THE APPLICATION OF AERIAL PHOTOGRAPHY
TO SURVEYS OF
POTENTIAL WASTE DISPOSAL SITES

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SUMMARY

The reorganisation of County boundaries which took place on 1st April 1974, resulted in a number of new responsibilities, and problems, for the County authorities.

Among these new responsibilities was the management of waste disposal, which previously had been carried out on a very local basis, by a large number of smaller authorities.

The management of waste disposal at County level revealed a number of major problems - one of which was the absence of a rapid, cost effective method of locating potential tipping sites.

The LOGORU report on Economic Spoil Management (April 1972) under the heading, The Technical Problem, states "The identification of all disposal sites and the estimation of their capacity is not so easy.......". "It is also practical to identify many of the disposal sites which may eventually become available".

The aim of this study was to investigate the feasibility of developing an accurate, speedy, cost effective and practical method - using aerial survey - for identifying, locating, mapping and measuring potential waste disposal sites.

Various methods of treatment and disposal are considered, and the financial and other advantages of tipping are discussed.

The aerial photograph is studied in detail to assess to what extent it can provide the information required for waste disposal site surveys.

The processes of air photo interpretation and photogrammetry are outlined, and related to the contribution they can make as a source of both qualitative and quantitative data.

The aerial photograph is compared with the main alternative sources of information: field surveys, Ordnance Survey maps, and published land use maps. Comparisons are also made in relation to the type of information that can be derived from these various sources, and the relative speed, accuracy and cost of using air survey methods.

A methodology was developed and tested at County level, and the following conclusions were reached:

i) That the use of aerial photographs and photogrammetry has substantial advantages in terms of the speed, accuracy and cost, in carrying out surveys for potential waste disposal sites, and

ii) That as well as searching for quarries and other excavations, there is considerable scope and merit for including derelict land, and combining tipping with land reclamation. Waste disposal should be treated as much as a land reclamation agent as an end in itself.

waste disposal, air photo survey, tip site surveys, waste disposal management.

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WASTE TREATMENT AND DISPOSAL

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WASTE TREATMENT AND DISPOSAL

1.1 INTRODUCTION

When the new County Authorities came into being in April 1974, one of their responsibilities lay in the field of waste disposal. Hitherto, waste disposal had been handled by a multitude of authorities ranging from large, thinly populated Rural Districts to small, densely populated Borough Councils. The new County Councils were often faced with a large number of small disposal sites with a low capacity, and with expensive schemes for high capital-intensive incineration plants. In particular, the Metropolitan Councils with their large populations and small areas had few disposal sites under their control.

Two tasks faced the new authorities, the first and most immediate problem was to secure the short term future and provide an adequate disposal facility. The second task was to plan out the most economical and socially acceptable method of disposing of the County's waste over the medium to long term period. Both these tasks, required as part of the basic information need, an inventory of potential waste disposal sites.

Aerial photographs have long been used for small scale land use surveys as well as for contouring and plan preparation. In recent years, developments have taken place in the field of large scale land use mapping, especially in the field of derelict land. Most of the new county authorities already have full county cover of aerial photographs, much of which was flown around the 1971 census year, and therefore the photographs form an immediately available survey base. In circumstances where recent photography is not available, the new authorities, with their larger financial resources, could afford to commission new photography.

To effectively manage the county wide disposal of waste, several major data inputs are required. Among these inputs are the determination of the amount and type of waste being generated, the location of the sources of generation, the alternative methods of treatment and disposal, and the capacity and location of available disposal sites.

Whatever method of treatment is carried out the final stage is some form of tipping, and this requires, in the first instance, a knowledge of all potential tipping sites in, or available to the county authority. The four main methods of treatment are incineration, pulverisation, composting, and controlled tipping, though other methods, such as baling and recovery, are less commonly used.

Prior to the work for this thesis, no evidence was found of a complete county survey having been undertaken in which aerial photography had been used as the prime data source for mapping potential waste disposal sites.

This thesis seeks to develop a rapid, cost effective, and practical methodology for such surveys which can be used by the new Waste Disposal Authorities.

1.2 METHODS OF TREATMENT AND DISPOSAL

(i) Incineration.

This method is most favoured in Metropolitan areas where landfill sites are thought to be in short supply. A volume reduction of up to 90% and a weight reduction of up to 40%[1] can be achieved. Obviously, this saves on both landfill site life and transport costs.

Old plant designs were based on separation/incineration lines. Paper, rags, non-ferrous metals and glass were extracted manually and ferrous metals recovered magnetically. These methods were suitable for refuse with a high dust content, as had occurred in the past[2,3]. Present designs, based on direct incineration involve the agitation of refuse on a continuous flow principle.

Problems exist in that refuse varies on a day-to-day basis, in both its physical composition and calorific value. Incinerators have therefore been designed to deal with a wide range of refuse. Toxic gases may be produced by incineration (sulphur oxide, chlorine and hydrochloric acid), especially where there is a high proportion of plastics in the refuse incinerated. Amounts of plastic remain small at present and the problem can be dealt with by installing a chimney of adequate height. Dust emission can also be a problem, in which case the use of dust arresting is necessary.

Modern incineration plants offer very little scope for materials recovery, except for the magnetic separation of ferrous scrap after incineration. The future position may alter as research indicates further recovery possibilities. In some plants heat recovery does take place, but the variable calorific nature of refuse usually makes it necessary for a back-up facility, using traditional fuel, to be installed.

Incineration processes are capital intensive: a recent installation in Sheffield cost almost £4 million,[4] and one in Birmingham cost £7 million, to build. A major problem lies in the projection of future refuse generation. If too high a capacity were to be installed, plant may become underused and unit costs increased considerably. Incineration costs usually vary between £7 and £8 per tonne[5] at 1975 prices.

Although the risks of water pollution from tipped incineration residues are generally considered to be lower than with crude refuse, inorganic sodium, chloride and sulphate materials are present in the residue. Care must therefore be taken with the disposal of residues which should not be assumed to be inert.

1.2 ii) Pulverisation

Pulverisation consists of the mechanical treatment of solid waste to reduce the average particle size and therefore to reduce the void. Pulverisation therefore reduces volume and creates a material more easily handled in landfill sites than crude refuse. Pulverised refuse is less liable to be windblown, has a lower fire risk, is less attractive to rodents and other pests and is less offensive visually. Less cover is needed for controlled landfill and biological breakdown is accelerated due to the decrease in particle size. It is theoretically possible to reduce volume by 87%, but an average of about 33% is usually all that is achieved.

Pulverisation plant can be either the hammer-mill or rotating-drum type. With hammer-mills, reduction is achieved by impaction and shredding. Rotating-drum machines pulverise by attrition and abrasion, moisture being added to the drum to reduce the strength of paper and other fibrous materials. The overall costs of pulverisation vary between £3.50 and £5.00 per tonne[5] at 1975 prices.

1.2 iii) Composting

Composting is basically a biological process in which the organic material in waste is converted to a more stable material by the actions of micro-organisms, already in the waste. The aim of composting is to create the optimum conditions for decomposition to take place.

The value of this method of disposal is that it produces a relatively inert residue. Initially, composting was considered to be advantageous as it produced a saleable residue which could be used as a soil dressing or a fertiliser[6]. However, the product was found to have a low market demand as it had little fertiliser value and could be toxic!

A 50% volume reduction can be achieved. There are, however, two problems in that up to 50% of refuse cannot be composted, having to be treated by some alternative method, and that the problem of lack of fertiliser value increases as putrescent material decreases as a percentage of total refuse.

This method is finding less favour as other methods of disposal increase in efficiency. The residue can, however, be used as cover for crude refuse and for a final soil dressing when the site is finished.

Costs are usually about £6 per tonne of crude refuse[5] at 1975 prices.

1.2 iv) Baling

Baling of salvaged material, for transport away from the recovery site has long been practised, but little thought has been given, until recently, to baling crude refuse to facilitate transport to landfill sites. Simple baling systems have been used both to Japan and the United States, where refuse has been compressed into bales and retained by means of wire, plastic or an agglomerating substance. This practice obviously leads to extra expense and the introduction of extra material to be disposed of. A new system[7] recently introduced from the United States has been installed in Glasgow and Leeds. This system produces bales which have been compressed beyond their "yield" points. These high density bales form a volume as small as 1/15th of the volume of the equivalent mass of crude refuse. In addition, because the bales have been compressed beyond the limit of elasticity there is no need for a retention system. Each bale measures approximately 1m x 1m x 1.3m and weighs between 1100 kg and 1400 kg. The high-density baler can deal with almost every type of waste from ordinary domestic to motor cars and concrete blocks!

The advantages of this method of treatment lie in low transport costs and easily controlled disposal. The bales can be transported on flat-backed lorries, with only a tarpaulin for cover. Loading, unloading and disposal can be carried out with a fork lift truck. Ease of transport is matched by ease of disposal, with the bales being stacked in neat piles and requiring a minimum of cover.

Hydraulic pressures exceeding 2,250,000 kg are used to compress the solid waste into bales. As a consequence the density of the bales often exceed the density of the ground they are buried in. These densities range from 90 kg/m^3 to 270 kg/m^3, depending on the material being baled. Therefore, the disposal site can be used almost immediately the site is filled. Heavier buildings as well as lighter structures can be built on the site with very much less chance of deformation by settling.

Another beneficial point is that during compression most of the air is squeezed out, thus minimising bacterial action and overcoming problems of wind blow, pest and odour.

1.2 v) Recovery

Other methods of disposal basically centre around material recovery. Table 1.1 shows a typical analysis by weight of municipal refuse[8] in the United Kingdom. This refuse is generated at about 12.6 kg per household per week and is subject to an increase of about 1% in weight per annum. Even a superficial examination of the composition of refuse shows that much of it has a potential for recycling or, through thermal processes, providing heat energy.

Amongst materials suitable for recovery are paper, glass, ferrous and non-ferrous metals, plastics, rubber and textiles. Indirect recovery includes the production of heat by incineration, fuel oil by pyrolysis, and solid fuels ethyl alchohol through hydrolysis.

1.2 vi) Controlled Tipping (Sanitary Landfill)

This is the most widely used method of refuse disposal, and is the final stage of all refuse disposal methods, excepting complete salvage. The main problem is that tipping has acquired a poor reputation in the public mind and is associated with unsightly masses of rubbish, wind scatter of paper refuse, various forms of infestation and bad odours. Nuisance can be minimised providing that the tipping practice accords with the correct rules of sanitary landfill[9] in a controlled tip. The Ministry of Health in its annual report for 1931/2[10], published a list of precautions which should be taken when disposing of solid waste. These recommendations were updated by the Working Party On Refuse Disposal (1971)[1], which put forward the following Code of Practice:

i) Refuse should be formed into a layer as soon as possible after tipping and not later than the end of the working day on which the refuse is received.

ii) The layer of refuse should be formed using a tractor equipped with a blade or other appropriate levelling device. Refuse should be deposited on the surface of the tip behind the face and partially compacted by the tractor before being pushed over the face.

iii) The layer of refuse should be formed so that it does not exceed 8ft. in depth, after initial compaction. Where the material is pulverised refuse, it may be necessary to restrict the depth of each layer to 4ft. after compaction on some sites close to development.

iv) As tipping proceeds (and not less frequently than at the end of each working day) all tip faces and flanks should be consolidated and formed to a gradient not steeper than one in three by driving the tractor up and down the tip face.

v) The tipped material should be progressively covered, so that all surfaces including the tip face and flanks are covered at the end of each working day, with a layer of suitable sealing material, spread so that it is not less than 9in. thick. The thickness of covering material on layers formed solely from pulverised refuse need not exceed 6in.

vi) All large articles such as furniture or hollow containers should be tipped in front of the tip face. They should be crushed, broken up or flattened by the tractor and covered each day by other refuse, in such a position that they are not within 3ft. of the tip surface or 6ft. from the tip face.

vii) Any material consisting wholly or entirely of fish, animal wastes, condemned food, including tinned or packaged food, or highly obnoxious matter should be tipped in front of the tip face and covered immediately by other refuse in such a position that the material is not within 3ft. of the tip surface or 6ft. from the tip faces and flanks.

viii) Screens should be erected at intervals near the tipping point, having regard to the direction of the prevailing wind so as to reduce to a minimum loose paper, plastic sheeting, etc., being blown from the place of deposit.

ix) No less frequently than once a week, any loose refuse, tins, bottles, etc., which may be lying on the tip site should be gathered and removed.

x) Such action as may reasonably be necessary should be taken to prevent the deposit of mud on highways outside the tip area by vehicles travelling from the tip. Any deposits of refuse, mud, etc., on nearby highways or surrounding land caused through the tipping operations should be removed as necessary.

xi) Suitable arrangements should be made for dealing satisfactorily with any material which may be permitted to be accepted at the tip after normal working hours, e.g. facilities provided under the Civic Amenities Act, 1967.

xii) (a) No waste material should be burnt within the curtilage of the tipping site.

(b) Immediately on discovery, such emergency action as may be necessary should be taken to extinguish any fire in or on the tipped refuse.

xiii) To control infestation by insects and vermin, the entire tip should be inspected as often as is necessary and corrective action should be taken where required.

Tipping is normally undertaken in layers 8ft. in depth to allow for settling. Given that the minimum amount of cover material is 9in., it can be seen that the amount of cover material needed is approximately 10% of the total amount of refuse deposited.[11] The costs of controlled landfill vary, an average being about £1.00 per tonne at 1975 prices.

Certain features of tips aid in the breakdown of putrescent material within a tip. Saprogenic and Zymogenic bacteria are responsible for decomposition, whilst Pathogenic bacteria play no part at all. Of the Saprogenic and Zymogenic bacteria, the aerobic types are the quickest to act, their activity depending on the amount of oxygen entering the tip. To aid the establishment of aerobic conditions, the refuse should be tipped in fingers. Oxygen can also be introduced into a tip by means of air pipes. Another advantage of keeping the activities of the aerobic bacteria at a high level is that they produce heat. Pathogenic bacteria are destroyed by the temperatures created within the tip, as well as being attacked by the Saprogenic bacteria.[12]

The correct treatment can be found to render a site suitable for landfill but treatment obviously increases with the degree of protection required. In areas where landfill has been carried out over a long period of time, or where ground water has already been polluted, aquifers may have to be written off and disposal allowed (at any particular site) provided that surface pollution is controlled.

The major problem arising from tipping is that of water pollution. It is this factor that necessitates the formulation of a rigorous disposal strategy.

1.3 A COMPARISON OF THE ALTERNATIVE METHODS OF TREATMENT AND DISPOSAL

All methods of waste treatment eventually involve landfill in the disposal of the original or residual waste. The choice of method depends on the level of operating and capital costs, pollution risks and environmental impacts of the various options open to a Waste Disposal Authority. Each of the alternative methods requires land for the disposal of residues and it is a general rule that the total costs of each alternative are inversely proportional to the landfill space consumed by the system.

The United Kingdom annually generates about 15 million tonnes of domestic and commercial wastes, together with at least 20 million tonnes of industrial wastes. Only a small proportion is toxic and not suitable for a normal landfill operation, the remainder being suitable for landfill. The following three tables give an indication of the capital and operating costs, together with an estimate of the use made of each method of disposal.

There is a wide variation in the amount of landfill space consumed by each of the various systems with incineration being the most economical. Other systems like pulverisation and high density baling are next in scale, whilst controlled landfill requires the most land.

However, operational research is now indicating that the use of modern earth-compacting machinery, together with the fact that refuse settles over a period of time after the cessation of tipping, can lead to the achievement of densities for crude refuse approaching those for pulverised and even incinerated refuse. Incineration however still remains the system which uses least landfill space, but differences in space requirement are now lower than the theoretical differences between incinerated and crude refuse might suggest.

Capital projects in the waste disposal field are financed by local government and as a result of the financial stringencies imposed in the mid-seventies, local government has been forced to reduce capital expenditure. This has returned the emphasis to low cost landfill schemes and away from capital intensive, prestigious incineration plants. Whilst there may be a shortage of landfill space close to the main urban centres mineral extraction combined with a legacy of derelict and degraded land should continue to provide more space than is required for landfill. These sites are not always available or located in the most convenient places. Often the geology is unsuitable and other environmental factors may preclude landfill. However, as is shown later on in this thesis, adequate landfill reserves exist and this being so it is likely that landfill will continue to be the predominant disposal method, with the increasing use of bulk transportation systems to make use of remote landfill sites. In addition to the flexibility afforded by transfer stations and bulk haulage, the transfer station offers opportunities for both separation and reclamation.

1.4 THE REFUSE TRANSFER STATION

With the increasing use of more remote landfill sites Transfer Stations[13] are becoming a necessity in the modern waste disposal operation. The effect of a transfer station is to stabilise the disposal point for a given collection area, by creating a fixed point of delivery for the collection vehicles, with their high cost per tonne mile. The transfer station enables movement in bulk container vehicles, which have low costs per tonne mile. An additional saving can be made if some form of refuse treatment is included in the transfer station, i.e. reclamation or compaction.

Transfer stations come in a number of forms, the most common being:

1. Simple transfer and discharge
2. Compaction and discharge
3. Pulverisation, compaction and discharge
4. Baling and discharge

In each of these forms the station can be adopted to accommodate a number of roles as a transfer and reclamation point.

Table 1.1 TYPICAL ANALYSIS OF MUNICIPAL REFUSE IN THE U.K. (1975)

Dust and cinder	22.9%
Large cinders	4.5%
Paper	32.5%
Vegetable matter	19.3%
Metals	7.1%
Glass	7.9%
Rags	2.2%
Plastics	1.0%
Unclassified debris	2.6%
	100% Weight

Table 1.2 DISPOSAL METHODS AS A PERCENTAGE OF THE TOTAL (ENGLAND) 1974/1975

	Direct Landfill	Incineration	Pulverisation	Other	Total
Metropolitan Counties	81.2	16.0	1.1	1.7	100
Shire Counties	84.7	4.5	4.8	6.0	100

Table 1.3 DISPOSAL METHOD COSTS PER TONNE (ENGLAND) 1974/1975*

	Direct Landfill	Pulverisation Landfill	Composting	Incineration	Contractors Haul/Land's
Marginal Treatment Cost per tonne	£0.91	£3.88	£5.81	£7.55	£3.45

* Figures prepared by the Society of County Treasures for 1974/1975

Table 1.4 DISPOSAL METHODS CAPITAL COSTS PER TONNE PER HOUR (ENGLAND) 1974/1975*

	Capital per tonne per hour
Heat Recovery Incineration	£250,000
Non-heat Recovery Incineration	£200,000
Reclamation Transfer Station	£ 80,000
Pulverisation Transfer Station	£ 30,000
Simple Transfer Station	£ 20,000

*Figures prepared by the Society of County Treasures for 1974/1975

REFERENCES

1. Refuse Disposal; Report of the Working Party on Waste Disposal; Dept. of the Environment, H.M.S.O., 1971.

2. The Analysis of Domestic Refuse: Higginson and Fairlie; Inst. Public Cleansing, 1966.

3. Supplement to the Analysis of Domestic Refuse: Higginson and Fairlie; Inst. Public Cleansing.

4. Refuse into Energy in the City of Sheffield Refuse Incineration Plant: J.R. Holmes; Inst. Solid Wastes Management, Autumn Meeting 1975.

5. Reclamation: R.F. Millard; Solid Wastes; Vol. LXVI, 7, July 1976, pp 327.

6. Refuse Composting Plant at Warlip: W.R. Shirrefs; Public Cleansing; Vol. LX, 9, September 1970.

7. High Density Solid Waste Baler is Installed in Cobb County: M.A. Obermann; Waste Age, June 1975.

8. The Recovery of Useful Material from Refuse: J.R. Holmes; The Inst. Municipal Engineers; Monograph no. 27 in a series on the protection of the environment, 1975.

9. Controlled Tipping of Refuse: R.E. Bevan; Inst. Public Cleansing, 1967.

10. Annual Report for 1931/1932: Ministry of Health; H.M.S.O.

11. Disposal of Refuse and Other Wastes; J. Skitt; Charles Knight and Co. Ltd., 1972.

12. Anerobic Digestion of Solid Wastes: S.A. Klein; Compost Science; Vol. 13, 1, 1972.

13. The Millhouses Refuse Pulverisation Transfer Station, Sheffield: J.R. Holmes; The Chartered Municipal Engineer Vol. 102, no. 12, pp 237-244.

CHAPTER TWO

WASTE DISPOSAL MANAGEMENT

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WASTE DISPOSAL MANAGEMENT

2.1 INTRODUCTION

With the establishment of the new County Authorities at the beginning of April, 1974 has come their responsibility for the management of waste disposal.[1] Previously every local authority had the task of organising both the collection and disposal of waste. The problem was mainly small in scale and relatively limited in areal extent. Only where authorities had run out of tipping space or had built incineration plants, had there been any co-operation between neighbouring authorities. Few authorities have had the time, or trained staff to develop county wide waste disposal strategies, and with current economic and operational difficulties and constraints, the problem is likely to continue to be tackled in an ad-hoc and piecemeal fashion.

Several relevant studies have been undertaken by or for local authorities, mainly on the siting of large plant[2,3] but very few have been carried out on waste disposal strategy.

One was "Where to put solid wastes", a joint study between LOGORU and the West Riding County Planning Authority.[4]

It is doubtful, taking the country as a whole, whether there is a shortage of suitable tipping space. The increasing rate of mineral extraction is likely to make even more potential tipping space available in the future. Refuse disposal methods have so far concentrated on tipping and, because it is so economic, this is not expected to change significantly in the near future.

Prior to 1974 there were (including the G.L.C.) 1,174 separate authorities responsible for waste disposal, 804 of which stated that they had difficulty in finding tipping sites.[5]

2.2 THE CONTROL OF POLLUTION ACT (1974)[6]

The Control of Pollution Act, which received the Royal Assent in July 1974, replaced an earlier Bill, The Protection of the Environment Bill, which failed in February, 1974.

One section of the Act deals specifically with waste disposal and covers all waste except that arising from mines or quarries. The Act therefore specifically excludes colliery waste, which in the coalfield areas is likely to increasingly compete with other wastes for disposal sites. The Act requires that the waste disposal authorities ensure that adequate arrangements are made for the disposal of all controlled waste within its area. Controlled waste being that covered by the Act. It is also the duty of the authority to prepare a plan for waste disposal in its area and to issue a licence for a waste disposal site. The licence acts as a planning permission, covering the conditions under which a site must be operated. The granting authority has a duty to police licences, ensuring that conditions are fully adhered to.

2.3 LANDFILL SITE LOCATION

The new Local Authorities are required to produce waste disposal plans to cover the next ten years. In order to do this efficiently it is necessary to develop adequate and economic systems of data collection and data handling. Two major data needs are:

i) to identify types, sources and quantities of waste, and

ii) to locate, identify, map and measure suitable tipping sites.

A growing awareness of the problem and recent legislation have resulted in the establishment of a more efficient and more complete system of locating and recording types, sources and quantities of waste generated.

However, it is equally important to improve current methods of identifying and locating 'sinks' i.e. tipping sites. A quite small site may be more important than a large site if the smaller site is able to accept liquid or hazardous waste, particularly if the site is near the source of such waste.

Collection of data on potential sites could be carried out using planning permission details for mineral extractions: a map search would also be necessary. Sites could then be visited and the rather laborious collection of field data carried out. Individual knowledge of members of the planning team could also be utilised. However, it is obvious that none of these methods is particularly efficient. Sites quarried before the need for planning permission may not be recorded, and the individual's knowledge of the County will obviously be lacking in many areas, particularly with the introduction of non-local personnel into the new planning authorities. It is in the field of landfill site location that aerial photographs could play a significant role.

2.4 THE ROLE OF AERIAL SURVEY

A survey involving nearly three hundred planners was carried out by Brenda White[7], to determine the relative importance of the various data sources which they used. Figure 1 shows the results on a 14 point scale of comparative ranking of operational sources. The survey placed aerial photographs twelfth, with newspapers coming thirteenth and theses fourteenth.

The survey report comments on this marked under utilisation of aerial photographs by the planning profession, in which nearly three quarters of the sample group had either 'no' or only 'small' experience with aerial photographs.

Since this survey there has been a considerable increase in the general use of air survey by planners, however in terms of its potential as a data source it is still very much under utilised.

Nearly all County Authorities have at some time or another had their areas flown to obtain aerial photographs. It is not fully appreciated just how wide a range of environmental/landscape/land use information can be extracted from these photographs, using the technique of Aerial Photograph Interpretation (A.P.I.).

Most aerial photographs are taken with the camera pointing vertically down to the ground - hence the term vertical photography. These photographs are taken at regular intervals along the flight path and each print overlaps its neighbours by about 60%. The technique of aerial photograph interpretation involves the study of overlapping pairs of photographs in a scanning stereoscope.

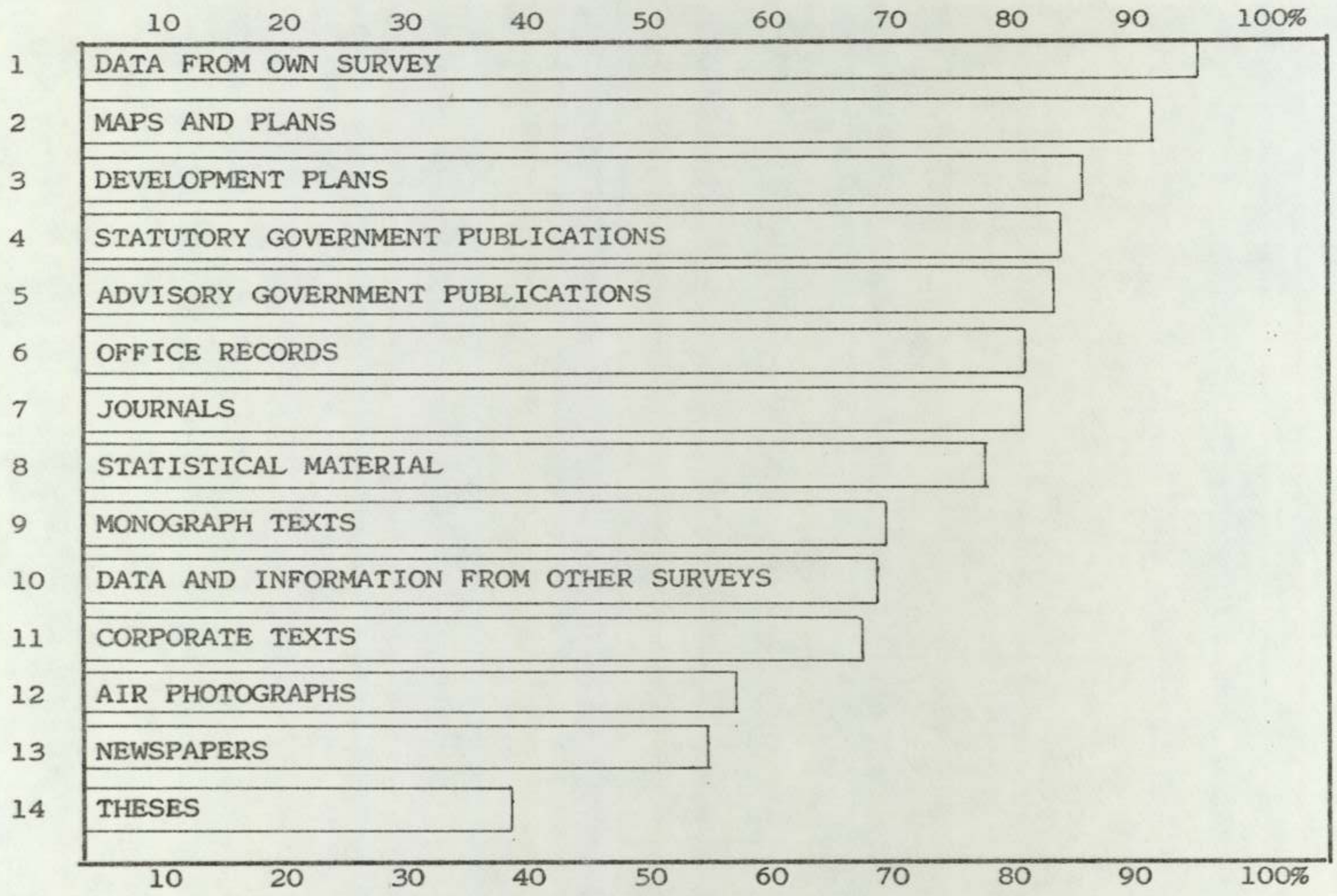
Using the photographs under a stereoscope, a county wide survey of potential tipping sites (whether excavations or ground-level derelict sites) can be carried out. The process can be completed in a relatively short time compared with other methods of county-wide survey, the main advantage being that of the large area which can be viewed at any one time. At 1:10,000 scale, a 9" x 9" photograph covers an area of approximately 2 square miles, whilst individual trees and motor vehicles can be discerned. Various attributes of each site can be listed to assist in identifying the 'possible' sites from the list of 'potential' sites.[8]

The final detailed survey to establish whether a potential tipping site can be used obviously has to include information on the geology and hydrogeology of the site and an intensive field investigation is required at this stage to acquire the necessary information.

Although the amount of detail which can be identified depends upon the scale and quality of the photography, the degree of expertise of the interpreter plays a large part in the accuracy and detail of the survey work. With photography at a scale of 1:10,000/1:12,000 a building of about 3 metres by 3 metres is discernable, whilst extractive plant and vehicles are readily seen. Using a precision stereo plotting instrument maps can be produced at scales of around 1:2,500 with contour intervals of 3 metres and accuracies at least equivalent to that obtained by traditional and more expensive field survey methods.

At scales of 1:3,000/1:5,000 it is possible to identify individual tree species, some types of manufacturing industries and even animal, vehicle and pedestrian densities. High accuracy plans can be produced at scales of 1:500 with a 0.3 metre contour interval, and from these contoured maps and plans it is possible to determine both areas and volumes of heaps and holes. Volumetric computation from aerial photographs is substantially quicker than traditional field surveys.

FIGURE 2.1 A COMPARATIVE RANKING OF OPERATIONAL SOURCES OF INFORMATION.



Source - B. White "Current Use of information in planning"

REFERENCES.

1. Local Government Act 1972. H.M.S.O.

2. Refuse Disposal in the High Peak Area: LGORU: Report C85: October 1970.

3. S.E. Dorset, Bournemouth and S.W. Hampshire Refuse Disposal Study: LGORU: Report C95: June 1971.

4. Where to put Solid Wastes: LGORU: Report 168: March 1974.

5. Refuse Disposal: Report of the Working Party on Refuse Disposal; D.O.E.: H.M.S.O. 1971.

6. The Control of Pollution Act (1974) H.M.S.O.

7. White B. "Current use of information in planning" Survey financed by the Office for Scientific and Technical Information. The Library Association 1969.

8. Ballam C.J. and Collins W.G.: Economic Advantages of using Aerial photography for Mapping Potential Tipping Sites: Solid Wastes. Vol. LXV. 10 October 1975.

CHAPTER THREE

A COMPARISON OF THE AERIAL PHOTOGRAPH WITH ALTERNATIVE SOURCES OF DATA

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CHAPTER THREE

A COMPARISON OF THE AERIAL PHOTOGRAPH WITH ALTERNATIVE SOURCES OF DATA

In order to properly assess the value of aerial photography (as a data source for identifying, locating, mapping and measuring potential tipping sites) it is necessary to make some comparisons with alternative sources.

This comparison needs to consider both the advantages and disadvantages in terms of the amount and type of information that can be derived; the speed, accuracy and cost of obtaining the information, and any problems of data collection and analysis that may arise.

The three major alternative data sources of potential tipping sites are

a) Field work

b) Ordnance Survey maps, and

c) Published Land Use maps.

Of these field work is by far the most common method of carrying out such surveys, although the other two sources are often consulted and used by county and district authorities.

Before making comparisons with other data sources there are certain characteristics of the aerial photograph which need to be considered.

The aerial photograph gives a 'true' picture of the 'total' visible landscape. The photograph makes no attempt to discriminate or select, but instantly records all that can be seen. This makes it quite unique and different from the other sources of data which select specific features for inclusion in a survey.

The map maker and field surveyor, whether compiling a land use map or an O.S. topographic map, will record only those items included in the key which have been previously selected and defined.

Once the map maker and field surveyor have completed their selection of data, and the survey is mapped, they cannot add to, or alter the definition of the features surveyed, without carrying out another data collection exercise.

By using aerial photographs it is possible, within certain limitations, to alter, add to or re-define the categories included in the original survey, without having to have another aerial survey flown. Furthermore in the case of aerial photographs the date of the original survey remains the same, hence it is possible to carry out surveys in retrospect: to carry out surveys to obtain information that was not previously needed or collected.

For example now that there is an urgent need to monitor certain aspects of the land and the environment it is possible to obtain previously taken aerial photographs and use them to collect new information, such as that relating to the rate at which tipping sites are being filled or new ones created.

All the photographs used in this study had been taken for the purpose of updating maps and the decision to use them for tip site surveys was made several years after they had been flown. The photographs provide a permanent record of the field situation at the time of flying: if there is any query, or the accuracy of the information is in doubt it is possible to consult the original to check, long after the original air photo survey was carried out. This is in marked contrast to a field survey, which is often impossible to check after a long period has elapsed since the original field work.

In considering the amount of potential tip site information which could be acquired from aerial photographs and field work the aerial photograph has a marked advantage in having a 'birds eye view'. Often in field work it is difficult to obtain physical access, and many sites are not visible from the field surveyor's viewpoint. The chances are that an air photo based survey will be more complete, in fact at scales of around 1:10,000 sites as small as 10m x 10m are clearly visible. A skilled interpreter could guarantee a virtually 100% complete site survey - an accuracy that would be both difficult and impractical to achieve in a field survey, where excavations are not nearly so easy to find as tip heaps.

The type of potential tip site information that can be obtained from aerial photographs is discussed in detail in chapter five.

It can be seen that, in terms of relevant information, there is very little difference between the type of information that can be acquired from aerial photographs with that obtained from field surveys.

On one hand 'Ownership' can never be determined from photographs and not always by field work. On the other hand micro drainage channels are easy to identify and map from aerial photographs but most difficult, and in some instances impossible, to locate in a field survey.

The information collected for a county wide survey of potential waste disposal sites, is outlined in chapter six, and is listed in figure 6.1, the survey schedule. As well as locating and mapping the 'potential' sites a considerable amount of additional information is necessary to assist in identifying 'possible' sites, and as a contribution to the data bank required for the proper management of waste disposal at county level.

Because the aerial photograph stereo model provides in a single viewpoint details of the site and its surrounding area, it enables the interpreter to rapidly and effectively establish the areal links between site and situation. In contrast the field surveyor can see only small, separate units, and only part of the total surrounding area. While maps, even if they show the excavation, do not record much of the detail listed in figure 6.1.

Perhaps the most striking advantage in using aerial photography for potential tip site surveys, is the speed at which the information can be captured, extracted and mapped.

In terms of data acquisitions, most counties could be flown in a few days - so long as the weather is suitable. It is mainly the weather that causes delay in acquiring county air cover, not the technical problems related to the photographic systems.

The process of data extraction from the photography may be compared with the process of identifying the information from a field survey, and in this activity the difference in the time taken is quite spectacular, with the air photo approach being generally about ten times as fast.

In both air and field surveys the information needs to be transferred to a map. In air survey (photogrammetry) this process requires very little field control, and the mapping is carried out using stereo plotting instruments which range from the simple to the sophisticated.

Here too, the air survey approach is much faster, and although it is difficult to give precise values it is not unreasonable to suggest that air survey plotting is between five and ten times faster than field surveying.

The most significant cost factor in using aerial photographs is whether suitable photography already exists - as in most caes - or whether a special flying programme needs to be undertaken, and paid for.

If suitable photography exists then the total cost of surveying and mapping should be about one quarter the cost of an equivalent field survey.

If a special flight has to be undertaken then the two costs may be about equal, BUT the air cover obtained can be used for a whole range of other surveys - derelict land, natural environments, and topographic mapping - and the photography itself will comprise a good data bank investment.

Yet another, very practical, advantage of using aerial photographs is that the entire operation can be carried out with the utmost confidentiality; without either the permission or knowledge of the land owner, or private companies with a commercial interest in tipping.

The 2nd Land Utilisation Survey of Britain contains in its notation[1] four items which might include potential tipping sites.

2b. The extractive industry which includes e.g. collieries and gravel pits.

2c. Active or abandoned tips and other derelict land.

2d. Public utilities and refuse disposal sites, and

4. Derelict land, which includes bombed sites, disused collieries or railway sidings.

The problem is that it is generally not possible to differentiate potential tipping sites from the various other land uses included in these four elements in the legend.

Although the field work was entered directly on 6" to the mile (1:10,560) O.S. maps, these field sheets are combined in sets of eight, and a double sheet is published at a scale of 1:25,000. Over 3,000 field workers were required to map the 20,000 6" sheets covering Great Britain.

One problem was to ensure that the field workers were consistent with each other in the identification of the units being mapped. The Land Use Survey Handbook[1] gives detailed explanations of the agricultural categories - especially of crop types - but it is not so explicit concerning those categories which include derelict land and the extractive industries, and this is a major source of likely error.

The Land Use Survey Handbook[1] states (page 4) "Much of the value of land use survey depends on the simultaneity of mapping, to give a synoptic picture of the whole country".

It was the original intention to complete the entire survey during one summer. However, this did not materialise, and the practical result is that a 1:25,000 double sheet showing the land use, may have had as many as eight different field surveyors, and the field work may be spread over several years. In contrast a team of about six skilled interpreters using aerial photographs could cope with the land use mapping of a county, and it could well be that the photography could all have been taken during the same week. This situation helps to ensure a high degree of consistency in the data extraction, and that the end product is a synoptic picture of the field situation.

Ordnance Survey maps and plans also purport to show the type, location and distribution of quarries and pits. The types of excavations and amount of detail varies with the different scales and series of maps published.

However, there are some limitations in the information shown on these O.S. maps: only two types of excavation are included in the legend on 1:50,000 scale maps, and four on 1:25,000 (and 1:10,000) scale maps. The excavation site boundaries are only approximate, considerable use is made of symbols, and, except by non-quantitative hachuring, there is rarely any indication of the variation in relief in and around the site.

From the aerial photographs the precise boundary of the site can be determined and a grid of spot heights, or contours, can be compiled, from which the area and volume of the site can be calculated.

The Ordnance Survey has a continuous revision programme to keep its maps up to date. All changes are recorded, and when they have reached a certain level a revised map is published, though it may be several years before the extent of the change has grown to this limit.

Furthermore the revised sheets are based on the 1:2,500 scale (1km x 1km) sheets, so a single 1:10,000 scale (5km x 5km) sheet does not necessarily show the field situation at a given instant in time.

Figure 3.1 emphasises this point, and illustrates the actual situation existing in part of the West Midlands. In this single 1:10,000 O.S. Sheet published in 1970, the dates in which the field work was done range from 1950 to 1968! In contrast the date of the air cover over the same area was September 8th, 1971.

FIGURE 3.1 A COMPARISON BETWEEN THE DATES OF SURVEY FOR AN ORDNANCE SURVEY MAP AND THE EQUIVALENT AERIAL SURVEY.

DATE OF SURVEY DIAGRAM · 1:10.000 OS MAP (1970)

1950 - 67	1950 - 54	1951 - 52		1965 - 66
1951 - 64	1951 - 65	1952 - 64		1954
1951	1952 - 64	1952	1953 - 67	1955 - 67
1953 - 64	1952 - 66	1952 - 68	1953 - 58	1953 - 61
1953	1954	1953 - 67	1959 - 66	1953 - 62

O.S. COMPILATION DIAGRAM FOR A GIVEN AREA

O.S. maps are surveyed one grid sq. at a time, and thus one sheet can have survey dates covering several years

BUT

DATE OF SURVEY DIAGRAM - AERIAL PHOTOGRAPHS

SEPTEMBER 8TH
1971

AERIAL PHOTOGRAPHS GIVE YOU IMMEDIATE COVER OF A LARGE AREA

REFERENCES

3.1 2nd Land Utilisation Survey
Land Use Survey Handbook
Alice Coleman. KRA Maggs.

CHAPTER FOUR

AERIAL PHOTOGRAPHS

CHAPTER FOUR

4.1 CAMERA AND FILM REQUIREMENTS

In order to carry out detailed investigations from aerial photographs both camera and film have to be of reasonable quality. The "Manual of Photogrammetry"[1] lists eighteen factors which are important in the preparation of aerial photography.

1) The lens should be free of aberrations and distortions.
2) The shutter must be efficient.
3) The construction of the camera should eliminate all glare and extraneous light.
4) The plates should be sufficiently flat.
5) The film must be flat at the instant of exposure.
6) Filters should be used to correct the colour and to ensure an even spread of light over the exposed film.
7) An efficient magazine to accommodate the required length of film.
8) The camera should be calibrated in order to obtain the highest efficiency.
9) The camera should be mounted to absorb vibration and to maintain the verticality of the optical axis.
10) The operation of the camera must be perfect.
11) The other recording instruments (e.g. altimeter, date, etc.) must be efficient.
12) The successful control of temperature and humidity is necessary whilst photography is in progress.
13) It is necessary to adjust the exposure to meet the requirements of the flight mission.

14) The emulsion must be fine grained and highly sensitive.

15) Great care and skill is necessary in the processing stages.

16) It is necessary to obtain the correct aperture for the best resolution of the lens.

17) Weather conditions must be considered, and the flight conditions adjusted as necessary.

18) The skill and experience of the crew must be of a high order.

Weather conditions are no longer so limiting as they used to be. The degree of print contrast from the exposed film can now be varied by the use of an electronic dodging process.

4.2 TYPES OF AERIAL PHOTOGRAPHY[2]

Aerial photographs can be used in several forms: either singly or in various combinations, as direct copies from the original negatives or in corrected or partially corrected form.

(i) Simple Photographs

There are a number of different types of aerial photographs which can be classified according to the orientation of the camera axis.

a) Vertical Photographs

Vertical photographs are taken with the camera axis as nearly vertical as is possible; which, in practice, means to within three degrees of the vertical. The regular field of view with vertical photographs means that flights may be designed with about 60% overlap along the flight line and about 30% laterally. This permits full stereoscopic coverage of the entire area photographed. Also, as the geometrical relationships of vertical photographs are less complicated than with oblique photographs, actual measurements can be easily made from the vertical photographs.

b) Oblique Photographs

Oblique photographs are taken with the camera axis deliberately inclined from the vertical. There are two types of oblique photograph, the high oblique and the low oblique. Respectively these are, as their name suggests, taken at a large tilt to include the horizon and at a smaller tilt to exclude the horizon.

High obliques are used in areas of low terrain so that large areas can be covered with a small number of photographs. These photographs are fairly easily interpreted as they closely resemble appearances as if they had been taken from a hill top.

c) Composite Photographs

Composite photographs are made up either by using several cameras, or by using a multiple lens system on a single camera to take simultaneous photographs. These usually provide one vertical and two or more oblique photographs, thus each exposure covers a large ground area.

d) Simple Mosaic (or photo map)

Simple or composite photographs can be joined together to form a photo map. Because of the geometric characteristics of the aerial photograph the resultant map is not very accurate.

ii) Corrected Photographs

These are produced from the original negative but in this process certain corrections are made to reduce or eliminate the geometric errors inherent in aerial photographs.

a) Partially corrected (RECTIFIED)

These are photographs where the three dimensions of tip, tilt and yaw on the photographs are corrected to give a result which contains errors due only to variations in ground relief.

b) Fully corrected (ORTHOPHOTOGRAPHS)

The orthophotograph requires a stereoscopic plotting machine to assist in producing the print from the original photographic negative. The resultant positive is a true to scale air photograph, which has all the details of an aerial photograph, together with the dimensional accuracy of a true plan. Although this is a very useful planning tool it is very expensive to produce.

c) Controlled mosaic (or photo map)

Rectified photographs may be used to compile a partially accurate photo map, and orthophotographs used to compile a true to scale photo map.

4.3 AIR PHOTO SCALE

The approximate scale of the aerial photograph (Figure 4.1) can be obtained by measuring a distance on the photo (d) and its equivalent distance on the ground (D) Scale = $\frac{d}{D}$. However as the two triangles df and DH are similar, then $\frac{d}{D} = \frac{f}{H}$ where f is the focal length of the camera, and H the flying height, above ground level, of the aircraft. This expression scale = $\frac{f}{H}$ holds true only when the camera is truly vertical and when the ground is flat: conditions which rarely prevail. Linear distortions occur when there is tilt on the camera and when there is ground relief. These distortions are not very significant in this study because, except for volume determination, the photogrammetric requirements for site surveys are not very rigorous.

The practical significance of these distortions is that they increase radially from the centre of the photograph, so it is best to use the centre parts only of the photo. This is possible because of the 60% fore and aft overlap which occurs in all normal air surveys.

4.4 AIR PHOTO INTERPRETATION

There are two stages in the process of air photo interpretation. The first is to identify the feature on the photo, and the second is to determine the significance of that feature in relation to the purpose of the study.

To assist in this process the detail recorded on the aerial photograph is considered as being composed of a number of specific features which can be considered separately. These include tone, texture, size, shape, shadow, pattern and location.

i) Tone

The tone of an object is its degree of greyness - from white to black - which produces a grey colour on a monochromatic photograph . It depends on the sun angle and the time of day and year. The angle of reflection of sunlight also plays an important part; thus a body of water can appear as a uniform dark tone on one photograph, and as a speckled tone on the next photograph. This is due to the different angles of reflection of sunlight from the wave surfaces. However tone is a useful indicator and enables the interpreter to distinguish between, for example, a quarry face still being worked - which would be light in tone - with a disused quarry face where vegetation had covered the surface - which would be dark in tone.

ii) Texture

The texture of a photograph is the sum of a number of tonal responses and is usually described in terms of smoothness, or roughness, of the surface of the object. Some quarries contain water and one indicator of this is the existence of an area of very smooth texture in the base of the quarry. This is in contrast to the usually rough, undulating surface of a quarry floor.

iii) Size

Both area and volume are among the more obvious featues seen on the aerial photographs. Knowing the approximate scale of the photograph it is easy to estimate or measure the area or volume of an object. This is significant in the reconnaissance stage of potential tip site surveys to identify those sites which are too small to be included, and in the later stages to determine volumes (i.e. tip capacity) to identify viable, i.e. 'possible', sites from the 'potential' sites.

However, relativity is very important, especially with height. Single storey buildings can look similar to multistorey buildings when veiwed from above, except when compared in height with each other and objects around the buildings, e.g. garages and hedges.

iv) Shape

Shape, from the viewpoint of the air photograph interpreter, is completely different from shape as viewed from ground level. Cooling towers, which have a characteristic "egg-timer" shape when viewed from ground level, appear as a small circle within a larger circle when viewed from above.

When inspecting both size and shape, stereoscopy is very important as it imparts a three dimensional aspect to the photographs. Identification is made much easier than if a single photograph only is used.

v) Shadow

Shadows are an invaluable aid as they provide a profile representation of an object. Electricity pylons are seldom seen on small scale aerial photography as the girders are too thin. However, the shadow thrown by the metal structure can usually be seen.

vi) Pattern

Pattern is created by a grouping of objects on the ground surface. Pattern can either be regular, as in a modern housing estate, or irregular like a river delta.

vii) Location

Location includes both local i.e. site, and regional i.e. situation, and can be described as the spatial relationship between one object and another. Site and situation are often key factors in identifying a feature on the photography. The occurrence of quarries along a river valley floor suggests sand and gravel extraction. Evidence of cooling towers suggests a power station: the occurrence of playing fields encircling a large building suggests a school site. A railway station can be described as a building adjacent to railway lines, within the same boundary limits as the railway lines, often associated with sidings and a service road. Other associated features include a platform, foot-bridges, signal box and paths across the lines.

Although these various features are here considered in isolation, it is generally a combination of these features which is used to identify most of the detail extracted from the photography.

As explained elsewhere in this thesis, the knowledge and experience of the interpreter is of paramount importance when using aerial photographs as the prime source of data. In studies and work connected with the earth and environmental sciences, and of planning, a knowledge of the landscape (both natural and man made) is essential. There are many features of the landscape which are difficult to identify out of context, and without knowledge of the processes which produced those features. One good example is that of field patterns, where the field features vary depending on the particular farming practice in operation.

Aerial photographs should whenever possible be studied with the aid of a stereoscope, as more detailed information can be obtained from a three dimensional image than from a single two dimensional photograph. Changes of slope, unless severe or accompanied by a drastic change of vegetation, are not discernable on a single photograph. The exact location of boundaries is usually quite clear on the three dimensional model. In fact, photo-interpretation from the single photograph is very limited, whereas the main physical limitations on stereoscopic work are the resolution and scale of photography, the type of stereoscope, and the experience of the interpreter.

The usual practice for stereoscopic scanning is to place overlapping photographs under a stereoscope. Some method of extracting information from the photographs has to be used, and consists of either marking detail on the photographs, marking detail on transparent overlays placed over the photographs, or transferring detail directly onto base maps. It is common practice to use a transparent overlay as this gives a permanent record of the information without marking on the photographs.

However, as locational detail has to be marked onto the overlays, to aid location on the base maps, this method does take rather longer than marking the photographs themselves. Any detail marked on the photographs should be lightly marked with a chinagraph pencil, so as not to permanently scar the photographs.

The information should be transferred on to base maps of roughly equivalent scale. Where the aerial photograph base map scale difference is greater than about 1:3 problems often occur in accurately transferring the precise boundary and location of a site.

4.5 STEREOSCOPES

The stereoscope is designed to present the two images, of an area of overlap, in such a way that a single, three-dimensional model is perceived. There are two basic types

i) the lens stereoscope, and
ii) the mirror stereoscope

i) The lens stereoscope (Figure 4.2(i)) is a simple instrument consisting of two convex lenses having a magnification of 2x, mounted about two and a half inches apart on a small frame.

Although this instrument is light, cheap and portable it has a major drawback in that it does not permit the whole area of overlap to be observed unless the photographs are cut or folded back. However it is a widely used field instrument.

ii) The mirror stereoscope (Figure 4.2 (ii)) uses both lenses and mirrors and is designed to view the entire area of overlap without physically disturbing the relative positions of the photographs.

These are manufactured with a variety of accessories, e.g. binoculars (3x and 8x); parallel guide mechanism which permits the whole area of overlap to be scanned without loss of the stereoscopic model; cantilevered support which allows easy access to the photos so that they can be annotated.

iii) The Interpretoscope (Figure 4.2(iii)) is the most expensive, the largest and most sophisticated stereoscope commercially available. It has variable zoom optics which give up to 15x magnification, and the pair of photographs can be viewed stereoscopically even if they differ in scale by a factor of up to 7.5. It incorporates a parallax reading mechanism to enable heights to be determined, and the base is a light table so that both prints and transparencies can be used. This is a highly specialised instrument which is unlikely to be available in the offices of county authorities.

4.6 PARALLAX BAR (Figure 4.3)

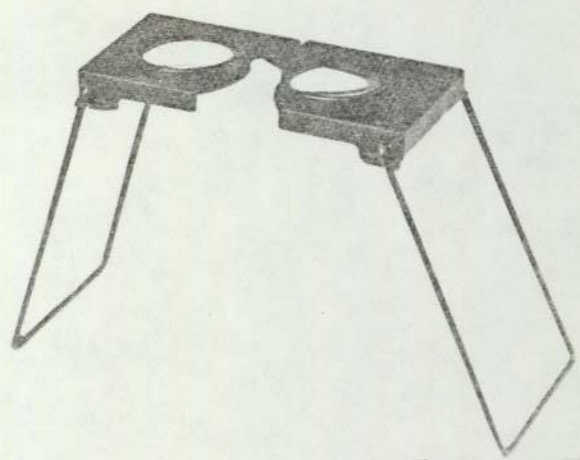
A parallax bar is used with a stereoscope to determine relative height differences, as when measuring the depth of a quarry or the height of a mineral waste tip.

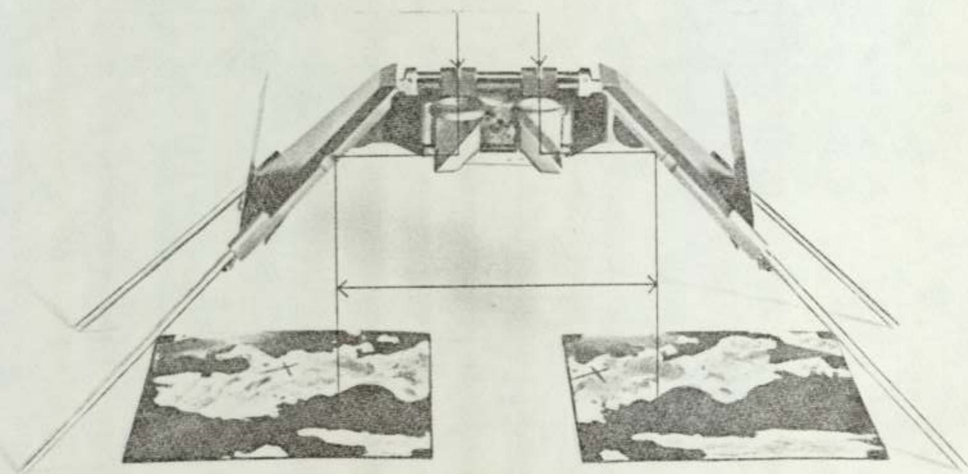
Absolute depths or heights (OD) can be derived if the measurements are related to a point of known absolute height.

This instrument is used for precise measurements of pairs of photographs placed on a flat, horizontal surface, consequently the uncorrected height values obtained will be of low order of accuracy. It is possible to improve the final values but this requires considerable expertise and a substantial amount of ground control. The simple parallax bar methods of heighting give only very approximate results, and is best suited to small scale reconnaissance surveys.

FIGURE 4.1 AIR PHOTO SCALE

FIGURE 4.2 STEREOSCOPES i) Lens
ii) Mirror





FIGURES 4.2 STEREOSCOPES iii) Interpretoscope

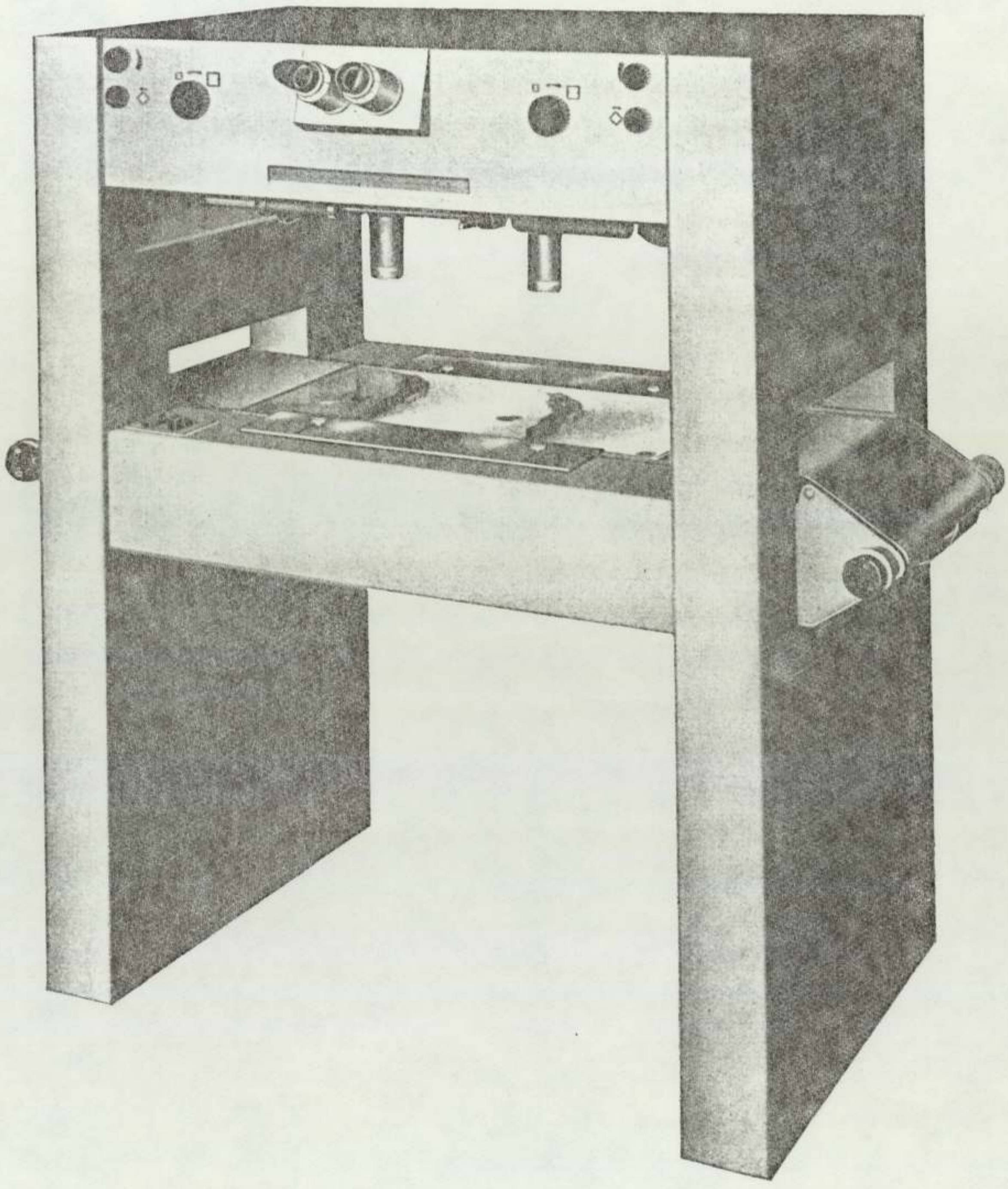
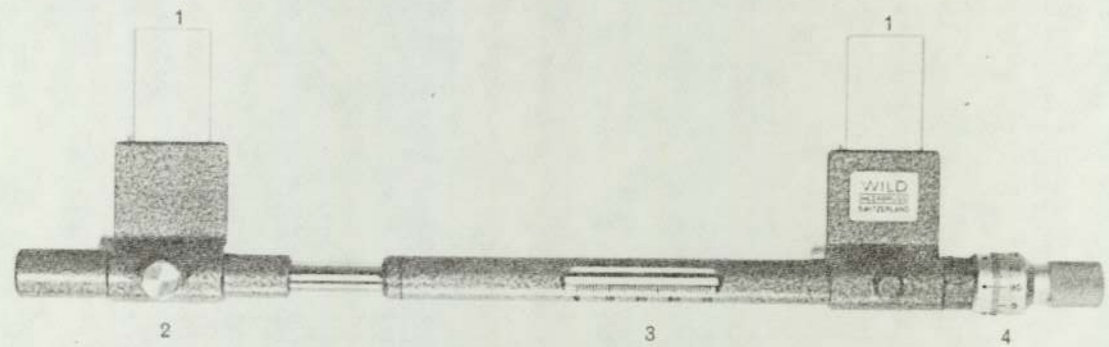


FIGURE 4.3 PARALLAX BAR



1 Removable glass plates with dot, circle and cross marks
2 Thumbscrew of spindle extension (coarse setting)
3 Millimetre scale of spindle
4 Micrometer drum reading to 0.01 millimetre

REFERENCES

4.1 MANUAL OF PHOTOGRAMMETRY
AMERICAN SOCIETY OF PHOTOGRAMMETRY 1974

4.2 MANUAL OF REMOTE SENSING
AMERICAN SOCIETY OF PHOTOGRAMMETRY 1975

CHAPTER FIVE

AERIAL PHOTOGRAPHS AS AN INFORMATION SOURCE FOR THE IDENTIFICATION OF POTENTIAL WASTE DISPOSAL SITES

Page

CHAPTER FIVE

AERIAL PHOTOGRAPHS AS AN INFORMATION SOURCE FOR THE IDENTIFICATION OF POTENTIAL WASTE DISPOSAL SITES

5.1 INTRODUCTION

The aerial photograph serves a variety of purposes. Its two principal functions are

i) as a land/landscape/environmental data bank, and

ii) as a visual illustration.

Both qualitative and quantitative information is recorded on the photographs in that it is possible to determine from them

a) What it is

b) Where it is, and

c) How much of it there is.

Even when using photographs singly a substantial amount of information can be extracted, but for most work adjacent aerial photographs are viewed in pairs under a stereoscope, or in a plotting instrument, in order to reconstitute in miniature a true to scale three dimensional landscape model.

If the photographs are to be interpreted objects must first be detected and identified within the mass of information contained within the photograph. To aid identification it is useful to classify features according to their size, shape, shadow, tone, texture, pattern and location. The accuracy with which features can be identified depends upon a number of variables. These include

i) the scale and quality of the photography

ii) the definition and notation used in the survey

iii) the extent to which the photograph records clues which aid identification, and

iv) the skill and experience of the interpreter.

The main difference between the field surveys and the aerial photograph interpreter is in the orientation of observation: the ground view being horizontal, whilst the aerial view is vertical. Most experience is indirect, as the air photograph interpreter may not come into contact with the features he sees on the photographs, so he is always comparing them, albeit subconsciously, with other features in his experience.

The information extracted from the photography is generally considered as being either quantitative or qualitative: though merely to map a quarry site is both, for it indicates what it is (a quarry site) and its areal extent (its boundary). However for the purpose of this section the two aspects of measurement (i.e. quantity) and identification (i.e. quality) are considered separately.

5.2 QUANTITATIVE ANALYSIS (MEASUREMENT)

i) Areas and Volumes

Areas can be found quite simply by studying the photographs and marking out the horizontal extent of a site on the photograph. The site boundary can then be transferred to a base map and measured using a planimeter, as shown in Figure 5.1.

The determination of volume is a more complicated process and requires the use of a photogrammetric plotter.

The plotter is used to construct an accurate contour plan of the site, together with any detail needed for a full site plan. The volume of the site can then be measured directly off the contoured plan, using a planimeter to measure the area within each contour line, or via a computer printout. Each contour interval is summed and multiplied by the average contour separation. Figure 5.2 shows a photogrammetric plotter - a Wild A7.

Accuracies of up to between 90% to 95%, in volume, can be obtained using aerial photographs. The more irregular the site shape and relief the lower the accuracy, which can fall to 90% for a very irregular site. The contour interval for the plan depends on the photograph scale and varies from one foot at 1:3000 scale photography, to five feet at 1:10,000 scale photography.

As well as determining the volume of the existing excavation, it is possible to calculate, and therefore forecast, what the volume of the quarry is likely to be when it reaches the excavation permission boundary. The latter calculation requires assumptions regarding maximum permitted extent of the site, the degree of slope of the sides and the final average depth of the excavation. Figure 5.3 shows an existing contour plan, and figure 5.4 illustrates a final proposed contour plan for when excavation reaches its maximum permissible extent.

When calculating the volume of a site it is essential to know the final level and form of the fill. Whether, for instance, the fill will tie in with the existing ground levels or even be raised to form a new landscape form, as shown in figure 5.4.

The main advantage of using photogrammetric methods for compiling site plans and determining volumes is that it is both quicker and generally at least as accurate as ground survey. In a ground survey the contours are compiled by interpolation between spot heights, whereas in photogrammetry the true ground contours are plotted directly on to the three dimensional ground model, viewed in the plotting instrument.

Where a large number of sites are being surveyed at a reconnaissance level it would obviously be uneconomic to subject all of them to the accurate determination of volume but it is possible to derive a very rough estimate of the volume of each hole. This can be done by obtaining a figure for the average depth of a hole from several parallax bar measurements within the site. The surface area of the site can then be measured from a base map, onto which the information has been transferred, and multiplied by the average depth. Another method, which is even more accurate, is to multiply the area by half the maximum depth of the site. These last two methods of estimating volumes are obviously inaccurate and should be used to obtain approximate volumes only.

ii) Distances

Owing to the nature of controlled tipping and the problems encountered from variable weather conditions, certain hazards are liable to occur. Significant factors in assessing likely hazards are, amongst others, the distance of the site to the nearest water course, and the distance from the site of any housing or settlement.

The measurement of distances directly from photographs involves certain inaccuracies. The gross error which would be found around the edge of a photograph with the maximum allowed tilt of five degrees would only be about 0.4%. This error is not large enough to be significant, bearing in mind that ground survey is most unlikely to be more accurate.

Distortion due to relief also occurs. This is caused when the photograph is taken,as areas of high relief are nearer to the camera than areas of low relief. As noted previously the photograph scale is inversely proportional to the flying height and so as the flying height above ground level changes due to differences in relief, the scale will also change.

iii) Housing densities

It is desirable for several reasons to carry out housing density counts along roads leading to the sites and along routeways likely to be used for haulage from refuse collection points. The best route being one which combines the shortest distance of haulage along acceptable routes, with one which involves disturbance to the smallest number of people. It is also necessary to have an idea of the widths of roads leading to a site. This information can also be easily obtained from aerial photographs.

For a housing density count one method is to count the number of houses along each road and then to give a density for each road or part of a road.

5.3 QUALITATIVE ANALYSIS (IDENTIFICATION)

i) Site accessibility

It is possible to derive,from the aerial photographs, the number of roads and tracks giving access to a site. Depending on the scale of the photography, information on the condition and width of the access roads or tracks may be ascertained. Precise widths cannot be measured at scales smaller than 1:10,000; neither can the exact condition of the road surface be determined. Scales of 1:5,000 or 1:3,000 would be the most useful, and it would be difficult to obtain this particular information from scales smaller than 1:10,000.

ii) Assessment of screening

Because the landscape is being viewed from above, rather than at ground level, only an approximate guide can be obtained, relating to existing and possible screening requirements from any particular vantage point. This total overview from above does have its advantage in that the site can be assessed as a coherent unit. Selected spot heights and slopes can be determined, and the volume of any available cover material, top soil dumps and spoil heaps, for example, can be calculated.

iii) Standing water

Pumping water from a potential disposal site is expensive and so it is necessary to locate sites where the base of the site is not below the water table.

The presence of standing water and its extent can be easily observed. The level of water in separate water bodies can be an indication of the type of water involved as shown in figure 5.5. If the levels are similar it is probable that the water is due to the site base being below the water table. Rainwater ponding would show different levels, depending upon the depth of each basin. It would be impossible to obtain more detailed information from a site visit without recourse to the very expensive business of boreholes. To obtain the same degree of information from a site visit, levelling would have to be carried out - which is a rather time consuming process.

iv) Site use

Whether a site is in use or not can generally be determined if certain features are evident. These include the presence of machinery, plant or vehicles, the condition of the quarry face, the extent of vegetation cover and the state of access roads. The quarry face, when still in use, usually has a white tone. This is probably due to the high reflectivity of fresh rock faces, whereas weathered rock surfaces have a darker tone, resulting from crumbling, mosses and lichens.

The state of preservation of buildings can also be an aid, not only in determining if a site is still in use, but also in determining if essential services such as electricity and water are still provided. An active or only recently disused site will be provided with both water and electricity.

The scale of the photography has much to do with the amount of 'use', 'non use' information obtainable. At 1:10,000 scale and the larger 1:5,000 and 1:3,000 scales, this is more readily seen. If the buildings are in a good state of preservation they could be used as garages for vehicles and as shelters for the workmen involved in tipping.

v) Drainage

The drainage can be most easily observed by reversing the positions of the overlapping photographs underneath the stereoscope. Relief is then reversed (psuedo-imaged) and even very minor drainage channels show up as ridges, which can be accurately mapped. The scale of the photography has very little effect on this information, the main restriction being that in urban areas where the drainage pattern is often obscured by land being levelled for building purposes and water channels being culverted.

Culverting is often necessary in waste disposal schemes, and as the length of water channels running through a potential site or diversion can be measured, estimates of the amount of culverting or diversion can be made. This helps in the comparison of costings for different sites.

vi) Geology

It is very important to know the geology of a site from the refuse disposal point of view. In many cases a Waste Disposal Authority will have access only to 1" Geological Survey maps, which do not give enough detailed information about each site. The West Midlands Survey area was covered, to a large extent, by the Carboniferous Coal Measures. From the 1" G.S. maps it was not possible to identify individual shales, sandstones and limestones. The geology of a site could be identified by this method as being, for example, a Carboniferous Coal Measure clay or shale.

Because larger scale geological maps i.e. 1:10,000 scale, are not readily available, some information has to be extracted from aerial photographs. Extracting geological information from aerial photographs cannot be carried out without the aid of geological survey maps. Aerial photographs will yield information on rock type, but not which horizon the rock belongs to. For example, a quarry may be identified as a clay quarry from the photographs but a geological survey map will show whether it is Gault or Kimmeridge Clay, Etruria Marl, Keuper Marl or a superficial clay deposit.

The aerial photograph will not by any one easily identifiable factor show the geology of a site. Instead a whole range of features needs to be studied, some of which are attributable to several different rock types, such as the shape of the hole, machinery, spoil heaps and the presence of water.

In some cases, the mineral being extracted from a quarry can be identified from aerial photographs, for instance most sand and gravel quarries have some form of conveyor belt leading up to a tower or sand hopper in which the sand is either stored, or loaded into lorries. In many cases small heaps of sand and gravel lie dotted around the site. The site is also usually shallow and found on valley floors. However, sand is also extracted from Terrace deposits, away from valley floors. These sites can be fairly deep and are nearly always dry.

Another means of identification is the shape. Sand and gravel pits are usually of regular shape, determined primarily by the boundary of planning permission and not so much by the geology and quality of the material being extracted. Thus the average sand and gravel pit has either straight or curved sides, many being square or rectangular, especially the Terrace Gravel deposits.

Most sand and gravel pits are waterlogged as their material is extracted from below the water table. In such cases,where still in use, small mechanical excavators or drag lines can be seen. In large pits barge hoppers are used to transport dredged material from where it is being excavated to the storage site. (The shape is again regular, consisting of straight or curved sides). Often the water bodies form a mosaic over the base of the area being worked. Typical terrace and valley sand and gravel pits are shown in figures 5.5 and 5.6 respectively.

Clay sites have few distinct identification features. They are usually much deeper than sand and gravel pits but can have either regular or irregular shapes. The problem is that clay can be won from several different rock types. They can be Coal Measures or Triassic marls, Fireclays, Cretaceous or Tertiary clays. Many of the more recent Tertiary clays are fairly uniform in thickness and composition. These less lithified clays have quarries which are usually deep, with regular, mainly rectangular, shapes. They are usually dry, but when working ceases fill up with rain water.

The older more lithified clays such as the coal measure clays often have less regular shapes, as the mineral extraction is determined by the fault pattern and by the various sandstone horizons usually occurring within the clay. For the same reason water bodies within these irregularly shaped pits are usually irregularly shaped.

Most extensive clay pits when in use or recently disused have fairly extensive works associated with them. These works are associated with either brick, pipe or tile manufacture, having chimneys and kilns with the buildings. The kilns often show a characteristic shape, rather like modern power station cooling towers, only on a smaller scale. Piles of bricks, pipes or tiles can also be seen stacked around a working clay pit.

One of the main problems with both sand and gravel and clay pits is multiple use. Superficial deposits of both sand and gravel and clay can be worked before the bed-rock is extracted. This often happens where valley gravels cover extensive clay deposits and in the Coal Measures where clay can be extracted prior to, and during, open cast coal working. Another characteristic of sand, gravel and clay workings is that there is very little waste material. Examples of clay pits are shown in figure 5.7.

The identification of opencast coal mining is much easier than the other types of mineral extraction. The most obvious detail of an open cast site is its size and depth. Although some sand and gravel workings can cover a similar area they are totally different in depth, method of working and shape. Open cast is also very distinctive!

Large drag lines are used to excavate the material, which is loaded into huge 45 ton dumper trucks. Considerable piles of spoil are usually in evidence around an opencast site, as are smaller areas of coal storage. Because opencast coal sites are usually short lived, the large areas of railway sidings, characteristic of deep mining, are absent. Because opencast mining is so short lived and the sites so large and obvious, reclamation is compulsory. Opencast mines in the process of being reclaimed are characterised by the presence of graders and scrapers and the slopes into the base of the workings are patterned with the wheel tracks of the grading machines. An example of an active open cast coal mine is shown in figure 5.8.

Quarries in other rock types are less easy to distinguish as the rocks are all massive and well lithified. Although limestones, sandstones, quartzites and igneous rocks are in general impervious to water little water is usually evident as these rock types are well jointed, thus enabling rain water to escape through the fissures and joints. These rock types are all subject to various degrees of faulting and so will show irregular shapes.

Most workings are for roadstone and other aggregates and thus have similar machinery. Limestone, worked for cement, lime and crushed aggregate, can be more easily identified by the presence of crushing machinery and piles of fine material, similar to that found with sand workings.

Rock quarried for aggregate or building stone will show piles of the processed material within the quarry. Crushing machinery is also used to create aggregate. Such quarries are becoming increasingly larger in scale. The plant necessary to process the raw material is highly capital intensive and requires a high throughput. The type of machinery associated with hard rock quarries is similar to that associated with sand and gravel quarries, the end products being similar, but usually larger in size. A hard rock quarry, in a metamorphic quartzite, is shown in figure 5.9.

It is quite often difficult to distinguish disused hard rock (limestone, sandstone, quartzite etc.) quarries from disused clay quarries. Both types can be deep and irregular in shape. The only indication may be that the clay quarry is likely to contain much more water.

vii) Water pollution

Perhaps the most important factor governing the use of a site for refuse disposal is the question of ground water pollution. Whereas the localised pollution caused by wind blown debris and traffic generation is shortlived, lasting up to several years at the most, ground water pollution is rather more persistent and difficult to combat. Determining whether a site is liable to pollute water bearing strata underneath it is a very expensive operation and is seldom carried out except in extreme cases where toxic liquids are to be disposed of.

Some of the earliest investigations of ground water pollution problems were carried out at Egham.[2] The results showed little persistent pollution where domestic refuse was tipped directly into water which was being aerated. However, in recent years very few studies have been made of ground water pollution from refuse tips in this country! Most of the work in this field has been carried out in the U.S.A. Several investigations of tipping sites in the U.S.A. showed lechates immediately underneath the tips which had concentrations as much as 100 times stronger than raw sewage. The lechates improved as they moved downwards through 12ft of unsaturated soil with the Biological Oxygen Demand reducing by 95%, however, the lechate was still stronger than raw sewage and could cause serious ground water pollution. Tipping directly into ground water was found to produce lechate of identical composition and characteristics as that produced by tipping at levels above the ground water. One of the main points raised by these studies was that under natural conditions the lechates will not be sufficiently improved, in moving through subsurface earth material before encountering the ground water, to prevent ground water pollution immediately below or adjacent to the tip.

Suggestions were made of methods to control pollution problems:-

a) To site tips in areas where there are large volumes of ground water flow thus giving dilution of the lechate to reduce its concentration below harmful levels.
b) To hydrologically isolate the tip from the tipping site and to treat the run off created. This can be

done by tipping into dense shales or clays.

c) To line the base and sides of the tipping site with impermeable material, such as asphalt or butyl rubber sheeting, above a soil cement and then to treat the lechate product using a policy of natural treatment is unadvisable in conditions where tipping is situated as near as possible to refuse generation points in urban areas. Therefore some form of treatment should be envisaged, either diverting run off into an already existing treatment plant or building a treatment plant on the site of the tip. It has also been suggested that by bringing a tip up to field capacity (field capacity is the amount of water that can be retained indefinitely against the action of gravity), lechate generation can be reduced. Field capacity can be attained artificially by recycling treated lechate back onto the tip surface.

It is important to know which rock types are reasonably safe to tip onto. However, the problem with detailed hydrogeological site investigations is the cost and accuracy. When tracing water movements around a site it is possible to sink a borehole in one position and not find the tracer, yet another borehole, only a few yards from the first one, could yield tracer in appreciable quantities.

The rock property which predominantly controls the movement of water through the rock is its permeability. The permeability of a medium refers to the ease with which a fluid will pass through it. However, a lithified rock has, besides its own permeability due to its rock type, a secondary permeability caused by its lithified nature. This secondary permeability is governed by the joint and fault structure and solubility. Thus limestone which has a low permeability due to its massive nature also has a high secondary permeability due to its well jointed character and solubility.

It is possible, by using geological maps, memoirs and water memoirs to gain some indication of whether tipping is advisable. The rock systems of a region can be divided into three broad categories:

1) A rock type onto which tipping is safe
2) A rock type onto which tipping requires site treatment
3) A rock type onto which tipping requires an uneconomical amount of site treatment.

It is not intended that hydrogeological data gathered in this way should be anything more than an initial approximation. However, the information can be used as a guide to work out the approximate value of a site for waste disposal. Detailed hydrogeological investigation, together with consultation with local Water Boards, can be undertaken for the sites which are selected for further investigation.

Figure 5.10 shows the flow characteristics of a few rock types[3], and if the flow characteristics can be used as an indicator, it can be seen that the clear gravel and sands are unsafe to tip onto. However, sand and gravel act as filters and so any percolates caused by tipping could be contained in such a tip.

Another factor which governs the movement of percolates is the saturation of the rocks underneath and surrounding a site. Unsaturated flow is the result of gravitational and capillary forces and is at a lower rate than saturated flow.

The information shown in table 5.1 has been taken from the Geological Survey Memoirs "Wells and Springs of Warwickshire" 1928[4], and shows the amount of information that can be obtained from this source.

It can be seen from the table 5.1 that the best rock types for tipping are the Cambrian Quartzites and shales, the Etruria Marl, the Keuper Marl and the Lias. Information on specific boreholes is also given in the Memoirs and could be of interest when dealing with a particular site.

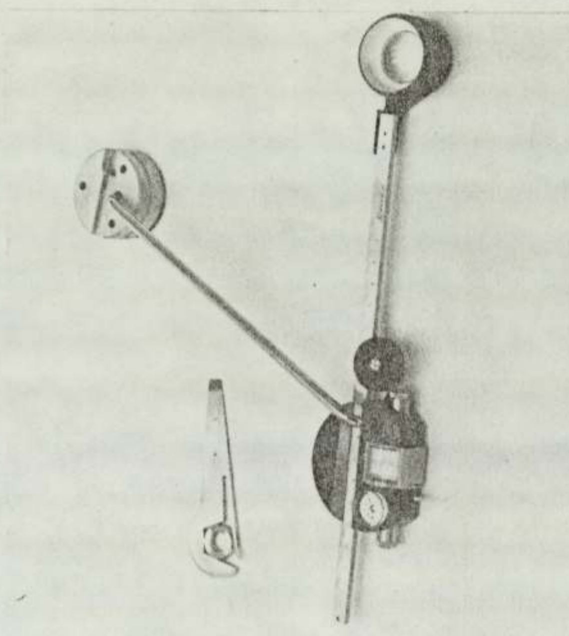


FIGURE 5.1 A PLANIMETER

FIGURE 5.2 A PHOTOGRAMMETRIC PLOTTER - WILD A7

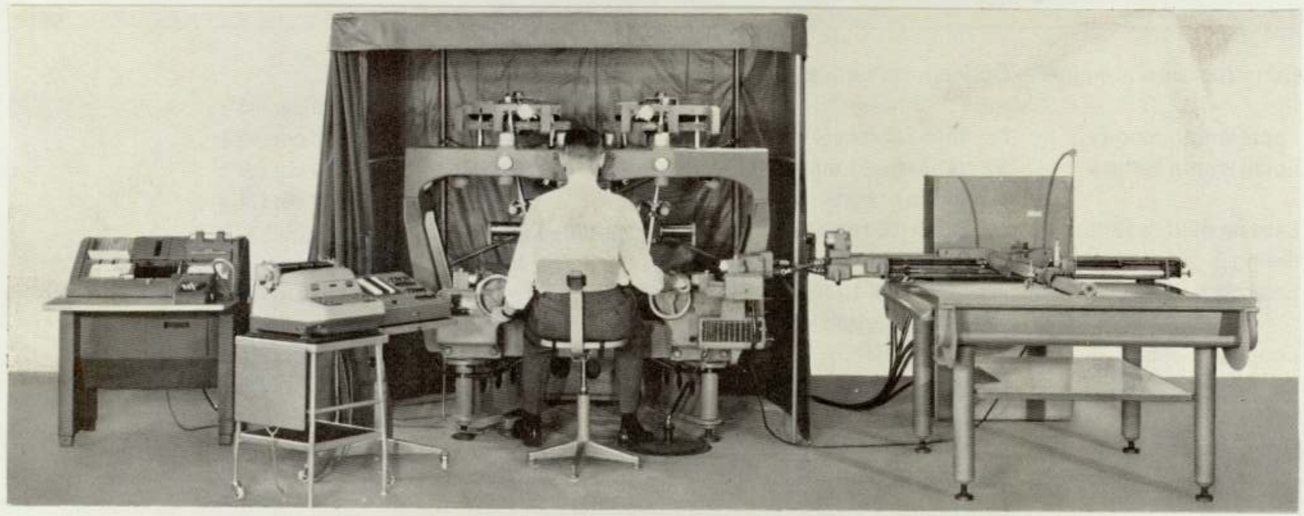


FIGURE 5.3 CONTOURED PLAN OF EXISTING SITE.

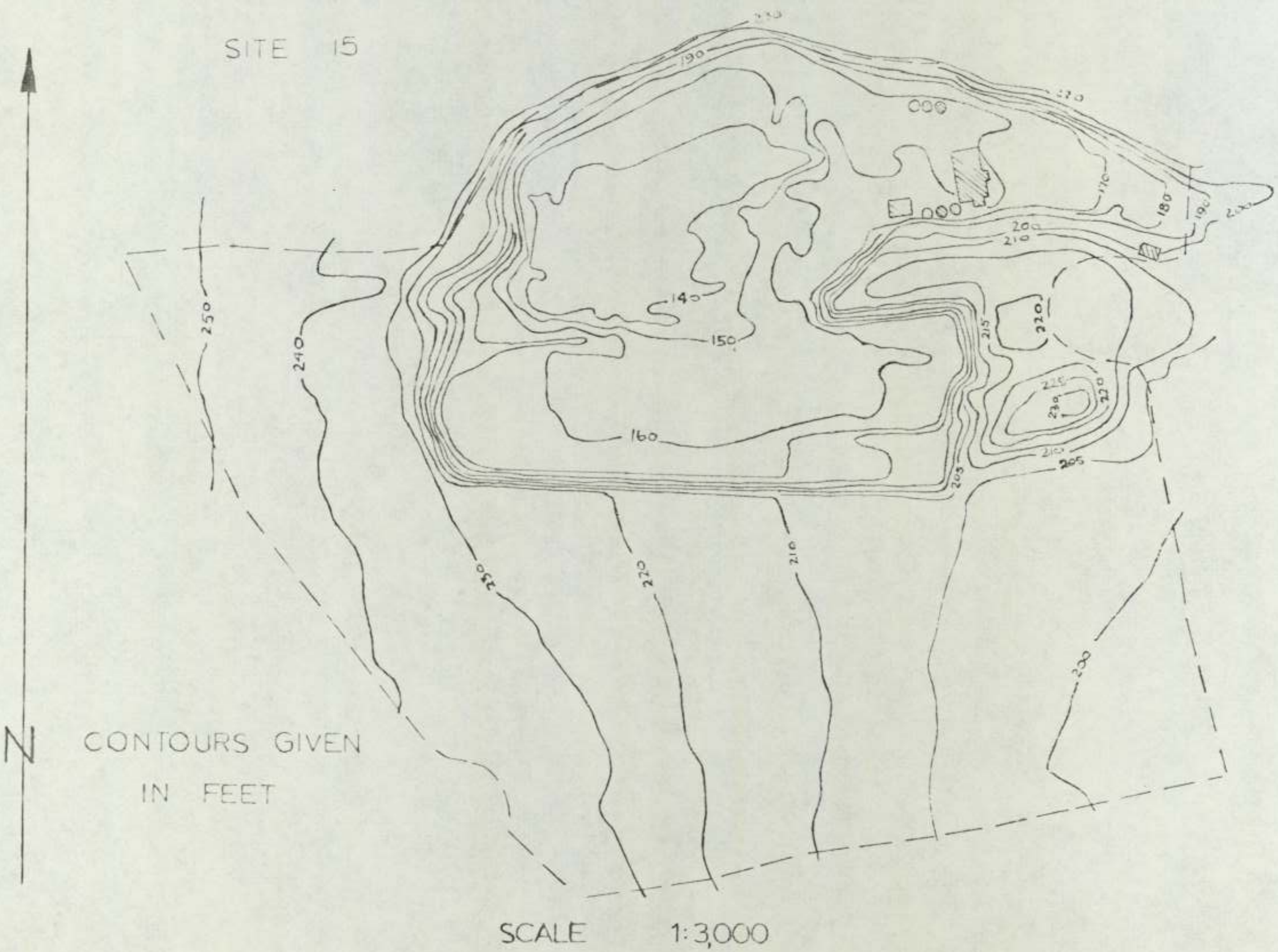
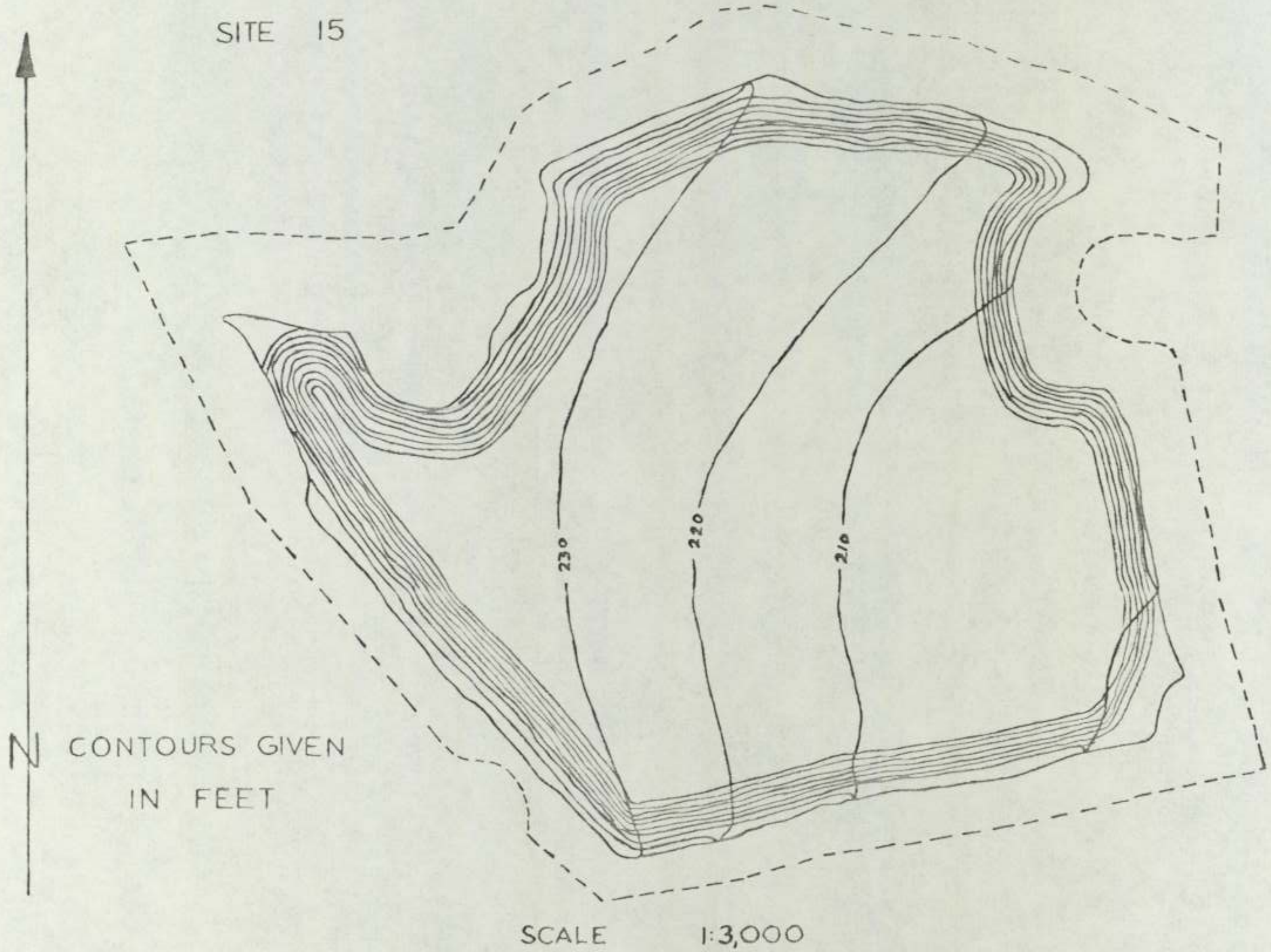


FIGURE 5.4 CONTOURED PLAN OF MAXIMUM PERMISSABLE EXTENT OF SITE.



Proposed excavation to 45° slope & 100 yards from permission boundary

FIGURE 5.5 A TERRACE SAND AND GRAVEL PIT.
(Ground Photograph Showing Detail From Aerial Photograph) 134.71 016

The level of water in lagoon A is 3 metres above water level in lagoon B (vegetation clearly shows water level usually higher). The water bodies shown are clearly not dependent upon a water table and are therefore standing water, due to rainwater ponding.

FIGURE 5.6 A VALLEY SAND AND GRAVEL PIT
(Now Used for Recreational Purposes). Aerial Photograph 115.71.143

FIGURE 5.7 A DISUSED CLAY PIT IN A COAL MEASURES CLAY.

The photographs show an irregularly shaped water body within an irregular excavation. Aerial photograph 140.71.094.

FIGURE 5.8 AN OPENCAST COAL SITE.

The buildings on the lower photographs show the scale of the workings.

Aerial photograph 140.71.098.

FIGURE 5.9 A SANDSTONE (QUARTZITE) QUARRY

The lower photograph shows an example of a type of crushing machinery, in this case mobile, commonly used.

Aerial Photograph 1.681.6829.

FIGURE 5.10 PERMEABILITY OF DIFFERENT CLASSES OF SOILS.

Specific permeability, k, darcys

10^5 10^4 10^3 10^2 10 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5}

Soil class	Clean gravel	Clean sands; mixtures of clean sands & gravel	Very fine sands; silts; mixtures of sand, silt and clay; glacial till; stratified clays, etc.	Unweathered clays
Flow characteristics	Good aquifers		Poor aquifers	Impervious

10^6 10^5 10^4 10^3 10^2 10 1 10^{-1} 10^{-2} 10^{-3} 10^{-4}

Laboratory coefficient of permeability, K_s, gal/day/ft^2

Table 5.1 SIMPLE HYDROGEOLOGICAL DATA.

A. Superficial Deposits

Boulder Clay	-	largely impermeable
Sand and Gravel	-	very good aquifer

B. Jurassic

Lower Lias	-	impermeable
Middle Lias	-	largely impermeable
Upper Lias	-	impermeable
Oolites	-	permeable

C. Triassic

Pebble Beds	-	good aquifer
Upper Mottled Sandstone		
Lower Keuper Sandstone	-	one of the best Midlands aquifers
Keuper Marl	-	largely impermeable

D. Carboniferous - Middle Coal Measures

Basal sandstone and conglomerate	-	good aquifer
Etruria Marl	-	little or no water
Halesowen Group	-	important aquifer
Keele Group	-	lower sandstones are water bearing and the surface is very permeable, due to weathering.

E. Cambrian

Quartzites	-	well jointed and carries water in the joints, especially around quarries. The rock itself has a low permeability and serves only as a water supply to small domestic properties.
Shales	-	Very poor aquifer with a high sulphur and iron content.

REFERENCES

5.1 Economic Advantages of using Aerial Photographs for Mapping Potential Waste Disposal Sites: Ballam and Collins, p485-495, Solid Wastes, Vol. LXV No. 10, October 1975.

5.2 Controlled Tipping of Refuse: R.E. Bevan: Inst. Public Cleansing: 1967.

5.3 Groundwater Hydrogeology: Todd.

5.4 Wells and Springs of Warwickshire: Geological Survey of Great Britain: 1928.

CHAPTER SIX

SURVEY METHODOLOGY

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SURVEY METHODOLOGY

6.1 INTRODUCTION

The work for this thesis was involved with two county wide surveys. The first was intended to be a purely reconnaissance survey of the County of Surrey, entailing the location of mineral excavation sites only. Ninety nine sites, many of which were flooded gravel pits in the Thames Valley, were located and mapped.

The second, much more rigorous survey, was carried out in the West Midlands and comprised a survey for derelict and spoilt land within the new West Midlands Metropolitan County area, together with a waste disposal site survey extending up to five miles outside the County area.

The extra area was surveyed because waste disposal is not just a county-wide problem, it is a regional problem and one which does not recognise County boundaries. It may be necessary in order to reduce costs for several Waste Disposal Authorities to combine, within a recognisable geographical boundary, where tipping site surveys and site use are concerned. Information gained from the West Midlands survey will obviously be of use to the three surrounding Counties. However, the problem of competition probably means that the information would not be divulged until after the West Midlands County Council had allocated its resources and applied for planning permission to tip.

The West Midlands was chosen as it was an urban area with a tradition of mineral extraction associated with industry. This is quite distinct from the rural and suburban/commuter areas within the County of Surrey.

The first stage of both surveys involved obtaining the aerial photographs, and an aerial photograph search was carried out using the Department of the Environment Air Photograph Library and the commercial companies to locate and select the most suitable recent cover. Unfortunately complete air cover at one date did not exist for the whole West Midlands survey area. Indeed, it did not exist at all for some sections of the survey area. After details of the various flights had been uncovered, the photography had to be acquired from the various organisations involved and a contract awarded to fly the areas not covered by existing photography. The photography used ranged from 1971, 1:12,000 scale to 1973, 1:5,000 scale. The organisations which were found to have air cover were:-

The Midlands Road Construction Unit
The National Coal Board (Northern Division)
The City of Coventry Planning Department
Huntings Surveys Ltd.
Meridian Airmaps
Fairey Surveys Ltd.
Storey Surveys

In the light of experience gained working on 1:12,000, 1:10,000, 1:5,000 and 1:6,500 scale photography; 1:10,000 scale photographs proved adequate for most purposes. However, most of the photography was at a scale of

1:12,000 and on these derelict and despoiled land sites could be identified down to sizes of 1/4 to 1/8 hectares; much less than the minimum survey unit of 1/2 hectare used in the surveys. At smaller scales of, say, 1:5,000 it was easier to identify sites, but one had to deal with over four times as many photographs than at the 1:12,500 scale. For most derelict land or waste disposal purposes, 1:12,500 scale photographs provide adequate information. There is also the point that visual impressions are improved when sites are viewed on a single stereo overlap, and that volumetric measurements are cheaper as fewer overlaps are required to contour individual sites. Also 1:2,500 scale plans and 1:25,000 maps can be easily prepared from 1:12,500 scale photographs.

6.2 METHODOLOGY

The map bases used for recording the survey information were the Ordnance Survey 1:10,560 and 1:10,000 scale maps. Unfortunately the survey was carried out during the O.S. metrification scheme and so the maps used were a mixture of both scales. It would have been advantageous to have commissioned a full set of 1:10,000 scale maps from the O.S. as having two scales of maps caused difficulty in matching up the edges of adjacent maps.

To enable the easy reproduction of the survey information, transparent overlays were made up, complete with title, scale, key and grid lines, to fit over the base maps. The information could then be transferred directly onto the overlay from the photographs without any confusion with the detail on the map bases. The overlays could be quickly reproduced with a dyeline printer, either in transparent or paper form.

The method of recording information during the Surrey survey was to trace the detail from the photograph onto a 9"x9" clear plastic overlay and then onto the map overlay. This can be a lengthy process as locational detail has to be recorded on the overlay in order to locate information on the base map. Even with marking locational detail onto the 9"x9" overlay it is often necessary to refer to the photograph when transferring information to the map overlay. Therefore, in order to save time on the West Midlands survey, site boundaries were recorded on the photographs with a chinagraph pencil (which is easily removed) and then, when an overlay was completed, the information was transferred directly onto the map overlay. The two main problems encountered with this method was that unless it was very thin the chinagraph pencil line tended to obscure the boundaries of sites on the photographs and it proved difficult to ensure that the pencil point was fine enough.

As the survey requirements laid down a minimum size of area to be recorded, and because the method of survey identified sites of much smaller extent than that stipulated, all boundary information was initially recorded on the map overlay with a blue pencil. A blue pencil was used so that sites which were larger than the minimum stipulated, measured from the map survey, could subsequently have their boundaries inked in black. In the reproduction process, the blue pencil lines are not reproduced and only the black lines appear. This had the effect of filtering out undersized sites. Unfortunately this method of reproduction has become rather expensive as the cost of the transparent material has rapidly increased but no alternative offers as much versatility. Another method of recording information would be to copy the detail directly onto a map base. This method would be suitable where one copy only of the information was needed, as reproduction is difficult. A photographic method of reproduction can be used but there is so much detail on the map that confusion can result. At this stage there was considerable discussion between the author and the County Authorities in an effort to compile a suitable notation for the two surveys.

The information retrieved from the photographs was tailored to the needs of a derelict land survey and for a reconnaissance survey of the potential sites for waste disposal.

Speed was an important element of the survey which necessitated using only the information obtained from the photography. The Local Authority concerned based its requirements on the list of items they had been told could be obtained from the photographs. Close consultations were maintained and thus many of the pitfalls of earlier surveys were avoided.

One prime cause of these pitfalls was where the body requiring the study or survey had not adequately defined the data to be collected.

In one instance an authority required the precise areas of all derelict and despoiled land, and had included in the notation a class for spoil heaps, and another for excavations - all to be measured. But they had not indicated whether the quite substantial areas of degraded land associated with heaps and holes should be included in the measurements. This resulted in some surveyors including the degraded land with the heaps, some with the holes, some with both and some with neither! These results could not be usefully aggregated or compared.

6.3 THE SURVEY SCHEDULE

The information required for the survey is given below and includes that required for both the potential waste disposal and derelict land site surveys. The information was recorded on a form (figure 6.1).

1. Map number. Each site number.
2. Geocode - four figure grid reference.
3. Road name or other local named feature.
4. Area of site.
5. Type of Dereliction

    a)...... Spoil Heaps
    b)...... Excavations and Pits
    c)...... Military and other Service Dereliction
    d)...... Disused Rail Land
    e)...... Disused Sewage Works and Installations
    f)...... Disused Waterways Land
    g)...... Neglected Waste Land
    h)...... Other

6. Tipping Site

    a)...... Yes
    b)...... No

7. Area of Demolition

    a)...... Yes
    b)...... No

8. Use or Disuse.

   a)...... Site in Use (last previous use)

   b)...... Site Disused

9. Wet or Dry (excluding stream, drain, river or canal)

   a)...... Water present on site

   b)...... Water not present on site

10. Buildings on Site.

    a)...... Yes

    b)...... No

11. Vegetation Type and Cover - Top Figure refers to extent of vegetation cover.

    a...... 0 - 10% cover

    b......10% - 50% cover

    c......50% -100% cover

    Bottom figure refers to dominant vegetation type

    t...... trees

    s...... shrubs

    g...... grass

12. Surrounding Land Use.

    I...... Industrial

    R...... Residential

    O...... Other

    Multiple use given when necessary

13. Geology.

    3...... Clay, Shale and Marl

    4...... Coal

    6...... Igneous Rock

    8...... Limestone

    9...... Sand and Gravel

    10...... Sandstone

14. Number of Access Points over 4m in width - holes only.

    * Complete access referred to as α

Figure 6.2 illustrates items in the above schedule including neglected waste land, disused canal and a demolition site. Other features include an open cast coal mine, various disused quarries and waste disposal sites.

Several problems were met with in using this schedule, the initial one being that everybody seemed to have their own definition of derelict land. The definition adopted for this survey was 'Any piece of land that was unmanaged',and included not only isolated tracts of waste land, but also land that looked unused even though it appeared attached to factories, offices and houses. This definition itself leads to problems when considering neglected waste land in the rural as against urban background. A parcel of neglected waste land in an urban area is relatively easily discerned, but place that same piece of rough pasture in a rural area, and difficulty is found in differentiating it from a piece of rough pasture used for sheep grazing or cattle grazing. So, for the purposes of this survey neglected waste land was treated exclusively as an urban or semi-urban feature.

Other problems were met in classifying a site as being either used or disused; this applied mainly to quarries where an after use was concerned. For the purpose of the survey the use/disuse category was used to describe the most recent use of the site. Obviously an extra category for previous use should have been used, i.e. quarry with infill (domestic refuse), rather than be recorded simply as a quarry or waste disposal site.

Two of the Local Authority requirements were to identify disused British Rail and disused British Waterways land, but these two requirements entail knowledge of ownership, and this aerial photographs cannot give. Further problems were met with in deciding whether rail or canal networks were actually disused. This could be important as the infill of railway cuttings and canals could provide useful waste disposal sites. The only way to identify disused canals is to observe whether they are infilled. It is difficult to classify as disused, a canal which is not filled in. It is possible, given the right lighting conditions and 1:5,000 photography, to note the canals choked with vegetation. However, such vegetation may be floating and it is possible for pleasure craft and even transport barges to use such a waterway. Such classification would be equally as difficult in a ground survey as with an aerial photograph survey.

Railway disuse is somewhat less difficult. The track can be easily identified except where hidden in a cutting, or by shadow, and often bridges are removed. However, if the track and bridges have not been removed, it may be impossible to identify disused rail land, although noting the presence of rolling stock is also of some use.

Yet another problem occurred when dealing with vegetation; here, the information obtainable from the photographs was much more detailed than that required by the Local Authority. A classification of how much vegetation occurred on each site was required. Instead of equal three part division into 0-33%, 34% to 66% and 67% to 100%, it was decided that a division into categories covering no or very little vegetation cover, full or nearly full vegetation cover and an intermediate division, gave a more significant picture of the site. Thus the divisions finally chosen were 0-10%, 10%-50% and 50%-100% cover.

The survey was also required to show the dominant type of vegetation on each site, with trees, shrubs and grass taken as the main vegetation types. Here one meets the problem of the difference between the physical dominant type and the aesthetically dominant type, both of which can be observed from the aerial photograph. The physical dominant vegetation type, the observation chosen for the survey, is easily defined as the vegetation type which covers the largest part of the site: although the vegetation canopy is recorded on the aerial photograph. The problem with this definition is that different observations would be made if the photographs were taken in summer, than if they were taken in winter. If this definition were to be strictly adhered to in detailed ground survey, then it is likely that almost all sites would be classed as having grass as the dominant vegetation type. The aesthetically dominant type of vegetation on a site can be defined as that vegetation type which is visually dominant as viewed from outside a site.

This is probably the observation that would be made for a ground survey, whereas a quick survey from a car would result in a site being viewed from outside. The whole of the site could be obscurred by trees or bushes, except for the small observed section: thus the site description could be incorrect.

There is a need here, in order for the full picture to be given, for two observations. One observation of the physically dominant type of vegetation and another observation of the visual aesthetic dominant type of vegetation.

The final problem in the survey schedule was that of surrounding land use. The requirements of the Local Authority was for the surrounding land use to be given as Industrial, Residential or Other. There is no problem with strict interpretation of such a requirement, however, if one is considering reclamation priorities and the information required for such, then clearly the information is inadequate, as it may be immediately surrounded by small fields with an outer ring of housing If the schedule is to be strictly adhered to then the land use would have to be classified as "Other". However, the site may well be in full view of a large housing estate. Here we have again the difference between the actual situation and the visually aesthetic situation. Again, a site may be surrounded on three sides by industry and on the remaining side by housing, in such a position as to view the whole site. So, as in the vegetation section of the schedule, there is also a need for a visual-aesthetic appreciation of the situation in the Surrounding Land Use Section.

An essential element of a Waste Disposal Site Survey is that the survey should record not only the actual situation, but also some degree of aesthetic appreciation of the situation. The problem here is that each person's definition varies of what is aesthetic and pleasing and what is not. But it should be possible to define much of the aesthetic appreciation in terms of actual situation, such as the percentage tree cover along a line dividing a site from a road or other vantage point. This can go some way towards solving the problem of landscape quality and its measurement, a problem which has been the subject of much research.

6.4 SURVEY PRESENTATION

Information was presented for the Derelict Land Survey in the form of a transparent map overlay (figure 6.3) at 1:10,000 scale (or 1:10,560 scale) with site boundaries and numbers marked on the overlay, together with a schedule form for each map overlay. Sites were identified by a specific number on each sheet, which related to the number given to that site in the accompanying schedule. The Waste Disposal Survey information was presented on the same medium but with the area, geology, state of use, wetness and number of access points clearly marked together with the site boundaries. (figure 6.4).

The only post-survey problem was that of the differing scales of the base maps, though with a little foresight this problem would probably not have arisen.

The full potential of this survey was limited due to the fact that the photography was almost three years old when the survey was carried out. Field checks showed that many of the sites were found to have a changed use or had been enlarged by further excavation or tipping. If the survey had been completed within a few months of the date of photography it would have had even greater value and field work would not have been needed. The West Midlands County Council, in fact, followed up the aerial photograph survey with a field survey recording the data listed in figure 6.5: of the 15 items listed only five could not have been identified using aerial photography. However, these five items could not all have been obtained even from a site visit. It is questionable that ground water level could be obtained from observation, as borehole information would probably be needed. Site ownership may not be discernable even on a site visit if the site is disused. Services are usually buried and can only be located by enquiries with the relevant organisations. Finally, in most cases ownership can be discovered only from land records.

6.5 A GRADING SYSTEM FOR POTENTIAL SITES

After carrying out the field surveys the County Council graded sites into four groups, as shown in Appendix 1. However, this grouping could be over-simplifying the situation as it takes no account of the size of the site, and little account of how wet it is. An alternative to grading sites on this system is to take account of all the factors that can be defined from aerial photographs and to derive a score for each site, based on its usefulness for waste disposal.

Obviously some factors have more control than others over the site's usefulness, such as whether it is used or disused, and so a weighting system could be applied. As each waste disposal site is different from any other, a weighting derived solely from a cost basis would be very difficult to devise. For example the costs of laying roads on each site are different as are pumping costs to remove water. Whether the site is in use is an important factor and so these two 'use' categories have to be separated.

The volume of site is also very important as it determines the capacity of the site as tipping space. However, in the reconnaissance stage of the survey the volume need not be precisely determined.

The factors which it is possible to obtain from aerial photographs, and which could be used in a site grading system, are as follows:-

1) USE OR DISUSE
2) DISTANCE FROM CENTRE OF COLLECTION AREA
3) WETNESS
4) ACCESS
5) DISTANCE TO HOUSING
6) APPROXIMATE VOLUME, OR SURFACE AREA
7) GEOLOGY

1) Use or disuse - these should be separated completely as active sites can rarely be used for disposal purposes.

2) Distance from centre of refuse collection area - Here distance is directly related to cost and can be scored as one ½ point for every one mile from the centre

of collection.

3) Wetness - this bears some relation to the size of the site. An amount of water on a large site would have to have a different score from the same amount on a smaller site. A percentage water cover would have to be used in the absence of figures for depth of water. This could be scored as:-

dry - 5% cover...........0 points

5% - 25% cover...........1 point

25%-75% cover...........3 points

75%-100% cover...........10 points

4) Access - two access roads are usually required to speed the flow of vehicles to and from the site. Access may also be required for the public, so the best arrangement would be to have three access points. However, two access points would be adequate. The score here could be:

three or more access points.......0 points

two access points.................½ point

one access point..................1½ points

no access points..................3 points

5) Distance to housing - this can be scored on the number of houses within 100 yards of the site boundary. However, account must be taken of the type of housing, for, although rather unethical, the practical aspects of opposition to tipping from the different classes of society is generally taken into account.

	Low value housing Council	High value housing
	Points	Points
0 houses	0	0
1-10 houses	1	2
More than 10 houses	6	8

6) Volume or Area - The measurement of volume for each potential site is a lengthy and relatively expensive process so the surface area may have to be used.
It is difficult to determine to what extent the size of a site increases its value as a disposal site, compared with the other factors. A suggested weighting would be as follows:-

0 - 5 acres..........10 points

5 - 10 acres.......... 5 points

10 - 20 acres.......... 2 points

20 and above .... 0 points

7) Geology - This score should be based on the possibility of aquifer pollution and should be scored:-

Good aquifer............20 points

Poor aquifer............ 5 points

Non-aquifer............. 0 points

The following are fictional examples.

Site A - Disused	Score
2) Distance - 3 miles	1½ points
3) Dry	0
4) Three access points	0
5) 6 houses in 100 yards(council)	1
6) 12 acres	2
7) Clay - non-aquifer	0
	4½ points

Site B - Disused	Score
2) 7 miles	3½
3) 5% cover	10
4) 1 access point	1½
5) 42 houses (high value)	8
6) 6 acres	5
7) Sand - poor aquifer	5
	33

Site C - Disused	Score
2) 7 miles	3½
3) 4% cover	0
4) 1 access point	1½
5) 42 houses (high value)	8
6) 32 acres	0
7) Clay - non-aquifer	0
	13

If this system is carried out, the volume of the lowest score sites can be found up to such a number that the total waste disposal capacity needed is obtained. This is a simple system designed for short-term objectives and as such takes no account of usefulness insofar as reclamation is concerned or routes available to the site. These are all longer term or subsequent stage considerations.

6.6 FINAL SITE SELECTION

The site grading system covered in the previous section should reduce the number of 'potential' sites, in the original survey, to a more manageable number of 'possible' sites. The next stage would be to investigate each of the 'possible' sites in detail to establish which sites could be used for waste disposal.

Site volume is one of the necessary items of information that should be determined at this stage. As has already been noted earlier, determination of the volume can be carried out more accurately, quickly and almost certainly more cheaply by using aerial photographs. This is, however, dependent on the scale of photography available and in general 1:10,000 scale photography would be the smallest scale for an acceptable result.

Water pollution, both surface and underground, is another relatively expensive factor to determine. Boreholes may be necessary to establish the geology of a site and exhaustive desk studies of site history would be undertaken. Such a study may locate information on mining records and similar documents, which would appertain to the likelihood of lechates reaching underground mine workings.

The provision of services, access arrangements and traffic routing also need to be established. Finally, the question of ownership arises and whether or not the owner wishes to lease or sell a particular site. Although compulsory purchase is available to Local Authorities, such an option normally only arises as a last resort, and is nearly always a lengthy and costly business.

In a full scale survey for waste disposal sites, as described in this thesis, final site selection should be carried out as a computer operation. The combination of cost factors such as transportation from various waste collection areas, costs of purchase or lease of disposal sites, and the cost of site works, are normally too complicated, especially in metropolitan counties, to be determined manually. The study carried out by LGORU for the West Riding County Council[1] involved computer use and involved several options based on cost and the availability of the disposal site.

Another factor, which in the past has not been taken fully into account, is the possibility of using waste disposal as a means of reclaiming derelict land. This possibility is discussed in chapter 7.

6.7 SURVEY RESULTS

The West Midlands Survey resulted in two series of 1:10,560 (or 1:10,000) maps covering the entire area of the County of West Midlands. The first series showed all derelict land sites and was accompanied by a set of site schedules, which gave all the information described earlier in this chapter. The second series of maps showed all the potential waste disposal sites located by the survey of derelict land, and was also accompanied by a set of site schedules.

Owing to the length of time spent on the survey and the fact that it was carried out towards the end of the two year study period, it was not possible to follow up the original survey along the lines of the grading system suggested. The only results available for the survey are those of the number and total area of both derelict sites and potential waste disposal sites in the West Midlands. The results are set out in table 6.1. As can be seen from these results, there is no shortage of potential waste disposal sites within the County of West Midlands and, whilst acknowledging that not all these sites may be suitable for disposal purposes, there should be an adequate supply of waste disposal sites for some time into the future.

In addition there is certainly no shortage of derelict land for which waste disposal in one form or another could act as a land reclamation agent.

FIGURE 6.1 THE SURVEY FORM.

Map No.

Site No.	Geo.Code and Road Name	Area (acres hectares)	Type of Derelic-tion	Tipping	Area of demoli-tion	Use or Disuse	Wet or Dry	Blds. on Site	Veg. Type & Cover	Surround-ing land use	Geology (section 9)	Extra No. of access points (holes only

FIGURE 6.2 AIR PHOTOS 139.71.245 WITH TRACE OVERLAY.

IN POCKET

FIGURE 6.3 DERELICT LAND SURVEY OVERLAY.

IN POCKET

FIGURE 6.4 POTENTIAL WASTE DISPOSAL SITE SURVEY OVERLAY.

IN POCKET

Figure 6.5. FIELD SURVEY FORM. WEST MIDLANDS COUNTY COUNCIL.

POTENTIAL WASTE DISPOSAL SITE SURVEY

SITE NAME

GRID REFERENCE

DISTANCE FROM BIRMINGHAM CENTRE (MILES)

SITE DETAILS	POSSIBLE INFORMATION SOURCE
(1) AREA (ha.)	AERIAL PHOTOGRAPH
(2) USED/DISUSED	"
(3) WET/DRY	"
(4) NUMBER OF ACCESS POINTS	"
(5) SITE VOLUME	"
(6) SURFACE DRAINAGE	"
(7) TYPE OF AREA - RESIDENTIAL/ INDUSTRIAL/RURAL	
(8) NUMBER OF HOUSES WITHIN ½ Km.	"
(9) TYPE OF SITE - MINING/SAND & GRAVEL/ ETC.	"
(10) AVERAGE DEPTH OF VOID FROM GROUND LEVEL	"
(11) LOCATION OF PROPERTY	"
(12) WATER TABLE DEPTH FROM SITE FLOOR	BOREHOLE DATA
(13) ROCK TYPE	GEOLOGICAL MAP
(14) OWNER/TENANT OF SITE	LAND RECORDS
(15) EXISTING SERVICES TO SITE	GAS BOARD/WATER AUTHORITY ETC.
(16) PREVAILING WINDS	METEOROLOGICAL RECORDS
GENERAL COMMENTS	

Table 6.1

SURVEY OF DERELICT AND POTENTIAL WASTE DISPOSAL SITES IN THE WEST MIDLANDS

(AREA IN HECTARES)

ACTIVE (DESPOILED)				DERELICT WASTE			TOTAL		POTENTIAL WASTE DISPOSAL SITES	
TIP	MINERAL WORKING	OTHER	TOTAL	DERELICT	WASTE	TOTAL	AREA Ha	NUMBER OF SITES	AREA Ha	NUMBER OF SITES
267	154	140	601	1535	2761	4296	4897	2404	2063	240

REFERENCES

6.1 "Where to put Solid Wastes": Report No. 168: March 1974.

CHAPTER SEVEN

REFUSE DISPOSAL AND LAND RECLAMATION

CHAPTER SEVEN

REFUSE DISPOSAL AND LAND RECLAMATION

7.1 INTRODUCTION

Refuse, whether domestic, trade or industrial, has traditionally been viewed from the negative aspect of it being a totally useless material, to be dumped in the nearest convenient hole. Then, as time proceeded and the composition of waste became more variable, it was realised that refuse included useful material. Ferrous wastes were probably the first to be reclaimed, using magnetic systems. Today reclamation from refuse is a large and capital intensive industry: now plants are on stream, providing mechanical or chemical methods of separating and reclaiming an increasing fraction of today's refuse. However, no matter how much reclamation is carried out, - the residue will have to be disposed of by landfill. One of the most modern processes developed at the Warren Spring laboratories, still has residue of between 20% and 50% of the total original volume.

All other methods of waste treatment, whether incineration or pulverisation, although reducing the physical volume of material to be disposed of leave a residue which must be landfilled.

Landfill then is a necessity with all current methods of refuse disposal. But it is a necessity that has always been identified in the public eye as an unwanted necessity, associated with flies, rats, disease, odour, blowing paper and unsightliness. As has been discussed in chapter 1, under proper systems of management and treatment, landfill can be a reasonably problem-free operation. Modern methods of landfill can be regarded as a means of land reclamation - infilling disused quarries and restoring to use other forms of derelict land. Solid wastes can be taken as having a positive value as a resource material to improve land and to create new landscapes.[1]

Although disused holes in the ground form the most obvious type of land to be used for landfill, other types of derelict, despoiled or degraded land can be utilised and improved.

7.2 DERELICT, DESPOILED AND DEGRADED LAND

Derelict, despoiled and degraded land is a much under-used and under-rated land resource. The Derelict Land Survey of England[2] co-ordinated by the Department of the Environment in 1974, identified a total of 96,656 hectares of derelict land, abandoned mineral workings, and land covered by permissions for surface mineral workings and mineral waste disposal. Not all this land is suitable for waste disposal and not all of it is in the right place. The terms Derelict, Despoiled and Degraded are defined as:-

1. Derelict Land is disused land which has been so damaged by industrial or other development that it is incapable of beneficial use without treatment.
2. Despoiled Land is land at present in use which becomes derelict if operations cease and no

restoration were carried out.

3. Degraded Land is land which has been allowed to degenerate through neglect.

In the Survey degraded land was divided into "degraded industrial land" (land within the curtilage of industrial sites), "other degraded land" (which largely comprises neglected sites in residential areas, showing no evidence of former land uses), "demolition sites" and "disused allotments". (This category of Degraded Land was not included in the Department of the Environment Survey 1974).

The six Metropolitan Counties together with Greater London, contain only 8% of the land with permission for surface mineral working in England, as shown in table 7.1. However, 25% of the derelict land total falls within these areas.

The highly populated metropolitan areas have the largest amount of refuse to be disposed of and have generally been thought of as having a low capacity for landfill. Past disposal site searches have largely ignored most derelict land and have concentrated on a search for disused mineral workings. Hence the idea that landfill capacity was lacking resulted in expensive incineration schemes.

In addition to the land identified by the Survey described in this study, similar land has been identified in subsequent surveys using aerial photographs undertaken for Merseyside[3] and South Yorkshire County[4] Councils. In all three Metropolitan Counties the amount of degraded or waste land identified has been of the same order of area as the amount of derelict land. There is therefore an additional source of land for refuse disposal over and above the number of excavations that are usually sought for disposal sites.

In the case of Merseyside, where there were only 131 hectares of mineral workings, some of which were shallow sand and gravel workings, though 1,427 hectares of degraded land were identified.

Table 7.2 summarises the results of all three surveys.

The consideration of land for waste disposal other than mineral workings is of permanent importance in Metropolitan areas, where the amounts of refuse generated are large in comparison with the number of mineral workings which could act as disposal sites.

7.3 THE USE OF LANDFILL AS A METHOD OF LAND RESTORATION

As has already been stated, the traditional landfill site has been a disused quarry with occasional use being made of other sites, such as poor agricultural land. This use of non-quarry sites has in general only occurred in areas where a genuine shortage of quarry void existed. The use of modern disposal techniques and above all the stricter control over landfill brought about by increased skills and investment, has made it possible to extend the scope of landfill sites.

In the case of the County of Merseyside, where many of the 242 hectares of excavations are either active or already being used for some type of waste disposal, another 3547 hectares of land lie derelict or degraded. Whilst it is accepted that not all of this total of derelict or degraded land could be utilised for waste disposal a detailed examination would show that there is still a large area which could be utilised.

A type of derelict land in form similar to quarries that could be used, is the derelict railway cutting. Such cuttings already contain their own drainage system which could be utilised to drain off any percolate that may occur. The percolate could then either be fed into the public sewer system or a small treatment plant set up on site[5].

Obviously the type of treatment adopted for waste disposal has a considerable bearing on the types of land that can be used for landfill. Whilst controlled disposal of crude refuse can in theory be carried out within an urban area in close proximity to housing, the level of opposition from the local population is likely to restrict such activities. In addition, the level of investment required to efficiently dispose of crude refuse in such a way necessitates the use of large sites.

The introduction of Transfer Stations, which isolate the collection service from a rapidly changing pattern of disposal sites, will enable a large number of smaller sites to be used. Also the rate at which a site can be filled is increased. All refuse from several collection districts can be concentrated at one disposal point.

Some forms of waste material treatment will increase the number of sites available even more as site investment becomes lower. Such a system is the high density baling method described in Chapter One. The use of these bales not only enables a very high degree of control over the level of nuisance caused by tipping, but lowers investment in individual sites to such a degree that a large number of sites can be filled very rapidly. One of the major attractions is that the sites, after disposal operations have ceased, can be rapidly developed for uses other than recreational open space, thus giving a high value to the land and therefore helping to offset disposal costs.

7.4 CONSTRAINTS ON THE USE OF LANDFILL SITES

There are four major constraints on the use of sites for waste disposal; these are, water pollution dangers, land allocations, nearness of housing, and site size. The first constraint, that of water pollution, is described in detail in Chapter 5. In many cases groundwater pollution dangers are contained by a suitable bedrock and in others some form of treatment such as plastic/rubber seals or drainage can modify the problem sufficiently to make the site suitable. It has also been claimed that high density bales, being relatively impervious to water and having had the air space reduced to the point where bacterial activity is considerably reduced, may not create a pollution problem at all. In the case of the bales, percolation is so slow that dilution occurs to such an extent as not to cause a problem. Further research is required on this point, as the breakdown of the bales after a period of time may cause a severe pollution episode.

Surface water pollution is subject to the same problems as ground water, but is more easily dealt with by the installation of drainage systems. Land allocations form another constraint, to some extent solved by the use of high density bales. Crude refuse landfill sites have a limited spectrum of after uses, although recent research has shown that by the use of specialised equipment, crude refuse densities in landfill sites can approach 1.6 cu. yards/ton. This is very close to densities for pulverised refuse (1.67 cu. yards/ton) and compares with an original density (crude refuse) of 2cu. yards/ton. Land with an allocation for open space, or some other recreational use, can be utilised for crude refuse landfill. Other allocations, such as light industrial or residential, can be utilised if some form of treatment such as incineration or high density baling is adopted.

The extent to which the nearness of housing is a constraint depends on the type of treatment being used. As described in Chapter One, problems of windblow, odour and pest infestation can occur, though most methods of treatment reduce the problem to various degrees, the most efficient being incineration or baling.

Site size is another constraint (as discussed earlier in this Chapter). The different transportation methods as well as treatment methods have an effect on the required size of a disposal site. Transportation of crude refuse by collection vehicles, requires the highest level of capital investment and hence the largest sites which are the shortest distance from collection centres. The use of transfer systems and some form of treatment decreases site investment requirements, and this opens up the number of sites to be utilised. This permits the use of smaller sites at greater distances from collection centres.

7.5 CONCLUSION

The survey of the West Midlands Metropolitan County, carried out in association with this research project, was the first full county wide survey of potential waste disposal sites to be conducted on the basis of the methodology developed in this thesis.

This methodology has subsequently been used in the counties of Merseyside, Nottinghamshire and South Yorkshire, the first and third of which involved the author.

During this study the need for other related projects became evident, and it is suggested that future work should consider:

A) A more detailed assessment of the comparative costs of aerial surveys and field surveys.

B) The development of a methodology for identifying 'possible' and 'suitable' waste disposal sites from the reconnaissance survey of 'potential' sites.

C) An investigation into the problems, principles and methods of quantifying, or evaluating, site suitability.

D) A study, in which waste disposal was included as a major element, of reclamation criteria to determine priorities for county reclamation programmes.

The conclusions reached in this study are summarised below:

1. That the aerial photograph is a neglected source of useful and valuable information, which in itself is

a land use data bank.

2. That aerial survey is generally cheaper, at least as accurate, and very much faster than the equivalent field survey.

3. That aerial photographs at scales of 1:12,000 and larger, are necessary to provide the level of detail required for mapping waste disposal sites.

4. That the air photo interpreter should be skilled, and that modern stereoscopes should be used.

5. That the work carried out in this air photo study constitutes a first stage survey only, and that field work is an essential element in successive stages.

6. That the search for waste disposal sites should be extended to cover all types of derelict and despoiled land - and not restricted to excavations only.

7. That landfill operation should be treated as much as a land reclamation agent as an end in itself.

TABLE 7.1 DERELICT AND DESPOILED LAND IN ENGLAND: 1974.

Values in hectares (Ha)	Derelict Land		Abandoned mineral workings		Area covered by surface mineral tipping Spoil heaps		Permissions for working and waste Excavations	
	Ha	%	Ha	%	Ha	%	Ha	%
Metropolitan Counties + GLC	11529	25	622	27	4245	35	3078	10
Non-Metropolitan Counties	31744	75	1685	73	8015	65	33738	90
England TOTAL	43273	100	2307	100	12260	100	36816	100

In addition to the land identified by the 1974 Derelict Land Survey there is a considerable amount of degraded land not included in the 1974 Survey.

TABLE 7.2 A COMPARISON BETWEEN THE AMOUNTS OF DERELICT, DESPOILED AND DEGRADED LAND IN THREE METROPOLITAN COUNTIES.

In Hectares.

COUNTY	DERELICT LAND	DESPOILED LAND	DEGRADED LAND	TOTAL AREA	MINERAL WORKING
WEST MIDLANDS (1971)	1535	601	2761	4897	2063*
MERSEYSIDE (1973)	821	720	1427	2968	131
SOUTH YORKSHIRE (1971)	2053	2133	6170	10961	1473

* Includes some areas considered as potential Waste Disposal Sites, not classified as mineral workings.

REFERENCES

7.1 Landfill and its importance in the restoration of derelict land: R.E. Bevan: paper presented to "Waste disposal. Planning the way ahead" a conference organised by Redland Purle/I.S.C.O.L., University of London, May 1974.

7.2 Survey of Derelict and Despoiled Land in England 1974: Department of the Environment (3 volumes).

7.3 Merseyside County Council Report of Survey on Environmental Pollution and the Condition of land for the County Structure Plan, April 1976.

7.4 Derelict, Despoiled and Degraded Land Survey. South Yorkshire County Council Planning Committee Report, April 1977.

7.5 "Tip runoff: Willey's gets the treatment", Surveyor, 17th May 1974.

APPENDIX I

GRADING SYSTEM ADOPTED BY WEST MIDLANDS COUNTY COUNCIL

Initial survey studies to locate potential waste disposal sites have been concentrated in the Walsall/Sandwell districts due to the shortage of existing tipping sites in these two districts.

Grading of Potential Disposal Sites

The potential disposal sites have been initially graded into four basic types. An 'A' rating indicates the sites having the best disposal potential, with decreasing value being placed on the 'B', 'C', and 'D' grades.

The four gradings are briefly described below:-

Grade 'A'

Potentially useful site in existing state

(1) Disused site

(2) Easy road access

(3) Non-residential

(4) Dry or small amount of water

Grade 'B'

Minor work to make useful for tipping

(1) Used site

(2) Easy road access

(3) Partially residential

(4) Wet or dry

Grade 'C'

Difficult to use in existing state

(1) Used site

(2) Difficult road access

(3) Residential

(4) Wet

Grade 'D'

Totally unsuitable

Unsuitable for waste disposal.

Results

Of the 19 areas covered, corresponding to the ordnance survey map areas, two revealed no potential sites. The remaining 17 areas indicated 87 potential sites with a total area of 744.57 hectares (1840 acres).

The 87 sites comprise 17 grade 'A', 24 grade 'B', 11 grade 'C', and 35 grade 'D' sites.

The grade 'C' and 'D' sites possess features which preclude them from further consideration as waste disposal sites at this stage. However, the grade 'C' sites may be worthy of further consideration, depending on the overall outcome of the survey.

Programme of Work

Two of the sites have already had volumetric surveys carried out; the ownership and various details associated with these sites are already well established. Further investigations of these two sites have therefore ceased.

The 39 remaining grade 'A' and 'B' sites have now been passed to the County Planning Offices to establish where possible ownership details.

Programme for Volumetric Survey - Phase 'B'

The volume assessment of these sites should be delayed until land ownerships have been identified. Preliminary discussions should then occur with the owners and Planning/Regional Water Authority to establish the possibility of using the sites for the disposal of wastes. Sites rejected for the deposit of crude waste could then be considered for the disposal of inert materials.

Conclusion

This preliminary study has covered 19 areas out of a total 94. The initial results are extremely promising.

The 39 grade 'A' and 'B' sites under further consideration have a total area of 413.44 hectares (1020 acres). On the modest assumption that each excavation has an average depth of say 10'0", this would produce 16,500,000 cu. yds. storage space capable of storing 6,700,000 tonnes of refuse.

Economic Advantages of Using Aerial Photography for Mapping Potential Tipping Sites

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With the establishment, in April 1974, of the new Administrative Authorities comes their responsibility for the management of waste disposal. Previously every local authority had the job of organizing both the collection and disposal of waste, and the problem was mainly small in scale and relatively limited in a real extent: only where Authorities had run out of tipping space, or had built incineration plants, had there been any co-operative activity with neighbouring Authorities. Few Authorities have had the time, or trained the staff, to develop county wide waste disposal strategies, and with current operational difficulties and constraints the problem is likely to be tackled in an *ad hoc* and piecemeal fashion.

Several relevant studies have been understaken by or for local authorities mainly on the siting of large plant, but so far as we know very few have been carried out on waste disposal strategy: of these was one "Economic Spoil Management"[1] in which the authors were involved with L.O.G.O.R.U. and the West Riding County Planning Authority.

It is doubtful whether, taking the country as a whole, there is a shortage of suitable tipping space and the increasing rate of mineral extraction is likely to make even more potential tipping space available in the future. Leaving aside for a moment the administrative issues of local government boundaries, one of the main problems is concerned with transport economics—the location of, and distance between, waste generation points and suitable waste disposal sites. Refuse disposal methods have so far concentrated on tipping and, because it is so economic, this is not expected to change significantly in the near future.

A comparison of Refuse Disposal Methods[2] for the period 1966–67 is as follows:

Direct Tipping	90·4%
Separation/Incineration	7·6%
Direct Incineration	0·7%
Pulverization	1·0%
Composting	0·3%

Of the 90·4 per cent direct tipping, 71 per cent was controlled, 28 per cent semi-controlled and 1 per cent uncontrolled.

Even though in 1963 the refuse *disposal* responsibilities of the thirty-two London Boroughs were brought together under the G.L.C., *collection* was still undertaken independently by each borough.

Prior to 1974 there were (including the G.L.C.) 1,174 separate authorities responsible for waste disposal, 804 of which stated that they had difficulty in finding tipping sites!

Data Needs

The new local Authorities are required to produce waste disposal plans to cover the next ten years. In order to do this efficiently it is necessary to develop adequate and economic systems of data collection and data handling. The two major data needs are:

(i) to identify types, sources and quantities of waste
(ii) to locate, identify, map and measure suitable tipping sites.

A growing awareness of the problem and recent legislation have resulted in the establishment of a more efficient and more complete system of locating and recording types, sources and quantities of waste generated.

However, it is equally important to improve current methods of identifying and locating sinks, i.e. tipping sites. A quite small site may be more important than a large site if the smaller site is able to accept liquid or hazardous waste, particularly if the site is near the source of such waste.

Collection of data on potential tipping sites CAN be carried out using planning permission details for mineral extraction. A map search would also be necessary: sites could be visited and the rather expensive and time consuming collection of field data could be carried out. With this system however some problems arise in that the many sites quarried before the need for planning permissions will probably not be recorded. Also the maps of many planning authorities are inaccurate, mainly because they have not been kept up-dated.

The difficulties of locating new tipping sites is regarded by many waste disposal authorities as being a major problem, but existing published material, including O/S maps and plans, are almost always quite inadequate to supply this information which is regarded as essential for the development of economic waste disposal planning.

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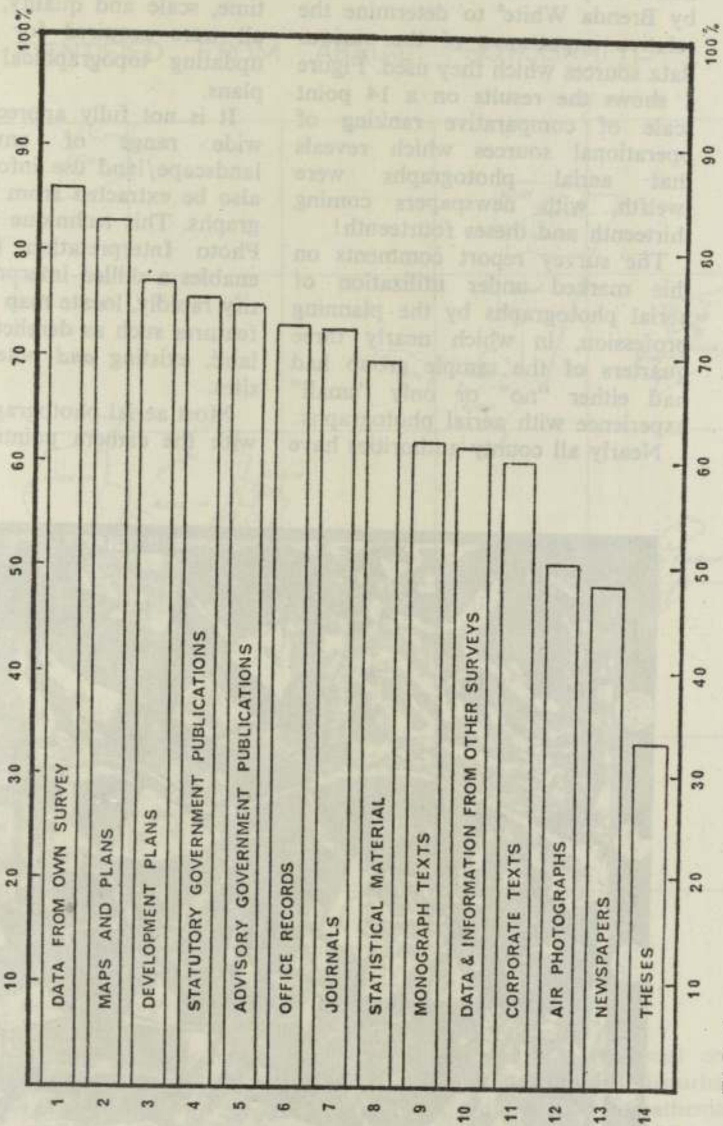

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At scales of 1:3,000/1:5,000 it is possible to identify individual tree species, some types of manufacturing industries and even pedestrian densities! High accuracy plans can be produced at scales of up to 1:500 with a one foot contour interval, and from these contoured maps and plans it is possible to determine both areas and volumes of heaps and holes. Volumetric computation from aerial photographs is substantially quicker than that obtained by traditional field surveys.

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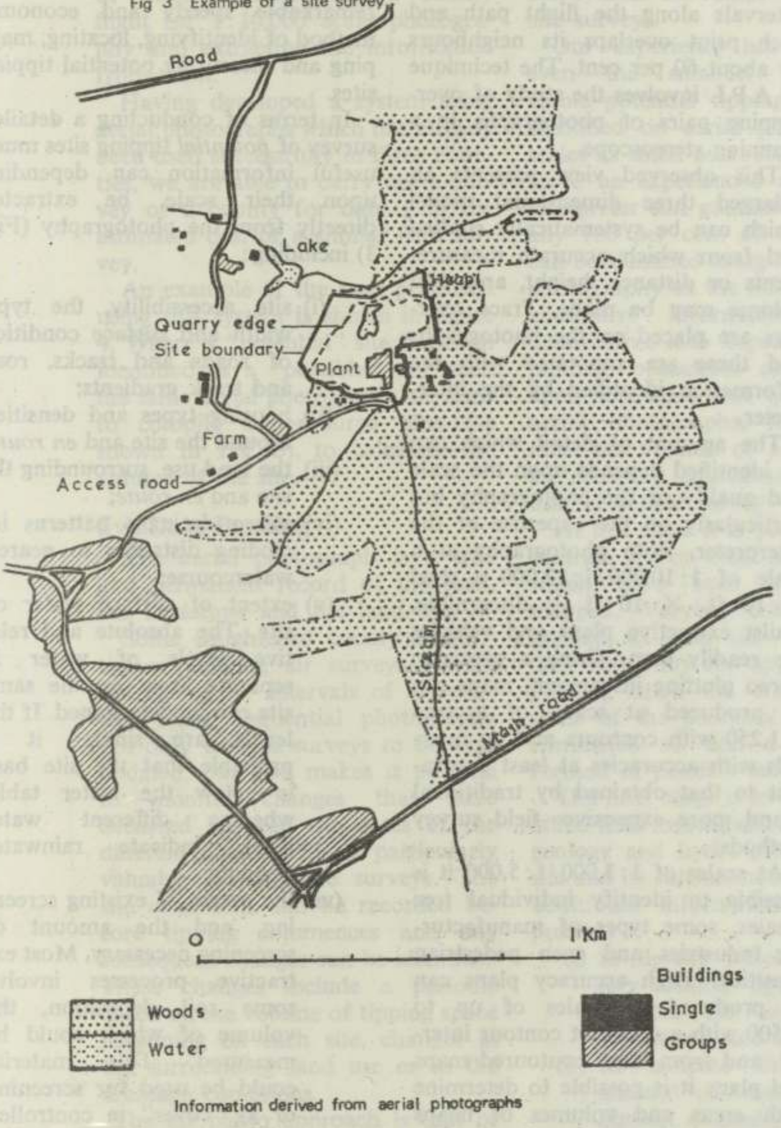

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The sum total of these two sets of information provides the waste disposal authority with a substantial amount of useful and relevant information at only a fraction of the cost of, and very much faster than, any alternative system.

At the University of Aston we have been involved with a number of air-based county surveys of both derelict and spoiled land, and more recently of potential waste disposal sites.

In assessing the advantages of air surveys as against the traditional field surveys for locating and mapping potential tipping sites, comparisons must be made in terms of:

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(ii) Speed.
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Even if no photography is available we have calculated that the cost of a traditional field survey of sites will be greater than the cost of both commissioning a county flight for 1:10,000 scale photography and extracting the information from them.

Having developed a system using aerial photographs which has already been used successfully in three counties, we are able to carry out a survey of a county for only ½ of the estimated cost of a similar field survey.

An example of the map produced using this system is shown in figure 4. Where a "potential" site has been identified as a "possible" site, then the same aerial photographs are used to compile a contoured plan (as shown in Fig. 5), to calculate the volume of the site.

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The aerial photograph is a true and permanent record of the land, the landscape and the land use.

Some enlightened county authorities are having air surveys carried out at regular intervals of three or five years. Sequential photography not only enables surveys to be kept updated, but also makes it possible to monitor changes that have occurred between the dates of the different flights. This is particularly valuable for tip site surveys. The site conditions can be recorded before tipping commences and any subsequent changes can be identified. These changes include a periodic check on the volume of tipping space remaining on each site, changes in the surrounding land use or in the drainage conditions.

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At this stage it is possible to concentrate just on those areas and sites which have been identified and mapped. Varying criteria can be applied to each site to determine their suitability for tipping, and, depending upon the criteria applied, some of the *potential* sites will be eliminated so that a new list is formed of *possibly suitable* sites.

The next stage is to carry out detailed field investigations of both the geology and hydro-geology of each site and its catchment area. With this additional information it will be possible

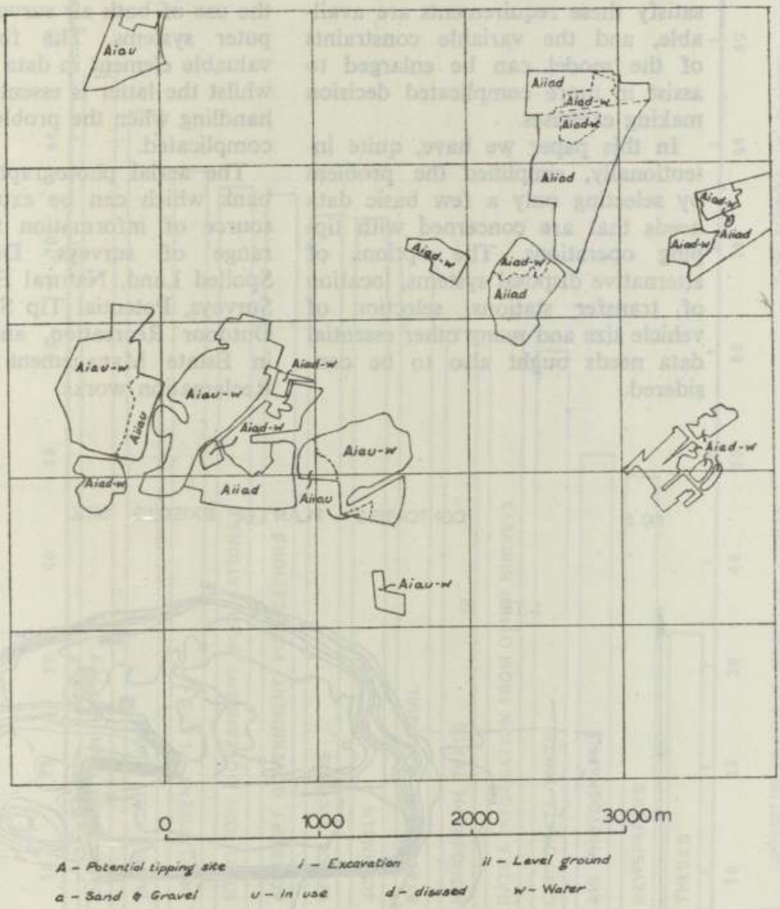
(i) to identify which of the *possibly suitable* tipping sites are suitable for *actual* tipping operations, and also

(ii) to indicate the type and amount of waste (hazardous, liquid, domestic, inert, etc.) each site could safely accept.

Assuming adequate records have been made of the source, amount and type of waste generated, the next problem to resolve is that of

FIG. 4.

POTENTIAL REFUSE TIPPING SITES IDENTIFIED FROM AERIAL PHOTOGRAPHS



matching this waste with the most suitable sink.

This match needs to produce a number of alternative options which satisfy, among other factors

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This requires that a mathematical model be compiled into which all information and the varying criteria are fed. In order to devise a rational disposal programme it is necessary to know

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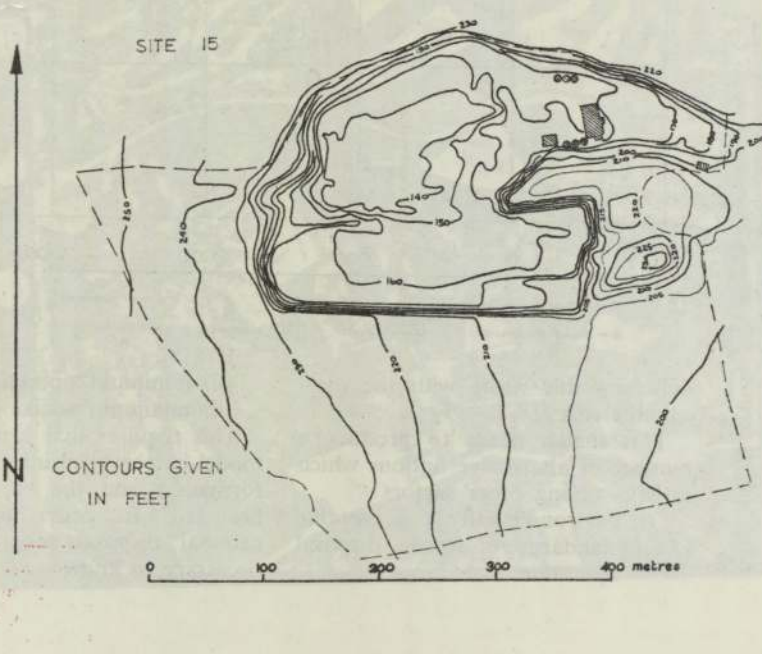
In this paper we have, quite intentionally, simplified the problem by selecting only a few basic data needs that are concerned with tipping operations. The options of alternative disposal systems, location of transfer stations, selection of vehicle size and many other essential data needs ought also to be considered.

Bearing in mind the complex nature of the problem at County and Metro District levels, it is highly unlikely that the new Waste Disposal Authorities will arrive at the best solution in terms of speed, economy and effectiveness without the use of both air survey and computer systems. The former is a valuable element in data acquisition, whilst the latter is essential for data handling when the problem becomes complicated.

The aerial photograph is a data bank which can be exploited as a source of information for a wide range of surveys. Derelict and Spoiled Land, Natural Environment Surveys, Potential Tip Site Surveys, Outdoor Recreation, and generally in Estate Management and Land Reclamation works.

FIG. 5. CONTOURED PLAN OF EXISTING SITE



The economic advantages of air survey increase substantially when they are used for several purposes. We would go so far as to say that for any county authority which is anxious to reduce the costs of its data acquisition systems, the air survey represents a very sound investment.

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Economic Advantages of Using Aerial Photography for Mapping Potential Tipping Sites

by Christopher J. Ballam, B.Sc.
and W. Gordon Collins, B.Sc., Ph.D., F.R.G.S.

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With the establishment, in April 1974, of the new Administrative Authorities comes their responsibility for the management of waste disposal. Previously every local authority had the job of organizing both the collection and disposal of waste, and the problem was mainly small in scale and relatively limited in a real extent: only where Authorities had run out of tipping space, or had built incineration plants, had there been any co-operative activity with neighbouring Authorities. Few Authorities have had the time, or trained the staff, to develop county wide waste disposal strategies, and with current operational difficulties and constraints the problem is likely to be tackled in an *ad hoc* and piecemeal fashion.

Several relevant studies have been understaken by or for local authorities mainly on the siting of large plant, but so far as we know very few have been carried out on waste disposal strategy: of these was one "Economic Spoil Management"[1] in which the authors were involved with L.O.G.O.R.U. and the West Riding County Planning Authority.

It is doubtful whether, taking the country as a whole, there is a shortage of suitable tipping space and the increasing rate of mineral extraction is likely to make even more potential tipping space available in the future. Leaving aside for a moment the administrative issues of local government boundaries, one of the main problems is concerned with transport economics—the location of, and distance between, waste generation points and suitable waste disposal sites. Refuse disposal methods have so far concentrated on tipping and, because it is so economic, this is not expected to change significantly in the near future.

A comparison of Refuse Disposal Methods[2] for the period 1966–67 is as follows:

Direct Tipping	90·4%
Separation/Incineration	7·6%
Direct Incineration	0·7%
Pulverization	1·0%
Composting	0·3%

Of the 90·4 per cent direct tipping, 71 per cent was controlled, 28 per cent semi-controlled and 1 per cent uncontrolled.

Even though in 1963 the refuse *disposal* responsibilities of the thirty-two London Boroughs were brought together under the G.L.C., *collection* was still undertaken independently by each borough.

Prior to 1974 there were (including the G.L.C.) 1,174 separate authorities responsible for waste disposal, 804 of which stated that they had difficulty in finding tipping sites!

Data Needs

The new local Authorities are required to produce waste disposal plans to cover the next ten years. In order to do this efficiently it is necessary to develop adequate and economic systems of data collection and data handling. The two major data needs are:

(i) to identify types, sources and quantities of waste

(ii) to locate, identify, map and measure suitable tipping sites.

A growing awareness of the problem and recent legislation have resulted in the establishment of a more efficient and more complete system of locating and recording types, sources and quantities of waste generated.

However, it is equally important to improve current methods of identifying and locating sinks, i.e. tipping sites. A quite small site may be more important than a large site if the smaller site is able to accept liquid or hazardous waste, particularly if the site is near the source of such waste.

Collection of data on potential tipping sites CAN be carried out using planning permission details for mineral extraction. A map search would also be necessary: sites could be visited and the rather expensive and time consuming collection of field data could be carried out. With this system however some problems arise in that the many sites quarried before the need for planning permissions will probably not be recorded. Also the maps of many planning authorities are inaccurate, mainly because they have not been kept updated.

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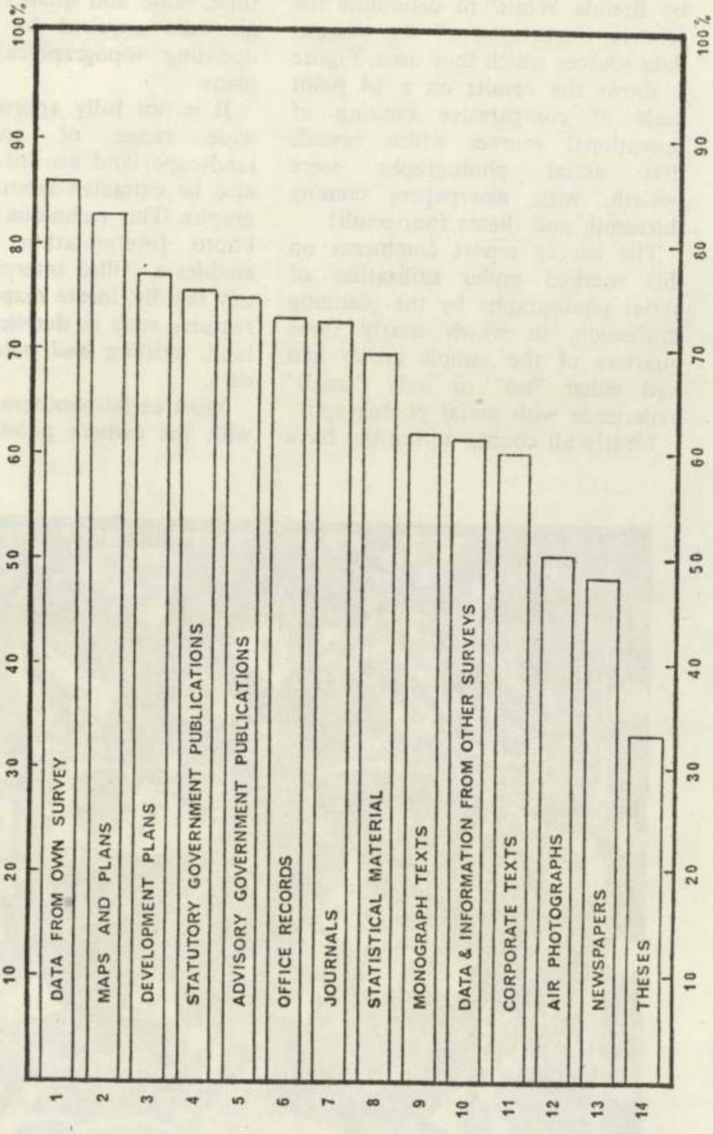

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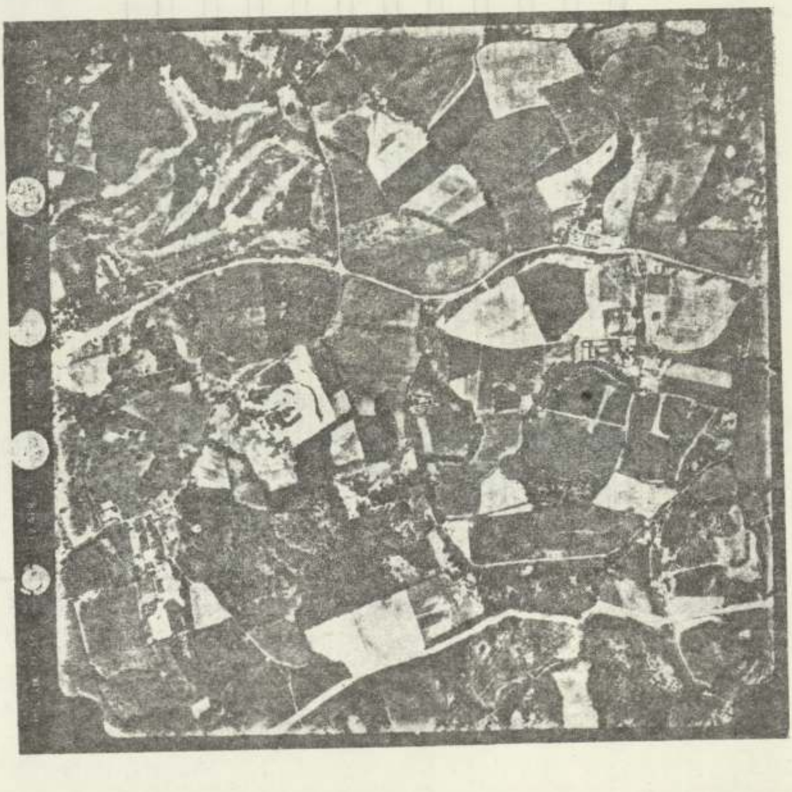

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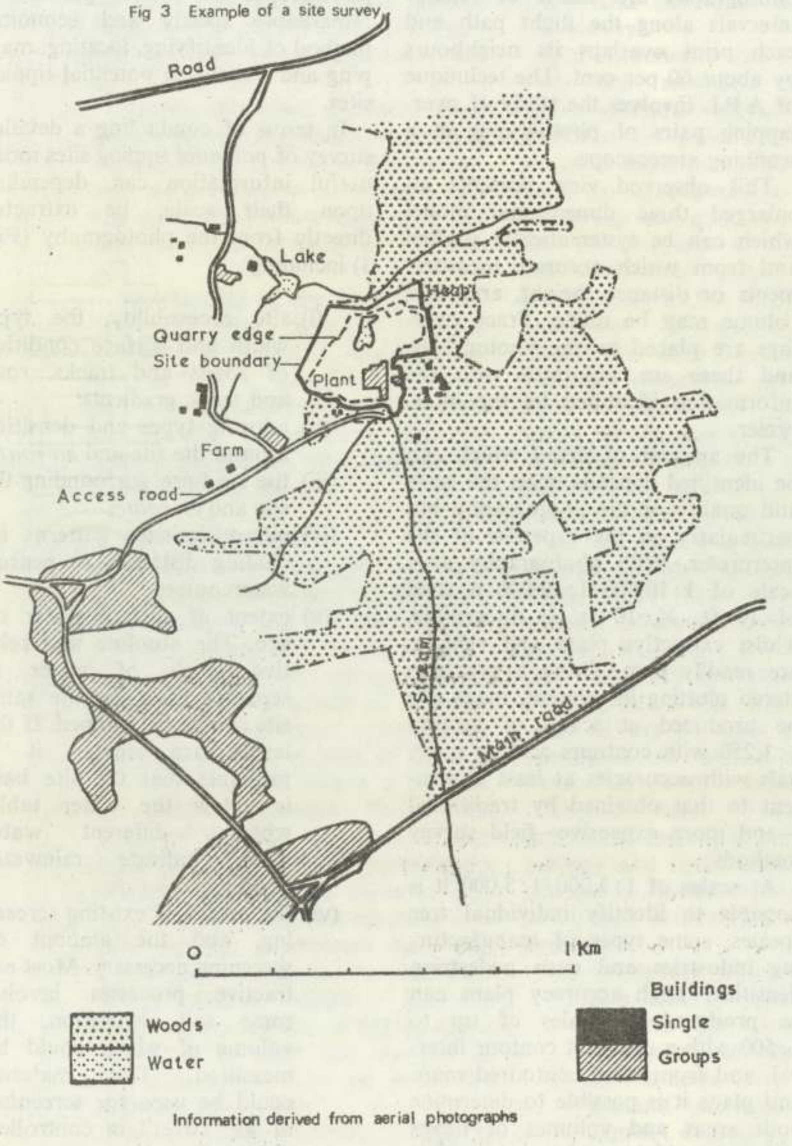

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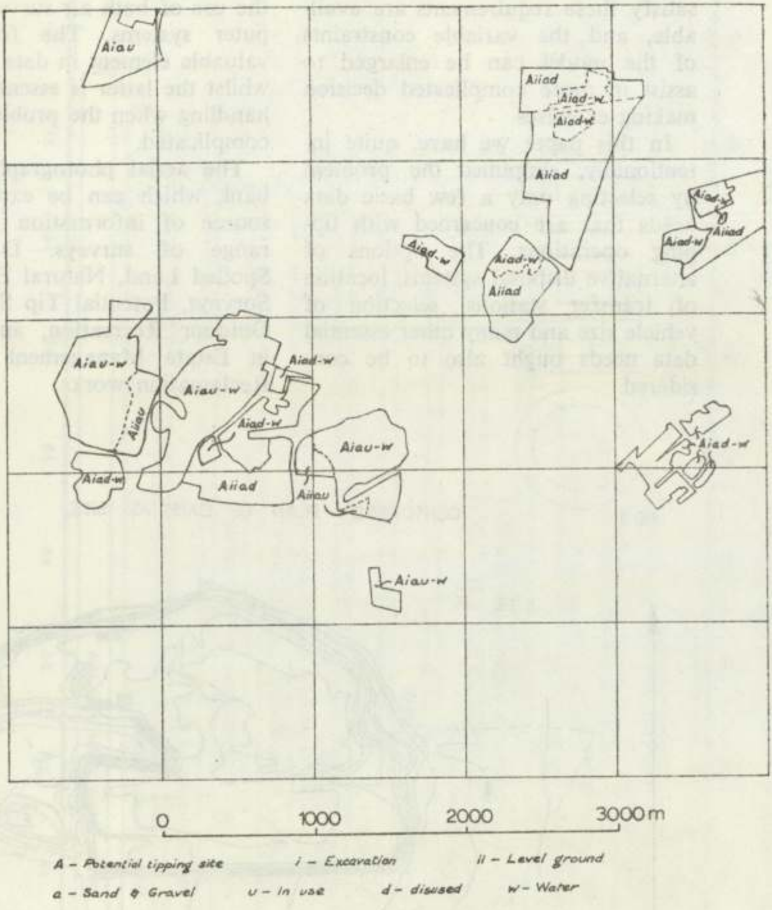

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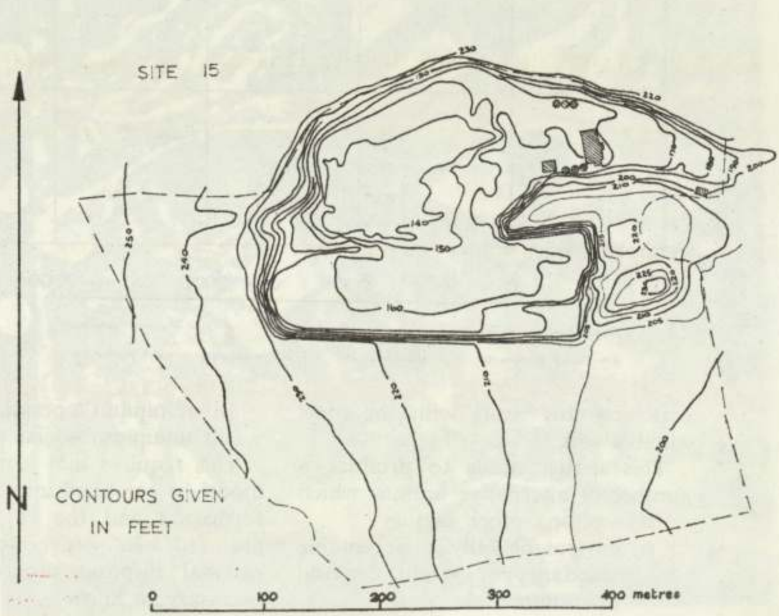

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