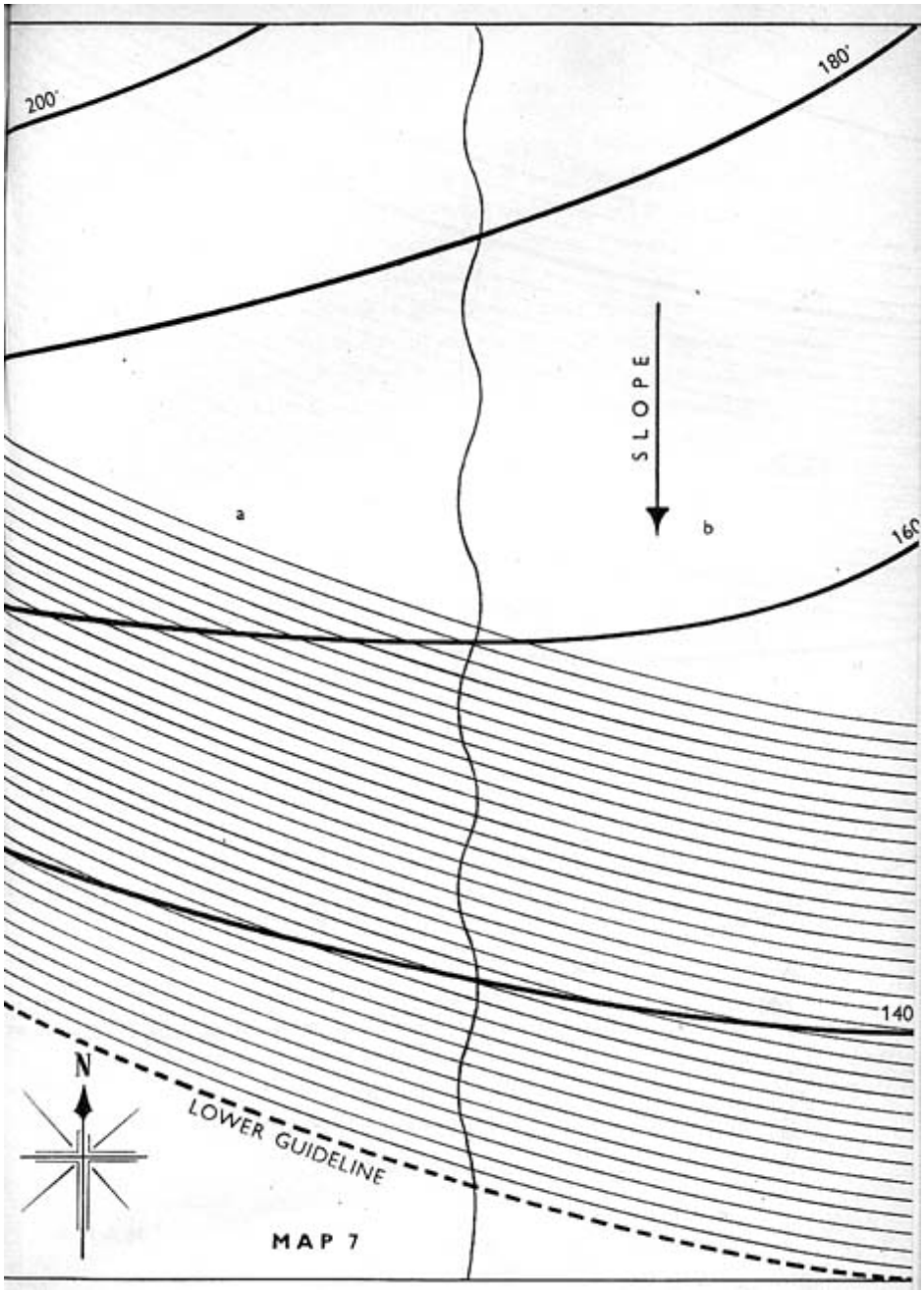
Keyline cultivation, although it may start on the contour, is soon "off the contour" by this parallel working. It is this off-the-contour effect that is controlled in Keyline in order to counteract the natural concentration of rain water in valleys.

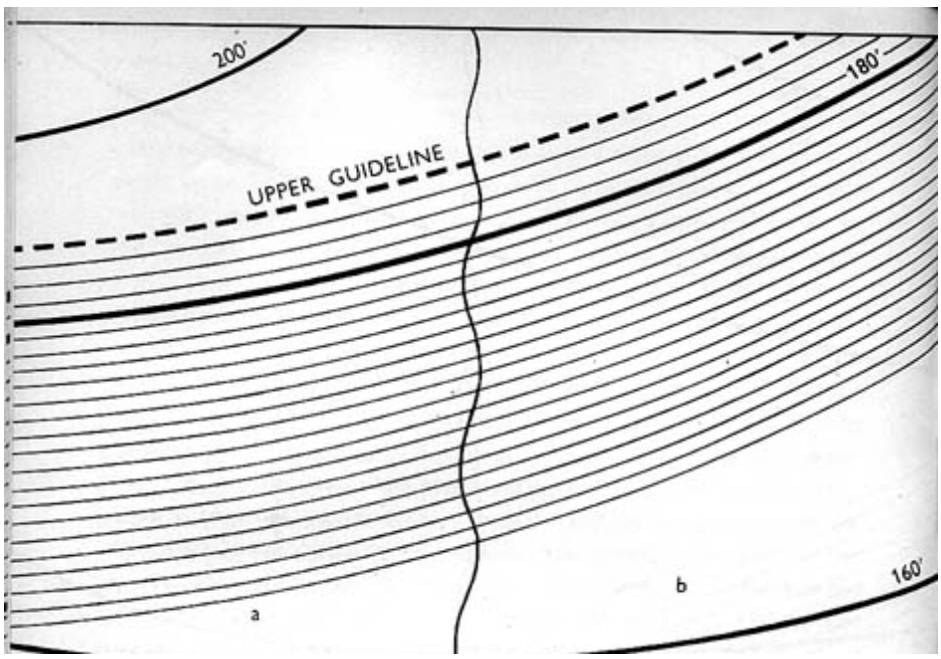
This controlled, and completely effective, drift-off-the-contour of Keyline cultivation is as fully applicable to areas of land which contain no valleys or depressions.

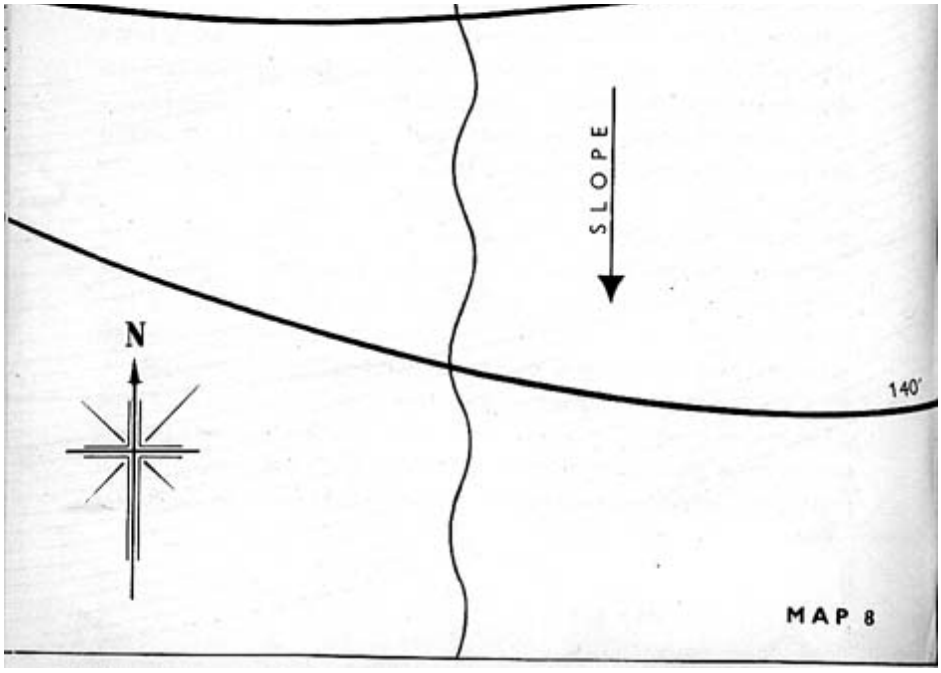
A paddock area with an even slope in one general direction is best developed from a Guideline located as high in the paddock as possible, and one that still gives a line of sufficient length to serve effectively as a guide for Keyline cultivation. Cultivation parallels this Guideline down the slope. The small areas left above this Guideline are cut out in any convenient manner. If such an area contained small erosion gutters they would be cured by this cultivation method.

Another paddock without a valley may have one side of the paddock steeper than the other. It may be necessary to drift the moisture in one direction while under different circumstances the opposite

may be advisable. This can be done by Keyline cultivation, as illustrated in Maps 7 and 8."







Map 7 illustrates a paddock area containing a steeper side, "a" and a flatter side "b". Assume that the area "a" is partly eroded and the whole paddock is to be Keyline improved. It will be necessary to counteract the fast run-off to the south-west from this area by an opposing drift in cultivation furrows away from this direction. A Guideline is located, the lowest suitable in this instance, and Keyline cultivation parallels this line up the slope of the land, as illustrated by the parallel lines of Map 7. These lines have a drift away from the natural run-off direction. Protection and development are thus secured.

We can now assume an opposite problem on the same area. "B" in this case is wet or swampy and "a" is very dry. A drift towards "a" of the surplus moisture of "b" is desired.

A Guideline is located in the highest, suitable position and Keyline cultivation parallels this Guideline down the slope of the land, as in Map 8. The surplus moisture of "b" now has a "drift" to the dry area "a", with the effect that both areas are immediately improved. The small areas left out of this parallel cultivation are worked out in any convenient manner. They will not affect the effectiveness of the work.

The sour wet area "b" is properly aerated for rapid improvement and surplus moisture drifts to the area "a" to improve it. Surplus moisture in these circumstances may drift along the tine furrows underground away from "b" until this area is left nicely moist, as distinct from wet. Moist soil-not wet soil-produces healthy pasture growth.

With an appreciation of the astounding effectiveness of Keyline cultivation and some experience of its use, it will be found that relative moisture content of problem land can be adjusted at will by the astute use of Keyline's off-the-contour type of cultivation.

CHAPTER 12

The Plan

FULL Keyline planning, as far as the development of farming and grazing land is concerned, is the logical use of all the methods of Keyline that have been discussed in this book.

Keyline timber clearing cannot be applied on cleared land, but the design of Keyline clearing to

"leave" timber as strips or belts can be applied in the growing of timber to aid soil development and for general usefulness. The growing of trees in suitable numbers cannot be attempted at once over all the farm area, but a tree belt can be grown in two or three years in a paddock that is conveniently closed for cropping. The immense satisfaction from a successfully grown timber strip in the first paddock would certainly induce the farmer to continue the programme into other paddocks when convenient.

Water conservation in Keyline and High Contour dams obviously can only be employed on farms of suitable land formations. These farms embrace huge areas of the most important land from a national point of view. Not only are these steeper lands capable of tremendous and profitable improvement, but by their effect on all the lower lands in their common catchment area exert an influence over many more people than live on them.

While Keyline dams and the High Contour dams of the Keyline plan are limited to properties with their own Keylines, the principle of locating some dams high on the farm is almost universally applicable and profitable. The design and the layout of farms should locate as many of the water-shedding areas and buildings as possible above these dams.

This would ensure additional water storage. Many of the dams below the Keyline will provide water by gravity pressure to operate spray irrigation and stock watering systems.

It is a principle of the Keyline plan that all land on the farm is made to absorb all -- or nearly all -- the rain that falls on it. Surplus rainfall runs off slowly along the natural flow lines of the land. Water is transferred for storage only and never to another valley for disposal. Rapid run-off and consequent erosion are fought or offset by the rapid development of fertile absorbent soils. In many places damages from present water runoff are accelerating. The Keyline plan first retards and then completely prevents the usual erosion of farming and grazing lands.

Keyline progressive soil development or any other Keyline work, by being complete and fully effective in each area on which it is applied, whether on the small paddocks of a farm or on a large grazing area, requires no outside co-operation or co-ordination.

It is completely effective as an isolated unit.

The Keyline plan operating on farms in an area of regional planning is complete in itself. Every farmer, by improving his land, is doing the best that is possible for the region, but he is still an individual working for his own pleasure and profit.

General land development is always vitally concerned with water. Whether the object is the conservation of water for the production of soil fertility and increased yields, or whether the aim is the control of water for flood prevention or irrigation schemes, the general subdivision of land into smaller areas and paddocks is best governed by natural watersheds.

Keyline planning of a large area of land first aims to divide the area into smaller units or paddocks which are suitable for later economical development and farm working.

A good contour map of the area is of great value in this planning. A map with contour lines at 20-foot vertical intervals is suitable for land containing slopes from gently to steeply undulating. Ten-foot contours are suitable for gently undulating areas and 5-foot for flatter slopes. On the flatter country contour intervals should be such that at least three contour lines are contained in the large paddock areas. With less than three contours such maps do not display a complete picture of the land for subdivision and development. Watershed areas both small and large can be located at a glance. Keylines and Common Keylines are readily found on the map; in fact, the geometry of the contour lines emphasises the Keylines. The steeper country appears to be narrower proportionately between the contour lines on the map than does the country of lesser slopes between its lines.

These maps enable the planning lines to be located in the approximate position in which they will be used in Keyline development on the land itself. Keyline areas, Chapter 6, located from these maps, can be readily plotted on the land.

Good farm contour maps as described are, however, rarely available now, but the importance of "planning the work then working the plan" in all matters relating to land development is such that the use of good farm contour maps should become general practice. It would be of tremendous benefit to the farmer if some service was available to produce farm maps quickly and cheaply. Parish maps are generally the only ones now available and these, increased to a larger scale, can serve as a basis for the mapping of the areas. Keylines as located on the property can be plotted on the parish map and so form a simple and effective farm map.

The largest suitable land unit for planned development is that contained in the watershed of a river system. Within this large area of land are contained the numerous smaller watersheds of the creeks and streams which flow to this river. Again, within these smaller watersheds are the lesser watershed areas of all the valleys which flow into the smallest watercourses. These lesser valleys are the valleys of the Keylines with which we are directly concerned in Keyline development. Single valley Keylines and Common Keylines form the lesser subdivision of the Keyline areas (Chapter 6).

When large land areas are cut up for sale they are usually subdivided along the lines of existing fences. As the likely fate of all large good land areas is subdivision into smaller farms, the initial subdivision into larger paddocks can be planned with a view to their later development into separate farms of a satisfactory living area. Watershed areas of the large paddock size may be suitable for this purpose. Good subdivision at this time will further enhance the value of the land when it has been developed.

On undeveloped land, which is many times the size of the potential developed living area, one such large paddock can be fenced adequately and Keyline developed to a profitable farm or grazing property.

Within this area the Keylines are first located. Development then follows the pattern of the various aspects of Keyline; timber strips are located; smaller paddocks are determined; buildings and yards, etc are located above the Keyline; irrigation areas are pegged below the effective water pressure level of the Keyline dams and High Contour dams.

The general picture of Keyline planning in undulating country follows a distinctive pattern. The flatter top country above the Keylines contains all the buildings, yards and their roads, as well as the numerous smaller paddocks necessary for the running of all farms or grazing properties. Tree belts are left in this area as described in Chapter 8. Immediately below the Keyline are the large paddocks for grazing and cropping. The lower boundary of this area forms the top boundary of another area of smaller paddocks. These make use of the gravity pressure of the high dams for irrigation. Timber belts are left on the formula suggested for Keyline clearing.

On this plan rapid Keyline development of this first area should pay for the progressive development of a large undeveloped area of land.

The cost of Keyline land development will be lower than the present development of such areas, but the actual cost of clearing may be higher because of the additional cost of the necessary planning that must precede this clearing. Extra cost over the usual unplanned clearing may be involved by the necessary supervision.

On land already fenced there is no need to alter the present paddock layout. As Keyline is generally complete and effective in itself in any area small or large on which it is applied, special fencing is not necessary. It may be necessary to dig under a fence in constructing a Keyline water drain to transport water to the Keyline or other dams.

The Keylines, which are the basis of this land planning, have been illustrated throughout this book on simple contour maps. Keylines will usually have to be located without the aid of maps. When the Keylines of Map 4 are to be located on the land illustrated in this map, but without the aid of the map, the Keypoint is located in the first valley. This is done by walking down the steeper head of the valley to the approximate point of the first main flattening of the slope of the valley floor. This is the point at which the valley floor first becomes as flat or flatter than the adjacent ridges.

This point, the Keypoint, is marked by a peg or stake in the centre of the valley. A line of levels, on the longest possible convenient sighting with the levelling instrument available, is then made to the boundary fence in one direction and through the valleys in the opposite direction. When the line of levels reaches the second valley it crosses this valley on the approximate Keyline of the second valley, and similarly, in the third valley.

At the fourth valley it would be obvious that the line is well below the Keyline of this valley. In this fourth valley a new Keypoint is located and a new Keyline extended to the boundary.

With this line of pegs as a guide, the location for all the Keyline dam sites is studied. If one dam only is to be constructed, the site in the first valley is selected. The reasons for this selection are given in Chapter 7.

The working Keyline will then be a drain to carry water to this site. The slightly higher position of the Keyline in the second and third valleys, made necessary by the fall in the Keyline drain from these valleys to the first one, does not present any problem. It can be taken as a usual rule that the Keylines tend to fall in the direction of the general fall of the country.

The actual position of the Keyline drain or other "marker" for the Keyline on the land can always be located or adjusted a little to suit overall circumstances.

The Common Keyline of two valleys may be made to serve the purpose of a common Keyline of three valleys by a little adjustment in its location.

While accurate levels are very necessary, the exact location of the Keyline is not necessary. It is the fact that the aggregate of all the cultivation runs parallel the Keyline and drift down and away from the valley that gives Keyline cultivation its powerful influence.

Referring to the area above the Keyline, Map 4, it will be seen that this land may be developed very rapidly by Keyline absorption fertility to a state where greatly reduced run-off water is available to fill the Keyline dams below it. Full use of the run-off water from buildings, yards, road, etc., which would be suitably located here, will supply the water to fill the dams. The road alone will shed a large volume of water.

The Keyline plan first develops fertility by maximum absorption in all pasture crop and forest land. This development starts in the steeper areas first. The other great aim of the Keyline plan is the conservation and profitable use of all water that flows to or on the farm. There is, however, no suggestion that large areas of land should be left undeveloped so as to provide a catchment area in order to shed water for conservation in dams. The use of this water to develop high yields on one portion of the farm at the expense of the larger undeveloped catchment area is completely unsound. This is not the way to either full progressive soil development or maximum yields and profit.

Keyline and High Contour dams for water conservation are located in the best possible sites for the effective and low cost application of the conserved water. Gravity pressure for spray irrigation and other purposes is much cheaper than pumped water.

The other dams mentioned in Chapter 7 are placed as indicated. The type of dam to suit the topography is obvious from the discussion in the earlier chapter. The overall aim is again the conservation of all the water that flows to and falls on the property.

First, conserve all the rainfall that is possible into the soil for the benefit of all the land and for the production of high fertility. Second, conserve all water that flows from any and all high sources into the highest suitable sites in the Keyline -- High Contour and Guideline dams. Third, provide for other and large storage capacity in lower sites in the contour dams of Keyline, the lower valley dam and the creek or stream dam.

From the economic aspect and the working of a farm some water storage must be provided.

The retention of more water in the soil by correct cultivation methods will provide extra profits. These should be used to pay for the capital cost of suitable dams for irrigation. This will provide further profits.

An overall scheme of maximum water storage can be undertaken on limited finance when each new storage in its turn is used to promote soil improvement and more low cost high yields. Any expenditure incurred in the construction of such a scheme of progressive water storage, including the drains for conserving or conveying water, is deductable in arriving at the taxable income of a primary producer for income tax purposes. Taxation is in this way designed to assist those who will develop the country.

CHAPTER 13

Floods or Keyline?

FERTILE soil grows good grasses and crops, which in turn feed and make healthy animals. The products from these things are the dominating factors in the health of the community. Poor soil grows poor grass, poor crops and animals, and these have a detrimental effect on the health of the people.

The vast difference in the flavour of salad vegetables grown on fertile and infertile soil should have been noted by everyone. The products of fertile soil sustain healthful life. The growth from poor soil is only suited to be again absorbed into the soil to help cure the ills of the soil.

The good farmer, by cherishing and improving the fertility of his own particular soil, is safeguarding the basic factors of the health and prosperity of every section of any community. At the same time he is in the first line of the general fight against disease.

Fertile soil is the basic factor in the health of the community. It is also of the greatest importance to the safety of all the land; it resists to an astounding degree the forces of soil erosion.

There are many other causes of soil erosion than those which may originate from the actions of our few generations of farmers and graziers. While no one generation of farmers caused a significant amount of soil erosion, the accumulation of soil damages from past generations have manifested themselves in greater soil movements in this last generation. The forces of erosion are accelerating.

Whenever run-off water is artificially concentrated, an erosion hazard is created. The damages from public roads and other sources completely outside the responsibility of the farmers and graziers cause widespread erosions on the farmers' own lands. Government stock routes and forests are not free from erosion. A bushfire from any cause is always a hazard. A careless camper, a cigarette from a motorist, a spark from a railway engine-all are serious in accelerating soil erosion.

There is, however, no doubt that concerted actions by the community of farmers and graziers could do more in much less time to stop erosion and the shockingly devastating floods, than all the authorities concerned, even with unlimited money.

It would take at least two years for the various authorities who would be concerned to agree on any plan. The work could have been completed by the farmers in that time. They would incidentally have increased the value of their land and made additional profit.

To be quite specific, if the Keyline plan was adopted by the farmers and graziers of the Hunter River Valley, the result would be certain and rapid.

Every farmer and grazier would enrich himself greatly by the resulting increased value of his land and the better quality of his farm yields. The whole of the Hunter River and its eroding banks and flats would be, protected by the farmer's work on his own land. Devastating floods would not occur again at such important population centres as Maitland or any other town on the river. Clear water would flow in the river all the year round and the flow would be more even and constant.

If we assume that the ancient flow of generally clearer water was compatible with the early better anchorages in Newcastle Harbour, may not a new flow of cleaner water result in gradually clearing the harbour, instead of the present continually increasing depositions of silt? Would not a constantly greater flow of cleaner water result in the removal of recently deposited silt from the lower reaches of the river?

All the huge water conservation projects and all the special dams for flood mitigation will not hold as much water as the land itself if all the soil is kept in a condition to absorb the rain when it comes. Dams for flood control are effective if they remain only partly filled, so that large potential storage is always available to act as huge shock absorbers for the floods.

To this new vast water storage capacity of the soil we must add the effect to be obtained from the Keyline dams, the High Contour dams and the others discussed in this book.

These dams, constructed as they are for use whenever required, with their pipe and valve outlets to provide water at the turn of a large tap, will form a tremendous buffer against floods. The conserved water is second only in low cost irrigation to the rain itself. The Australian drought-breaking flooding rains will then find a huge capacity in the farmers' dams ready to offset their intensity and destructive force. The drought will surely have warranted the use of the water of these dams and their capacity will be available for the flood rains.

From geological evidence it is apparent that floods did occur before the farming and grazing practices of our few generations of farmers greatly reduced the capacity of the land to absorb rainfall and retard the sudden flood. It is just as apparent that no rains of recent decades should have caused so much destruction. In this geological age of lower rainfall and drier conditions, every drop of water, including the rains that now cause our floods, should and could be used in the production of better soil. The soil would probably be better than that which previously existed in the Hunter River Valley.

These remarks are not a suggestion that the Keyline plan will in effect put the clock back one hundred and fifty years, nor is it suggested that the valleys and streams of this important river watershed will revert to their former state as regards the cleanness of the river flow and the reduction of the quick destroying flood. No! Much more than this is feasible. The whole of the land will rapidly become more fertile and absorbent than it ever was. The heights which the floods reached one hundred and fifty years ago, which were perhaps much less than those of to-day, would probably not be reached again.

There is no doubt that, at the moment, great flood dangers exist. There is also no doubt that projects of a national character in the construction of many flood control structures would greatly mitigate the danger of the big floods.

These works cost sums of money that to the ordinary mind are quite fantastic. They require for their finance a toll on the whole of the community. They cover with water large areas of very valuable

land.

From a practical business point of view, where is the flood control problem, or any other problem for that matter, if a highly profitable solution is found!

Against the Keyline picture of almost absolute control, we have the ever-present menace of the big flood with something much more than a possibility that a flood larger than the previous worst one could occur at any time with little warning. The only other hope of protection, which lies in the very remote future, is the construction of fabulously costly Government projected flood control dams. If and when sufficient of these are constructed they would not have as great a combined water storage capacity as that which can be had at very little cost in the soil itself by Keyline Absorption-fertility.

The reason why soil erosion control or soil conservation has not been accepted by a very large percentage of land owners is simply that these matters are not always good business. Too often it is something to be attempted reluctantly and postponed very easily. The approach is negative, the cost real, and the profit remote.

The phrase "Prevent erosion and save the soil that is left" lacks inspiration.

Why not, as far as the farmer and grazier is concerned, forget erosion.

Instead, build better soil structure, improve soil fertility, make, manufacture and create deeper, more fertile soil just by providing soil with the capacity to absorb fertility. If a sheet eroded area or an erosion gully is in the path of the better soil drive, convert it; engulf it in the waves of fertility.

If a Shire Council or the Main Roads' Board is causing large quantities of water to be diverted on to the farmer's land, thereby causing destruction, diffuse it, disperse it, absorb and conserve it in dams. It may be dirty water, but it is water. It is the greatest factor, as far as the average Australian farmer is concerned, in fertile soil development and better yield.

The failure generally to treat agriculture in its entirety by sectionalising and subsectionalising too much with inadequate means of proper coordination has led to a completely unnatural and artificial basic approach to land matters. The soil has been lost looking for the crop. The land is being lost while only three or four inches of topsoil is used. Improving and progressively increasing the depth of the soil is the first basis of any permanent yield improvement. Any and all other means of improvement may then logically follow.

Absorption-fertility is real fertility. It is not doctored nor drugged soil.

It is the great privilege and responsibility of the farmer to give himself, his family and the community the benefit in health and wellbeing to which they are entitled from The Fertile Soil.

CHAPTER 14

Before and After Keyline

BRIEFLY recorded here are some experiences and incidents that were associated with the development of the Keyline plan.

Between the years 1943 and 1950, the experiments which I carried out on my properties were based on my own experiences, coupled with some of the methods recommended by the Soil Conservation Services of America. The use of contours and gently failing drains are not the particular invention of soil conservationists but were used thousands of years before the modern understanding of soil erosion. My use of these land engineering principles then followed more closely those of the mining

and construction engineer than the soil conservationist.

For a few years following 1944, the Geography Department of the University of Sydney took some interest in the work which I was doing., Geography students used the property for some time for practical map reading and survey instrument exercises. Their work was later coordinated by the Geography Department into a complete contour map of the area. This map has been of considerable value.

Where formerly only week-end work on my part was possible, in 1948 more was to be done. That year a qualified geographer was employed by me. As part of my business already included work which could be classed as land development, I had in mind providing increased service in "Planned" land development. Results were not satisfactory and the idea was dropped.

I will not describe these earlier works, which included the construction of many miles of drains built with all types of implements from the smallest ditchers to the largest tandem drive road graders. As far as I am concerned, they were all valuable experience, but they did not in any way satisfy my main aim for "planned" land development. All these earlier works, with the exceptions mentioned, have now given way to Keyline.

It is, however, worth while recording the last system of soil conservation drains which were built during 1951.

This last area was badly gullied and surface eroded. Still believing that protective drains were necessary on such country, and may continue to be so, the drain layout was designed to suit the working of the property after the problems of erosion had disappeared. The valleys of the area all drained to a rocky creek falling to the east at a slope of 50 feet to the mile. In order to bring the surplus water from the drains closer to the creek, all drains of the system -- except one -- flowed or had a fall to the west. This resulted, for instance, in the top drain of one valley, where it was 500 yards from the creek, being only a short distance from the same creek when this drain was carried across three valleys.

This greatly assisted the safe disposal of water without the grassed waterways of orthodox soil conservation.

To complete the stabilisation of all the valleys and their problem gullies, it was only necessary for me to start work on the most easterly gully and transfer the water from this valley to the next valley westward. With the first valley stabilised, the next was treated and its water transferred to the second valley, again westward, and so on.

All drains flowed from east to west. The highest drain on the east end of the area protected a series of small valley heads and transferred the water to a dam. The second drain broke the velocity of water from the steep valley heads and protected the larger valley into which these flowed. All the lower drains further ensured the safety of the whole area.

These details are given for two reasons. Firstly, the layout of the drains which was the result of some years of experience was, I believed at the time, quite good. Visitors who had some knowledge of these matters commented on the excellent layout. Secondly, these were the last drains for "protection" which I constructed. Before the western end of the area was started, the basis of the Keyline idea was originated. The whole drain system was later plowed out and Keyline development instituted. The extreme western area, where drains were not constructed, was developed solely on Keyline. The work took little time, and cost approximately one-tenth of the work which had been done at the other end of the area.

This fine system of drains was never required. None of these drains is left except those which transport water to the dams. Not only was Keyline work a fraction of the cost of the other development, but in itself was much more effective in building the soil. By instituting Keyline

cultivation for absorption-fertility, erosion was immediately controlled, but the Keyline work itself was a part of ordinary farming. Keyline work in these circumstances costs nothing.

Ten years ago, when the first system of sloping drains and banks was started, I begrudged seeing water leaving the property, knowing it ,would almost certainly be needed in a few weeks. The absorption banks and pasture furrows of orthodox conservation are very effective in preventing this loss. These were given some thought. However, I had a fixed notion that my property should eventually look better than these works would permit. I did not use either the absorption bank or the pasture furrow. A programme of contour deep ripping was started instead to keep the water on the farm. Ninety and one-hundred-and-twenty horsepower crawler tractors were used and hundreds of acres were deeply ripped. Furrows were 24 and 36 inches apart. Some of my deep ripping experiments are recorded in "Soil Erosion in Australia and New Zealand," by Prof. J. Macdonald Holmes, Ph.D. Contour deep ripping is mentioned later.

Some years ago I used the "silt dam" and "stone check walls" of soil conservation to catch some of my own soil. The area above these structures has now been "Keylined" and the stone check walls removed. These structures are not used in Keyline except to "check" soil and water flowing onto a farm from another area.

The technique of Keyline conversion-year cultivation to convert poor land rapidly to absorption-fertility methods is vouched for from experience. The low cost continuance of the methods, following conversion-year cultivation with the implements now used, will be experienced by many Australian farmers this year (1954) who used conversion cultivation last year. I have seen conversion-year cultivation, followed by good rain, change soil structure in a few weeks.

The amazing results of the methods of Keyline progressive soil development that quickly increases both soil fertility and actual depth of fertile soil are completely satisfactory.

Deep ripping on the contour 9 or 10 years ago was at first thought to be worthwhile. Now I know that with the big rippers and high power I employed this can play no important part in practical farming. The experiences were, however, of great value in the later formulation and proof of Keyline progressive soil development methods.

Here I stress the fact that this work was not on small plots, but covered hundreds of acres.

The Keyline development of valleys has stood the test of rainfall of near our district's maximum intensity -- Richmond, N.S.W. Twenty-two inches of rain in six days, eight inches falling on the sixth day, gave an unexpected test to a large area of new work without damage. Two feet depth of water on this sixth day flowed down a newly Keyline cultivated valley. The heavy, wet-plowed soil on its rough chiselled bottom did not move. If this bottom had been of even, all-over depth from ordinary cultivation, a heavy soil loss would have resulted.

I had experience of the control, conservation and transport of water as a mining engineer. This experience has been the real background of my work in land development. For the conservation of water on my property, I constructed 10 years ago the first "high dam", which we call Quarry Dam, with a 4-inch pipe through the wall and gate valve outlet. Quarry Dam, which has no natural catchment, is filled by a drain which collects water from a shire road. Water will flow from the road into this dam after little rainfall which will not cause waterflow anywhere on the property. A main line and spray lines from this dam give completely effective and low cost spray irrigation on an adjacent lower paddock. Good crop or high pasture yields can be produced any time without pumping the water for spray irrigation. Six dams on my properties have pipe and valve outlets through the walls. Five dams are filled by water-collecting drains. Some of the dams can be filled from larger dams by turning a 4-inch gate valve. These earlier water conservation works are now streamlined in Keyline planning with the proper placing of the dams of the Keyline plan and the logical fixing of Irrigation areas.

Working originally without the Keyline plan, much clearing was done before I realised the value of planned clearing. Later on timber strips from 30 to 70 feet wide were left along contours. This idea now has a very definite and logical part in Keyline planning.

I have Keyline dams in use with irrigation outlets from which a turn of a 4-inch valve starts a line of sprays. Keyline timber strips are flourishing with a Keyline road below them. The road is stable and does not wash.

Eroded valleys have been restored by both Keyline and other methods. Holes to 12 feet deep were satisfactorily treated with the Graham Plow as suggested.

Steep country which was developed on the Keyline plan is growing better pasture, and much better tree growth in the timber strip has resulted.

Slopes with a fall of one in three were first Keylined. Then slopes to one in one were Keyline improved. These have had the test of heavy rains without damage and now grow improving pastures.

The clearing of timber from valleys was decided on and practised some years ago. This was done doubtfully at first, but all experience since confirms the practice. A Keyline or Guideline timber strip can cross a valley as part of a strip and presents no problems. These timber strips are thriving on the property.

Keyline cultivation in its use for improving soil for pasture improvement is outstandingly beneficial. Very steep slopes which I once believed impossible of economic improvement are handled simply and profitably.

A valley on, my farm, shaped like an amphitheatre, formed by the joining of two smaller and steeper valleys, had two wet, sour runs through its upper part. These joined, forming a boggy patch through the lower level of the valley. One working of Keyline cultivation completely transformed this valley. The water and reedy rubbish disappeared with the wet runs. Moisture and growth is even throughout the whole valley.

Another valley of totally different aspect was a problem before Keyline. It had very narrow, steep shoulders and no soil in the bottom, because of a too-rapid water run. It was of no use or value and looked ugly. Five stone check walls or soil-saving dams were put in to stop the damage and save some soil. Immediately following the Keyline idea the area above was Keyline cultivated and a crop sown. The stone checks were removed from the valley and with the rest of the strip it received one working with spikes on Keyline cultivation. The wheel tractor could just make the gully crossings. The valley is now stable and improving with fair pasture. The dry and barren shoulders of the valley get their share of the moisture which the steep valley formerly drew from them. They are growing good pasture.

Two areas of poor sandy soil with plenty of rocks came up for improvement a few years ago. The first area was protected with a well-designed layout of contour banks and drains. Heavy rain brought us out at 2 a.m. to watch the drains work. We worked all night but eventually breaks in the banks of the poor sandy soil won. Later they were repaired and worked, but were always a worry, especially in heavy rain at night. The banks were easily damaged by tractors also if care was not always exercised. We postponed commencing the second area, which was steeper and poorer.

Following the Keyline idea, the drains were ploughed out and the area Keyline cultivated. The postponed area was Keyline cultivated and sown. Heavy rain no longer causes any worry -- it can only do good.

As mentioned, many miles of banks and drains that formerly worked well in moving water safely off some areas have been ploughed out. We now keep the water in the land. Rain outside our

absorption and conservation capacity moves off safely along the country's natural flow lines.

The only drains ever needed on our undulating to steeply undulating country were water conservation drains that transport water for storage or transport stored water for use. These have been retained. None is in, use for soil conservation. I do not use even the word "conservation" in association with soil. It is inappropriate. I am not interested now in soil conservation, only soil development, soil structure, soil fertility, increasing soil depth, and, of course, water conservation.

Two types of soils only, Wianamatta shale clays and Hawkesbury sandstone, are found on our properties. Both are characteristically poor. The shale-clay soils in their natural condition take rainfall slowly and dry out rapidly.

The sandstone soils are usually pale yellow and as poor as they look. The poor quality of these two soils has really been a great advantage in development in the last few years. It took me years to realise this advantage. If wrong methods are used on the clays they become apparent, when the signs can be read, within a season. Wrong methods on fertile soil may not manifest themselves for a decade or two. When right methods are used on the poor clays this is also quickly apparent, but on fertile soil it may not be clearly shown for a long period. This is also generally true of the smaller areas of poor sandy soil.

Recently, walking over two paddocks with a visitor in wet weather, we noticed that mud built up considerably on our boots in one paddock but in another paddock did not do so. Both paddocks carried the same soil type (shale clay), but the one with the sticky soil was nearly a year behind in Keyline Absorption-fertility development.

Our shale and sandstone soils resemble each other a little more closely as they improve. The shale is becoming friable, looser and crumbier while the sandstone is developing some "body". Both are becoming darker.

Last year a portion of a paddock was deliberately over-cultivated during experiments with various types of cultivating points. The areas both above and below this paddock were more correctly cultivated. Results of development and growth on the over-cultivated area was watched following the sowing of the whole area. Germination was generally good. The first effect noticed was slight soil movement on the over-cultivated area. Growth here was not noticeably poorer, in fact all growth was apparently good.

Large numbers of crows were seen flying over the over-cultivated land and investigation disclosed millions of cutworms at work on the H.I. rye, cocksfoot, lucerne and other grasses in the sowing.

The workers on the farm were anxious to destroy them, each with his own favourite poison. I disapproved and said that we would watch to see what would happen. Both men forecast rapid destruction for all the pastures, particularly the adjoining ones above and below. Two weeks later the pasture on the over-cultivated land was gone. However, of the cutworms that infested it in millions, not one could be found on the other areas. The cutworms disappeared without having been seen anywhere else.

On the face of this, it appears that the over-cultivation was the only factor that influenced the course of the infestation. However, this may be too much to deduce from the isolated nature of the occurrence. The fact that I expected the cutworms to stay in the over-cultivated area may just be coincidence. I do not believe, however, that the happening was extraordinary; I believe it was a simple matter of cause and effect.

The infested area, overcultivated as it was, surface sealed to a marked extent with the rain, and the first evidence of something wrong was seen in small erosion gutters in a few places as mentioned.

The cure for this strip of soil, although it was at first too fine from over-cultivation, was further

cultivation. But this time the sealed surface was worked once with spikes two feet apart. There is a sufficient pasture growth again apparent to ensure a good pasture with correct treatment. There was also heavy resultant growth of weeds, which were mulched mowed prior to the cultivation.

In the process of finding a few right answers, a remarkably comprehensive knowledge of what not to do was acquired.

Efforts have been made to pose land-use and land-development problems to the Keyline methods. This led to the conclusion that my own properties presented as many problems as any other properties examined. With the simple solution of many apparent problems, the scope and usefulness of the whole system of Keyline has extended and broadened. Now it seems that forest, town, region and state planning will be assisted as well by Keyline consideration.

A study of Keyline principles generally is greatly assisted by accurately drawn contour farm maps. These, however, are rare. The few Australian farmers who have them are asked, as a great favour, to make their maps available to me for copying and study. The contour maps required for my purposes need to be accurately drawn of the valley regions. Contours only roughly interpolated are not of use.

A great deal of satisfaction is experienced in the developing and improving of the property seen from Keyline work. The satisfaction is always tinged with impatience to see the next result.

Where Keyline timber strips are seen there is a very definite "new look" to this landscape.

Ordinary things like weather have a different aspect. Heavy rain or a fierce thunderstorm is a welcome experience. It will not now damage any part of the land; it must do good. Even a long dry spell is an interesting test of the moisture-holding capacity on an earlier Keylined paddock.

Following 440 points of rain in six months, one paddock not Keyline treated was dry and dead; another one first Keyline cultivated nearly two years before was growing green grass.

The possibility of damage from a bushfire is greatly diminished. The hazard paddocks Keyline cleared can be ploughed, cropped or hard stocked to protect the rest of the property from a fire danger area.

A dry, hot and oppressive day is bearable if a pool of water is visible with a few green trees near it, and a line of Keyline sprays look hopeful and friendly. Cattle look comfortable in the shade of a Keyline or Guideline timber strip.

The planting of trees to fit in with the Keyline scheme of things has been commenced. Results are not far advanced, but good effects from the methods suggested are clearly indicated. The rate of growth of these young Australian trees suitable for the particular district, planted as suggested, is rapid. It will not be long before a good "show" is seen,

Some difficulties in the location of fencing seemed apparent earlier, Contour fencing was first thought to be necessary. With Keyline there is, however, little advantage from contour fencing. One placed along and below a Keyline may be useful or along the top boundary of an irrigation area.

Some doubts may arise in the Keyline planning of difficult and unusual areas. In these instances I have found it to be better for a Common Keyline to be right in general than to be influenced too much by a particular problem area. The problem will soon disappear. If Keyline's diffusion and downhill from the valley and "off-the-contour" type of cultivation is kept in mind, no doubt a little "adjustment" to favour this aspect will induce even absorption for the awkward spot.

Overall purposes need not be altered to suit Keyline. Keyline will suit almost any land purposes desired.

A great deal of time was lost originally by too much concentration on mechanical methods alone without realising sufficiently the necessity of understanding the facts concerning the life of the soil.

All sorts of experiments at adding something to the soil have been conducted. Dolomite, lime, superphosphate, fertiliser and trace elements were used.

An extraordinary thing has happened.

Without regard to what was added, on all areas where the methods of Keyline Absorption-fertility were effectively followed, there is, after two years, little noticeable difference to be observed in the pastures from the various treatments. Ail appear equally good. Some lucerne and clovers showed definite signs of deficiency following conversion-year Keyline cultivation, but twelve months later both were in a lush, healthy condition.

I believe now that the requirements of the soil which are provided by the various absorption processes must be supplied before any deficiency tests can have real value. Trace elements testing of poor grass lands will be greatly assisted by first providing these absorption factors. If a deficiency then is apparent it would in all probability be a true indication of a definite need.

At the time of writing, glaring examples of right and wrong methods are seen on my properties. Two poor soil paddocks, both treated correctly for absorption-fertility and then sown to a crop for mulching, were sown with pasture. One is growing an excellent pasture, the other nothing but weed and rubbish. The only difference I know of is in the aeration of one -- the good pasture -- and lack of it in the other, which was left surface sealed after heavy rain.

Many of my earlier failures of pasture and crops are now more clearly understood.

Relative pasture growth on land differing in cultivation treatment only showed rates of growth in the spring of two inches per day, against three-eighths of an inch per day. This was the difference between Keyline Absorption-fertility and shallow disc cultivation on my shale soil.

Last autumn the poor disc-sown pasture was Keyline cultivated to improve the soil. The pasture is now improving rapidly.

By clearing areas generally considered too steep, much more good timber and more pasture land is secured. The timber is better spread over the property also and more useful for shade and protection.

The sowing methods mentioned have given excellent results. Pasture seed sown with a flow medium through the combine with the cultivating rows removed and planted in the moisture zone produced a better result with one-third of the quantity of seed than that which was earlier sown under conventional methods.

I have mentioned the Graham Plow. There is no need to be either reticent or boastful of the qualities and capacity of the Graham Plow as the outstanding implement of progressive soil development both crop and pasture land.

I felt that I knew, some years ago, just what type of cultivation was necessary to give my soil the opportunity for rapid development I designed and constructed several implements to do this, and they did in fact, give a suitable cultivation, but they were slow and costly in operation. They were generally very strong and rigid. The design that enables the Graham Plow to do so much so quickly and cheaply obtain: its results from the absence of costly and ineffective rigidity. The big shanks are springs, and each operates against a coil spring, which produces an oscillating digging effect. The result is instantaneous and continuous adjustment to the varying pressures at the digging points.

The effectiveness of this double spring action has been tested by comparison with the single spring

of the shank, without the coiled digging spring. I have found that the double spring is at least one gear of the tractor more effective at the same digging depth.

The safety effect on both the tractor and the implement of this digging mechanism enables rougher country than could be formally cultivated to be rapidly and very profitably developed. Stump and boulder country can be converted to very valuable farming and grass lands. When these are in the steep country they protect the lower country from water run-off.

It is one of my misfortunes that I did not "discover" the Graham until early in 1952.

As mentioned earlier, I do not fully subscribe to the belief that food supply will become a critical shortage factor in population trends Transport and exchange of food supply may fail. The opposite effect, that of over-supply, is more likely to pose a problem of production costs to the Australian farmer. Here the greatly reduced costs of soil improvement for crop yields and pastures that are effected by these methods may be of vital importance. However, whether prices tend lower or not, lower costs and higher yields from continually improving soils are satisfactory aims themselves.

The Keyline plan is not old. It is barely three years since I first visualised the Keyline as I looked up the steep valley heads just below "Nevallan" Homestead. I had been wandering about inspecting some work which had been completed that week. My eldest son, Neville, had just arrived and walked down the slope to me. I explained my new idea to him. We walked over the hills of "Nevallan" until dark, picking out the position of this "line". We became more excited about it, as we found it to be a constant feature and not just something that was peculiar to one or two valleys.

During the following year many family discussions developed the theoretical and practical aspects of "the line". At first it was seen simply as a cultivation guide which gave promise as a means of developing poor erodable land without the usual costly drain systems. We used to refer to Keyline cultivation as "the valley method of cultivation". It was tried out as a cultivation guide on a high steep paddock that had been previously worked. We hoped for heavy rain to test its efficiency. On a Sunday afternoon shortly afterwards heavy rain commenced. With tremendous interest and indeed some excitement we watched its effect while five inches of rain fell. There was no damage. At no time during this storm did water lie in the tine furrows of the cultivation. A dam immediately below could have received any soil wash, but no water reached it. The "Keylined" land absorbed it. On the following Tuesday evening I noticed that the dam was filled, but no one had seen water run into it.

The Keyline plan now is complete as a general or basic guide for land development, but there is still a lot to be done.

Every method of agriculture which we have used is constantly being critically examined to determine whether it gets its result by extracting fertility or whether it conforms to. Keyline's conception of ever-increasing fertility by absorption.

Many new ideas and techniques that were indicated by the general course of the development of Keyline are now being tested. These include such items as pest control, pasture management, special sowing methods, and cheaper and more effective means for soil testing. New methods in the use of fertiliser and trace elements are showing great promise.

Very interesting results of various weed treatments and their effect on soil and pasture have been noted. Some of these weeds are likely to be of great importance and value in rapidly improving very poor soils.

I have no doubt that with the emphasis on absorption-fertility as much as on production, farmers and graziers will find many new and better ways of contributing further life and value to their Fertile Soil.

THE END

EPILOGUE

DURING the last few years we have had the pleasure of welcoming many parties of visitors to "Nevallan" and "Yobarnie". Included were groups of students, agriculturalists and scientists, as well as many farmers and other friends.

Some Government agricultural officials have visited us, but as "Keyline" was not then fully developed, no explanation of this aspect of the work was discussed. Consequently, there has been, at the time of writing, no official reference to "Keyline". Every facility, however, will be afforded any Government Department should it be interested in examining the principles of the plan on the land where it was developed.

Also, if any other groups or organisations should wish to examine the Keyline work, arrangements can usually be made to suit their convenience. As we do not live on the properties, facilities unfortunately are not available for casual visitors. Visiting arrangements are made through the address on the title page of this book.

It should also be mentioned that very little of the Keyline development on "Nevallan" can be seen from the roads, and none at all on "Yobarnie". There is actually less improvement in soil fertility now on "Yobarnie" after 10 years work than there is on "Nevallan" from two years of "Keyline" improvements. "Yobarnie" still contains areas of poor soil and, of course, some evidence of our earlier works. Keyline development has started and soil improvement will probably now be rapid.

Finally, to those farmers and graziers who will use all or any of the "Keyline" technique of this book, I wish them success and the same interest and satisfaction in the work of improving their land that I have experienced in developing the Keyline plan on "Nevallan".

Addendum

THE DEVELOPMENT OF NARROW TYNED PLOWS FOR KEYLINE

The basic principles used in Keyline of increasing the fertility of soils has not changed since they were first described in The Keyline Plan published in 1954. What has changed is the design of the cultivating equipment and the modification of the techniques for soil building that the newer designs have permitted.

The production of fertile soil from biologically inactive subsoil is not difficult and one technique is well known. We know that if sufficient quantities of dead vegetation and animal manures are available for composting, and the composted materials are blended into inert subsoils, rapid fertility can occur.

For broadacre farming however, there is never sufficient waste materials available. The soil and the soil life must be managed to produce its own composting material. Keyline techniques do just that and do it extremely well.

The Keyline processes for the enrichment of soil were actually well developed before suitable implements were found that would handle the job. Earth moving rippers were often used because of my father's familiarity with such equipment. Results with this equipment were sometimes spectacular, sometimes disastrous. Rapid changes and improvements in soil fertility levels were, however, being achieved with ever increasing success. At that time a Graeme Hoeme Chisel plow was imported into the country by a long time friend. This design looked very promising and the

implement was tried out. It worked well and was commercially available.

In June of 1952 my father and I were in the United States on another matter. While there, we called in at Louis Bromfield's well documented "Malabar Farm". The techniques of Keyline had, in my opinion, progressed well ahead of what was being done by Bromfield.

In Amarillo Texas we met Bill Graeme of the Graeme Hoeme Chisel Plow Co. A deal was struck where by we made the plow under their patent in Australia. The words and the concept "chisel plow" were unknown in Australia in 1952. The patent was found to be unenforceable in this country and so anybody could copy the designs. This inevitably occurred as Keyline ideas spread, so we were forced to go our own way. The plow was strengthened considerably until it "could go any where the farmer was game to take his tractor". That was my father's design requirements and consequentially, mine too.

Keyline soil building techniques were then slightly restricted by the limitations imposed by the plow itself and these are the techniques described in the Keyline books.

The plow business was sold in April 1964, with a proviso that P. A. Yeomans, and myself as the design engineer, had to keep out of the agricultural machinery business for a minimum of five years. The designs for a deep working, low disturbance chisel plow with the strength characteristics of earth moving rippers, a "sub soiler chisel plow" were moth balled.

They re-emerged, after this enforced hibernation, as the "Bunyip Slipper Imp" with "Shakaerator". This implement won the Prince Phillip Award for Australian Design in 1974.

The plow has an extremely strong, solid, rigid frame. The tynes or shanks are made from cast tool steel. They are narrow with a tapered leading edge. They travel through the soil with very little resistance, like a sail boats fin. The separate digging point is shaped like a long flat arrow head, tapering out to about 4" (100 mm) wide at the rear. The digging angle is very flat, only 8 degrees. A vertical "splitter fin" is incorporated on the top face, and becomes a vertical blade to the arrow head. In use, and in deep cultivation, the splitter fin initiates a vertical crack through the soil above, up to the surface. The side blades lift and loosen the earth between the shanks, and then allow it to re-settle. No mixing occurs between soil profiles and root disturbance is insignificant and gentle. After cultivation, the ground surface often appears as if undisturbed, yet is strangely spongy to walk on.

The Shakaerator is an off set heavy fly wheel, bolted to the plow frame, that assists soil shattering and reduces tractor horse power requirements in most soil types.

By then I had my own independent engineering business, and by constraint, not in agriculture. This was where the new plow prototypes were built. After my father's death in 1984, my company took over the complete manufacture of the plow. Improvements continued and six new patents have subsequently been issued. Three of which have won implement design awards at the Australian National Field Days.

The rapid soil building processes of Keyline were no longer restricted by the use of chisel plows, and the techniques were streamlined.

In addition, the use of this new plow enables the soil to absorb high quantities of run off from storms, and heavy downpores. This is the runoff that normally fills dams, and can often cause erosion. These effects have be catered for in the design of whole farm layouts. Greater emphasis is now placed on the location and size of the first dam constructed. This first dam now tends to be of greater capacity than previous designs called for. Fewer and larger farm dams now prove to be economically more viable. This first dam is sized and placed to so enhance the returns to the farm, that future dams can become self financing by the farm itself. My brother Ken has developed computer simulation design techniques by which such decisions can be idealised. Design errors are virtually eliminated in the process, and financial and ecological viability can be assured.

The Keyline soil building process is now much more rapid with the use of this plow. Many clones of the plow have now been produced, often with interchangeable components, and if used correctly these plows can be equally effective.

The real value, almost one might say, the cash value of a soil is determined, firstly by the basic mineralisation within the soil. This is ordained by its geological history and formation. The farmer is not able to change this, outside the addition of some exotic trace elements. And the second determining factor, is the amount of humic acids within the soil, their age and their stability. The fulvic acids are here considered as subvarieties of the humic acids. If both abundant minerals and abundant humic acid is present, the soil is acknowledged as basically rich. Farming can, and does, change the content of humic acid within the soil. Most classic current farming practices in the Western World decrease the humic acid content of soils. The resulting soil deterioration manifests itself as, increasing dependency on chemical inputs, increased erosion and rising salinity levels.

To produce good crops in rich soils it is generally only necessary to maintain, within the soil, reasonable levels of biological activity.

Humic acid is not a simple acid, like hydrochloric acid or sulphuric acid. Humic acid is hardly an acid at all. When organic matter has been through all the biological processes within the soil, very large, relatively stable organic molecules are the ultimate result. Their formation is extremely haphazard and their actual chemical composition can have millions of variations. They are mildly acidic and so collectively they are described as "humic acid". Individual molecules can contain thousands of carbon atoms. They are so big that they can be acidic on one side and alkaline a little further around the same molecule.

For the farmer they have two very important characteristics. For a plant to take up an element for its growth, it must be in an available form. However, if the elements in the soil were in soluble form, they would have long since been washed, or leached away. Something else therefor, must occur for plants to exist at all. When acids break down basic geological minerals, nutritious soluble chemical elements become available, and these, fortunately, attach themselves loosely to the highly variable outer surface of the humic acid molecules. The element is no longer soluble, but it is readily available to the tiny root structures of plants and fungi. As far as a plant is concerned, the humic acid molecule is a supermarket, and its outer surface is the richly stocked shelves.

Carbon dioxide dissolved in rainwater forms carbonic acid. This carbonic acid breaks down the fine rock particles, replenishing the shelves in the supermarket. Also, biological activity within the soil can produce tiny quantities of acids, a thousand times stronger than the carbonic acid of rain water. These acids make available to the surface of the humic acid molecule, elements that would otherwise be totally inaccessible or unavailable.

If the soil is devoid of biological activity, and the minerals in the soil have been used up by growing crops, re-mineralisation of the soil can only be achieved by the much slower use of carbonic acid derived from rain water. I believe this to be a considerable, although unrecognised, justification for the "long fallow". It takes a long fallow, or simply a long time, to re-stock the shelves in the supermarket. When only minimum biological activity can occur, then the concept of "resting the soil", starts to make sense.

Humic acid molecules can last thousands of years, and these were described in German literature as "Dauerhurnus" (dauer - German and endure - English). The long lived dauerhumus does not itself form part of soil biological activity. Other humic acid molecules however, do form that are much less stable. They can last anywhere from minutes to months. These molecules can, and do, get involved in biological activity. They contain, within themselves, protein and other similar structures containing nitrogen, as also do the long lived variety. Soil biological activity breaks down the short lived molecules and release a constant, and harmless trickle of ammonia to the fine plant roots, invigorating plant growth. This is "Nahrhumus", (nahr to nourish). Almost all of the nitrogen supplied to plants in healthy soil, is derived from this organic material within the soil.

It is well known that total soil organic matter constantly decreases with mono-cropping, and by the use of soluble chemical fertilisers, almost all of which kill earthworms and destroy microbiological soil life. The organic matter content decreases over periods, usually in excess of thirty years, and up to one hundred years, to a level of about half that in the original soil. Then a stability seems to be attained. This, it is claimed, proves that chemical agriculture does not continue to decrease soil fertility. I tend to believe that most biological activity has already ceased, and the organic matter, still in evidence by high temperature soil testing, exists only in the form of dauerhumus. These then are the extremely stable, but now empty, supermarket shelves.

So many problems are solved simply by increasing soil's natural fertility. And it all starts with dead plant material, air and water. Activity then starts, bacteria, fungi, actinomycetes and worms devour the dead plant material, die, and in turn devour each other. In the process, concentrated acids are produced that break down tiny rock structures, making available crucial elements in the life cycle. Complex humic acid molecules are ultimately formed. Some are broken down by more biological activity, producing ammonia for plant growth. Around others, the soluble newly released element become attached, but still available for healthy plant growth. Long chains of sugar like chemicals, polysaccharides, food stores for bacteria, are formed that bind the soil together. The tiny root like structures of fungi bind the soil particles in the same way. Small aggregates of these soil particles and sand and clays accumulate. In our hand we feel the whole thing as good soil structure.

Pieces of the less stable humic materials reform, and reform again until ultimately, relatively stable humic acid molecules are created. As the total organic content rises, earthworms move in and establish themselves. Their casts are a rich source of humus and their slimes and glues enhance soil structure. The soils ability to retain moisture, its "field capacity", rises dramatically and, to the farmer, rainfall patterns become less critical. This intense biological activity is the necessary "bio" in "biodegradable". Soluble heavy metals, poisons, become attached to the humic acid molecule and are no longer in solution and a threat. They won't be selected by the plants' discerning fine root structures.

Food producing plants grown on such soils are healthy, mineral rich and nutritious, and extremely resistant to insect attack. Weeds and non-food producing plants cannot compete in rich soils. This is not just accidental but logically inevitable.

For this all to happen, we must first structure an ideal soil environment, and then, if we can, we should water it.

The most rapid increase in soil fertility, and soil organic content in broadacre farming, is obtained by the utilisation, and the growth manipulation, of the legumes and grasses. The current model of Yeomans Plow was designed specifically, so that its use would create this idealised environment.

If conventional chisel plows are used to an excessive depth, for subsoil aeration and rain water retention, destructive mixing of soil layers results. For this reason, chisel plow use in Keyline required a program in which cultivation was only progressively deepened. Depth of cultivation was determined by taking a spade, and checking the depth of the root structures resulting from the previous cultivation. Tine spacings were kept at 12" (300 mm).

Because of the resultant damage to existing pastures, it was often risky, and it was not advised to cultivate when pasture grasses were in short supply, or when approaching a period of, possibly, hot dry conditions.

Using these new implements we can now recommend an initial cultivation depth of 8" (200 mm) or more. Any less than 6" deep the cultivating effect is similar to a chisel plow, with a typical V shaped rip mark of loose earth being formed. If a hard pan exists, and conditions are dry, large clods can still be turned up. By increasing the depth of cultivation, a point will be reached where clods are not produced at all. Horizontal fracturing spreads sideways from the plough point and surface disturbance is minimal.

Tyne spacings should be much wider than would be recommended for chisel plows. 24" (600 mm) spacings are perfectly reasonable. 18" to 20" (about half a metre) would be a good general guide. If horsepower is limited, it is wiser to maintain the cultivation depth, and, if necessary, decrease the number of tynes being used. In this way little pasture damage occurs, good deep aeration has been achieved, and enormous quantities of storm rains can be absorbed before any run off occurs. Even with no following rain, very little soil moisture will be lost. In many instances plant roots will gain access to otherwise unavailable subsoil moisture.

The subsequent grass growth should be mown, or heavily grazed by overstocking to achieve the same effect. Stock should be removed promptly to permit rapid unhindered regrowth of the more nourishing pasture grasses. Subsequent cultivation should be repeated at or about the same depth. These Keyline stocking techniques are detailed elsewhere.

Within weeks of the first cultivation the decomposition of cast off root structures, following mowing or grazing, can promote soil colour changes from biological activity deep in the subsoil. This is quite impossible using a conventional chisel plow.

Cultivation, prior to cropping, using this plow at these depths invariably and dramatically increases crop yields. These dramatic increases are not always permanent. I believe that the dramatic increases result from exploiting soil layers, that have been "fallowing" for hundreds or even thousands of years. The minerals having accumulated on clay particles, as they do on the humic acid molecules. The dramatic increase in crop yields can only be maintained, by the inclusion of grasses and legumes into the cropping programs. This is to promote biological activity, and thus maintain the supply of minerals and elements.

Again; So many problems are solved simply by increasing soil fertility.

Allan I. Yeomans

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21 ILLUSTRATIONS*

Plate 1: Meditation. At the High Contour dam on "Nevallan".

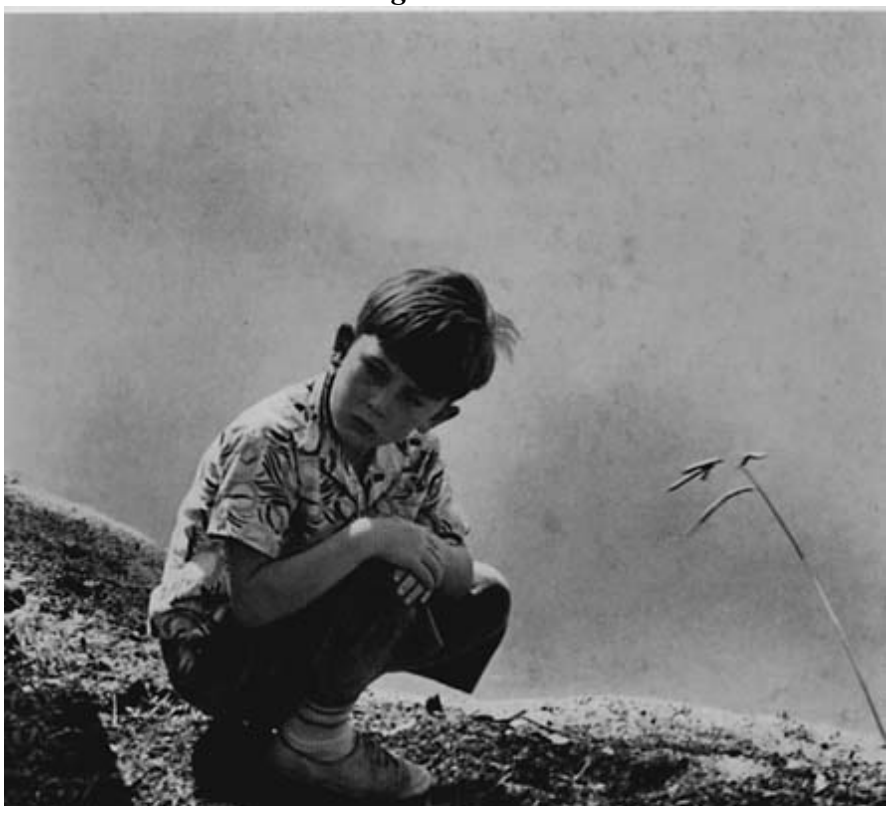

Plate 2: Aerial view of "Nevallan" homestead,with High Contour dam in the top left-hand corner of the picture. This dam, which is filled by drains, collectes its water from the roads and yards of the homestead area. It has 4-inch outlets through the end walls.

Plate 3: Sons, Ken (left) and Neville, in a newly planted strip of Tallow-wood trees. Trees were six inches high when planted in the Spring and the picture was taken in the following Autumn. The strip contains approximately 1000 trees (vide Chapter 8). Tallow-woods are not indigenous to our district, but are doing well to date.

Plate 4: A 10-foot Graham Chisel Plow and Crawler used for developing steep country up to 100% slope.

Plate 5: "Conversion-year" cultivation and erosion holes plowed out by the "Graham". "Pelican Rest" dam, built before Keyline was originated, has a 4-inch outlet.

Plate 6: Clearing, March, 1952, on "Nevallan". Coloured Plate 4 in Chapter 5 was taken near the log in this picture.

Plate 7: The same paddock as in Plate 6, nearly two years latere.

Plate 8: Son Allan takes a picture of a rogue. Timber strip is of gums and narrow leaf iron bark. Pasture contains clovers, lucerne, cocksfoot, etc. (Not irrigated.) "Nevallan", March, 1954.

Plate 9: Jack Matters and a rabbitproof flood-gate he built. Held down with rocks, flood-gate swings out with the floods. Jack is in charge of the two properties.

Plate 10: "Nevallan" boundary fence. Rabbitproof flood-gates and fences are essential in Australia for the maximum development of soil fertility.

Plate 11: A Keyline dam near "Nevallan" Homestead. This dam is replenished, when required, from "Four Fathoms" dam by means of a 4-inch outlet and drain.

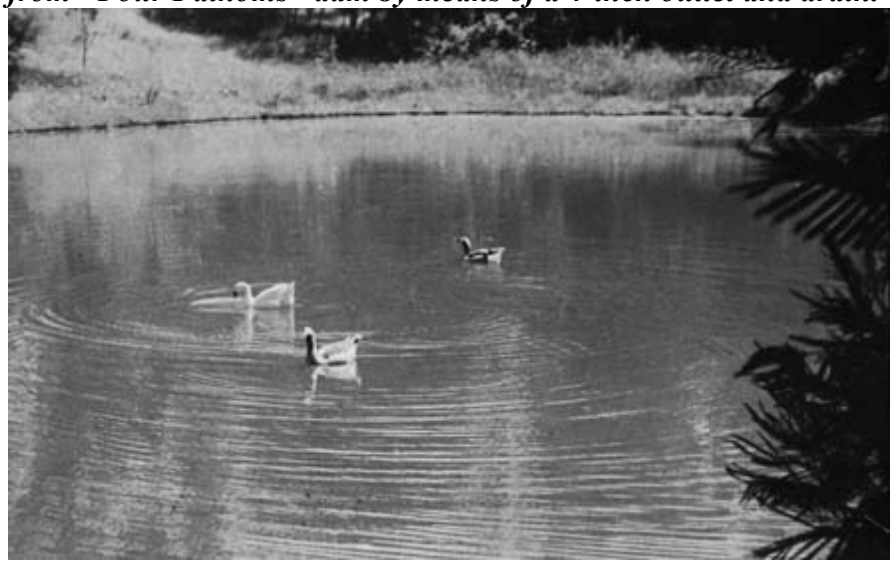

Plate 12: The 4-inch outlet of the above dam and the "manpower" required to operate it. A pipeline which is coupled directly to this outlet permits spray irrigation of the lower areas without pumping costs.

Plate 13: These trees are growing in near forest conditions. My wife and small son are the figures in the timber strip,which is a chain wide.

Plate 14: Steep pasture land just below "Nevallan" Homestead. Cattle are Herford steers. The area was "Keyline cultivated" six months earlier.

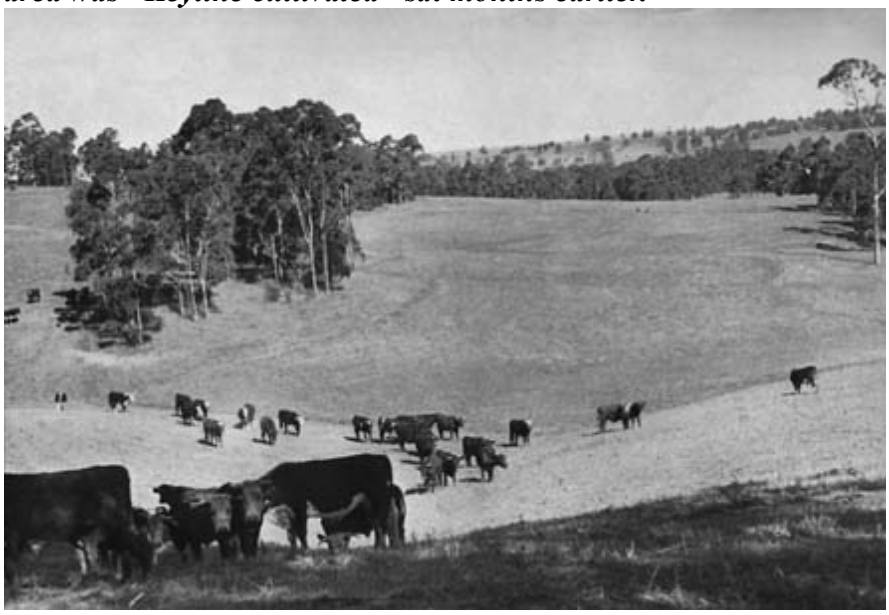

Plate 15: "Nevallan" Homestead

Plate 16: Allan's wife, Beverley, looking down Kenvale Valley, formerly eroded. Note lines of "Keyline Cultivation" for soil and pasture improvements on the left.

Plate 17: Four weeks later, shows growth covering Keyline cultivation lines. Jack Matter's sons, Norman and Dennis in the foreground.

Plate 18: Lower paddock on "Nevallan". It has been Graham plowed and pasture sown.

Plate 19: Small tractor and mounted Graham Plow. This combination does the cultivation work on "Nevallan"

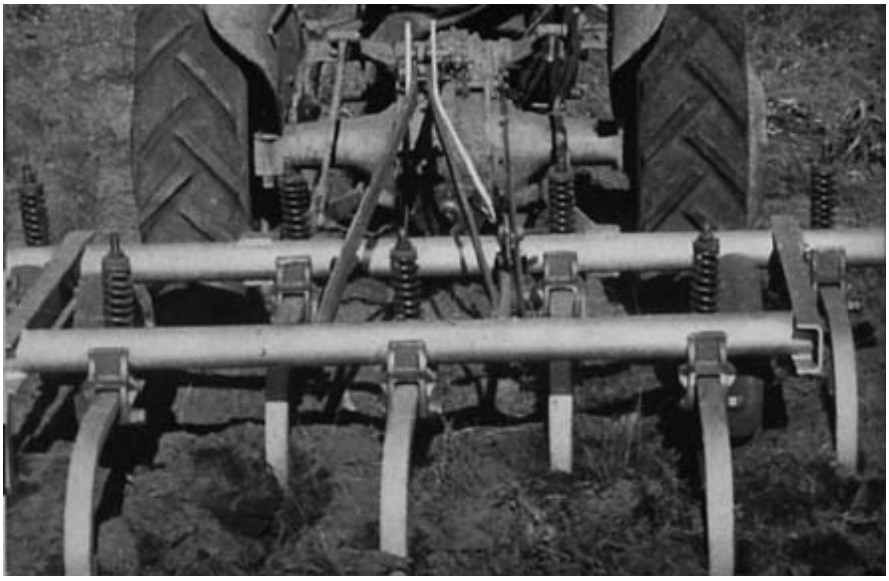

Plate 20: Shows the same area as seen in Plate 18, near the trees in the middle distance, 12 months later. Shorthorn steers on year-old pasture in Goondiwindi paddock. "Nevallan". Above the fence in the picture can be seen the stirp of newly planted Tallow-woods (shown in Plate 3), with five tree rows in the strip of 1000 trees.

Plate 21: An Australian Bush Scene--"Nevallan".