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Mortality in the shale oil areas of Scotland: a feasibility study

Marine WM, Annis R, Sklaroff SA



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OIL AREA OF SCOTLAND:
A FEASIBILITY STUDY

by

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November, 1982.

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A FEASIBILITY STUDY

by

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S U M M A R Y

This report develops the rationale for and explores the feasibility of doing a community mortality study of the shale oil area of Scotland. The major reason for being interested in health effects from the Scottish industry which existed from 1865-1962 is that a new industry is developing in the Western United States. With estimated oil shale rich reserves (30 barrels of oil per ton and greater) of 418 billion barrels of oil, an industry many times the size of the Scottish industry could be sustained for over 100 years.

The rationale for a community mortality study in addition to the 6000 shale oil employee cohort-study already in progress at the Institute of Occupational Medicine is as follows: the industry was so concentrated geographically that a community study can be viewed as an extended worker study; by its very design a community study would include retired and former workers still alive and living in the area in 1950 - groups not included in the current cohort study; the two counties within which the industry existed but was outside the shale area itself would provide a good population for mortality comparison in the worker cohort study; it would enable examination of risks to community residents not part of the industry; and it would enable potential risk from long-term environmental contamination from the industry to be examined.

The main findings are that the location of the industry in terms of size over time is verifiable from official census records, Secretary of Mines reports, location of shale mines and bings, and industry records. The Heavy Shale Area is confined to six civil parishes in West Lothian and Midlothian Counties which in 1961 had a population of 30,482. The Registrar General of Scotland has computerised cancer deaths from 1953 onwards and all deaths from 1971. Of great important methodologically, the deaths are identified by small areas so that separate age/sex/cause specific rates can be developed for the Heavy Shale Area, Light Shale Area and Non-Shale Area of the two counties. The population base is of sufficient size and structure that an adequate range of risk for most of the causes of death of interest can be measured. In addition to cross-sectional analysis of mortality, the use of birth-cohort analysis technique will provide a way to capture the mortality experience of those who lived at the time the industry was most active.

It is concluded that it is feasible to do a community mortality study of the shale oil area for cancer deaths since 1953 and all deaths since 1971. Only through such a study can we be assured of fully exploiting the health effect information from the Scottish shale oil industry.

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1. INTRODUCTION

In the aftermath of the Middle East oil embargo of the early 1970s, developed countries realised anew their energy dependence and vulnerability. In the United States it became a public policy goal to achieve energy independence by the year 2000 and the U.S. Department of Energy (DOE) was created to implement this policy. Extensive efforts are now being made to determine the availability and costs of developing and expanding alternative energy sources. Each energy resource is being examined in comparable fashion for the purpose of recommending what degree of emphasis should be placed on each option to enable the U.S. to approach energy independence.

The Health and Environmental Risk Analysis Program was created by the U.S. DOE to assess the relative risks involved in developing each energy alternative. For oil shale, the scale of operation for which risk is being estimated is expressed in terms of an industry capable of producing 1 million barrels of oil per day. This scale can be put into perspective by comparison with the size of the reserves in the Green River Formation of the Western United States, estimated at 57 billion tons of shale, capable of yielding some 418 billion barrels of oil. These reserves could sustain an industry several times the one million barrels a day level for over 100 years.

The Oil Shale Risk Analysis Program staff have reviewed all published health risk data from the oil shale industries of other countries - predominantly Scotland and Estonia - and have concluded that at present the quantification of health risks will have to be estimated solely from the information from surrogate industries.

Hope of developing health risk information from the oil shale industry itself rests with the study by the Institute of Occupational Medicine (IOM) now in progress. This study involves a group of employees of the Scottish shale oil industry which ceased operation in 1962 after over 100 years existence. This feasibility study will show that investigating community mortality in the shale area is a logical extension of the worker study and offers a way of fully exploiting the health effect information from the experience of the Scottish industry. The community feasibility study will seek answers to the following questions:

1. Can a general population associated with the industry be accurately identified by size and location over time?
2. Are demographic and death registration information available for analysis by small areas?
3. Are the small areas identified on the basis of degree of potential exposure to the industry of sufficient size and structure that a reasonable range of estimates of cause-specific mortality risks would be obtained?

Throughout this report the terms "shale oil" and "oil shale" are used interchangeably, based on usage of the former term in the U.K. and the latter in the U.S.

2. BACKGROUND AND RATIONALE

Estimation of potential health risks associated with the developing oil shale industry in the United States is seriously handicapped by lack of long-term health effects information from workers in the industry. COSTELLO (1979, 1980) undertook morbidity and mortality studies of all available oil shale workers in the United States. The inconclusive nature of the findings may largely be explained by the small number of workers - approximately 800 - and by the incompleteness of follow-up. The analysis was handicapped by the fact that workers were employed for only a short time in oil shale related work and had had previous and subsequent employment histories that included working in uranium mines.

As already noted, there are two areas of the world that have or have had extensive oil shale industries - Estonia and Scotland. The industry in Estonia is more recent and, while occupational health studies have been conducted (AKKERBERG et al, 1980) largely non-scientific factors have prevented full access to the data. Considerably more progress has been made in studying the health effects of the Scottish industry. The U.S. DOE has funded a study that is being conducted by the Institute of Occupational Medicine in Edinburgh. The study is primarily based on a cohort of approximately 6000 employees of Scottish Oils Limited who were members of a Provident Fund benefits plan established in 1950 for all employees at that time. New employees who worked two years or longer in the industry became members of the Fund until the industry ceased in 1962. A study of mortality of this cohort and clinical following-up of surviving members is in progress.

The rationale for conducting a study of the community mortality in the shale area in addition is as follows:

1. A community study of the shale area can be uniquely viewed as an extension of the worker study since, in the civil parishes where the industry was concentrated, it is estimated that 50% or more of the population were employees and their families (CONACHER, 1927). Recent studies in the United States have demonstrated significant increases in community mortality due to workers in the petrochemical industry where they represent a much smaller fraction of the community population than that in West Lothian (GOLDSMITH, 1977, and BLOT & FRAUMENI, 1976).

2. The current study includes only employees active in the industry during the last dozen years of an industry that lasted some 100 years. It does not include former employees and retired workers who were alive in 1950. In view of the marked attrition of the industry in 1925 when the workforce was reduced by half over a few years, a special opportunity existed for the elimination of the less fit with possible accentuation of this aspect of the "healthy worker" effect. Workers who retired before 1950 are especially important because they would have been active at an earlier stage of the industry when exposures were likely to have been greater. Recent follow-up studies in the coal industry which include both former and retired employees found a greater prevalence of occupational disease in these important subgroups. (SOUTER et al, 1982). Thus a community study would increase the number of workers available for study, and would widen the range of exposures likely to have been experienced.

3. The on-going U.S. DOE-funded mortality study of workers employed in the industry in 1950 will include both informal comparisons of occupational sub-groups and broad comparisons with

published statistics for Scotland as a whole. A useful adjunct would be to establish the mortality of the general population in the two counties where the industry was located but excluding the area where shale employment was high and where the industry was located. This would provide an almost ideal external comparison because it would be based on groups with similar socio-demographic characteristics.

4. A community mortality study enables one to examine the risks to those not actually employed by the industry, but living in the shale area and exposed to any air pollution and possible water and/or soil pollution from the industry. Since this industry employed males almost exclusively, the female mortality experience would give us a good indicator of community exposure only.

5. A community study may throw some light on the possible effects of long-term environmental contamination from the shale bings in Scotland. Recently completed studies of water quality from a modified in-situ retort in Colorado, U.S.A., demonstrated that a pattern recognition technique can be effective in identifying contamination from the retort (MEGLEN & ERICKSON, 1981). The same technique applied to samples of seepage water taken near a shale bing in Scotland demonstrate the continuing existence of run-off and suggests the applicability of this technique for an environmental assessment in the Scottish shale area (personal communication, DRS. ROBERT MEGLEN & WILLARD CHAPPELL, 1982). A more systematic reconnaissance study of environmental exposure is being proposed by the Applied Biochemistry Research Group, Imperial College, London (personal communication, DR. IAIN THORNTON, 1982).

3. SHALE AREA POPULATION

3.1 Sources of Data

Initial efforts were made to obtain workforce information from industry and union records. The only information located on unions has come from published accounts of wage disputes that required government mediation (JAMESON, 1903-4; SIMPSON, 1914; ASKWITH, 1917; and LAING, 1926). Anecdotal information indicates that all union records have been lost or destroyed (personal communication - MR. JOHN MACKAY, 1982).

Industrial records have also largely disappeared except for that kept by British Petroleum in its archives of Scottish Oils Limited (SOL) at its Grangemouth refinery. These archives were made available for review. The SOL archives contained the records upon which the current U.S.DOE-funded study is based.

The geographic location of the industry was determined by the geology of the area which has been reviewed and updated recently in terms of previous workings and present deposits (CAMERON & McADAM, 1978). These boundaries serve to corroborate the population-based information to be presented in this report.

Census data quoted are based on a thorough review of the Censuses of Scotland beginning in 1861. Another source of official records came from that published by the Secretary of Mines which annually reports the production of mined materials and the workforce required to produce them as well as some data on accidents. A further source of information about the shale industry came from the Lothian Regional Council regarding location of shale mines and bings (personal communication - MR. JAMES HENRY, Geologist/Planner, 1982).

3.2 Information from Census of Scotland (REGISTRAR GENERAL SCOTLAND 1861-1961)

Table 1 summarises information from the Census of Scotland on the shale worker population. There were so few female workers throughout the period that only male statistics are utilised. The first mention of shale mining as an occupation appeared in the 1891 Census. From the beginning the industry was almost wholly confined to two counties - Midlothian and West Lothian. The small numbers of workers in Lanarkshire (169 in 1891) and Fife (484 in 1891) disappeared by the

early years of the 20th century. The 1891 Census was the first and only time shale mining occupation was tabulated separately from coal mining. In 1891, shale miners were almost equally distributed between Midlothian and West Lothian counties - 2186 in the former and 2036 in the latter - and it is the only time the number of shale workers in Midlothian exceeded those in West Lothian.

In the 1891 Census there is no indication of the number of persons engaged in shale retorting and refining. An estimate can be arrived at from the 1911 Census which shows that at that date persons other than miners in the industry comprised 40.3% of the workforce. Thus, a total industry estimated workforce in 1891 is 7072. It was only at this early time that shale and coal workers were equal in numbers, with shale workers becoming a distinct minority in Midlothian by 1911.

Only the combined number of persons indicating either coal or shale mining as an occupation is listed in the 1901 Census. In the 1911 Census, a new section on Industry was added. Thus in 1911 and subsequently, the statistics are taken from the Industry section of the census and the figures for shale workers include those also engaged in retorting and refinery activity. Miners comprised 59.7% of the workforce engaged in the shale industry in 1911.

In 1911, the number of shale industry employees reached its peak from census figures of 8737 men. This includes 838 employees in the two counties associated with the mineral oil industry. Anecdotal data suggests that the actual peak number of employees was 10,000 during World War I. No specific tabulation of the number of shale miners was given in 1921 but can be estimated as somewhere in the range of 59.7% of the workforce based on the 1911 Census and 50% of the workforce based on the 1931 Census - i.e. between 4368 and 5216 men.

The remarkable thing about the 1921 Census was the way it showed the geographic distribution of employees within each county by Small Burghs and Districts of County. Table 2 shows that 95% of the shale worker population was confined to one District of County in Midlothian - Calder - and two Districts of County in West Lothian - Linlithgow and

Bathgate. In contrast, only 32% of the coal miners in the two counties are found in these areas, so that shale to coal worker ratios are 3.55 in Calder and 3.32 in Linlithgow and 0.94 in Bathgate. The geographic separation of shale from coal workers in Bathgate District of County is probably fairly complete also, since two of the five civil parishes included in Bathgate District of County are known to have no shale activity.

In 1931, a new classification of oil refinery industry was used so that total shale industry employees are determined by adding shale and oil refinery workers together. The 1931 Census shows for the first time a decrease in the number of workers engaged in the shale industry, the 5847 workers representing only 67% of the number employed in 1921. Fifty percent of the workforce was classified as engaged in the oil refining industry. There was no Census in 1941. In 1951, shale industry workers numbered only 3546, 40% of the number in 1921 and 61% of the number in 1931. Miners comprised 55% of the workforce in 1951. The 1961 Census for industry and occupation was a 10% sample for Scotland as a whole and no county-specific data are available.

In considering health risks, it may be useful to examine miners separately from retort and refinery workers. From the census figures the best estimate of number of shale miners is as follows:

	<u>Year</u>				
	<u>1891</u>	<u>1911</u>	<u>1921*</u>	<u>1931</u>	<u>1951</u>
West Lothian	2036	3609	3795	2473	1310
Midlothian	2186	1398	1421	439	645

*These numbers of miners are maximum estimates.

Restricting the ratio of shale to coal workers to miners - useful from the standpoint of considering occupational health risks such as pneumoconiosis which are restricted to mining, the ratios for the two counties become:

	<u>Year</u>				
	<u>1891</u>	<u>1911</u>	<u>1921</u>	<u>1931</u>	<u>1951</u>
West Lothian	.63	.50	.49	.33	.19
Midlothian	.53	.11	.14	.04	.06

3.3 Information on Production and Workforce from Annual Reports of Secretary of Mines (SECRETARY OF MINES, 1875-1962)

Figure 1 shows the number of employees engaged in shale mining from 1875-1938 and the number of tons of shale mined from 1875-1962. Employee figures are missing for the years 1891, 1892, 1894, 1894, 1901 and 1902. A total of 164 million tons (2240 pounds/ton) of shale was removed over the entire period.

The figure on the number of employees engaged in mines agrees very closely with those obtained in the section above from the census with each year. The national strike in 1921 would be expected to lower the Secretary of Mines' figures somewhat, but the lower estimate from the census agrees with the 1920 and 1922 Secretary of Mines' report. Unfortunately, the way records were kept by the Secretary of Mines changed after 1938 so figures on numbers of miners are not available after that date. However, the 1955 miners from 1951 Census figures fits well with the production figures of 1.4 million tons, since in 1938 when 1.55 million tons were mined, the Secretary's report indicated 2017 miners. Shortly after 1951, production began to fall and undoubtedly the number of miners employed decreased also. The SOL archives contain the number of employees in the industry during the last seven years (1956-1962) which were as follows: 2837, 2734, 2515, 2340, 2220, 1906 and 664. (These figures include only shale-related employees of SOL). The SOL archives also contain employment information that fills in the gap between 1938 and 1951. The total workforce in 1940, 1942 and 1946 was 4921, 4847 and 4300 persons respectively with miners comprising 2376, 2361 and 1863 persons respectively.

Independent confirmation of the figures from the Secretary of Mines Reports and the Census was found in The Report of a Court Investigation Concerning the Wages Position in the Scottish Shale Oil Industry (LAING, 1926). The industry presented the number of employees in November 1925 in this report. The 4315 miners agrees with the Secretary of Mines

Report for 1925 and the total number of employees (6882) is intermediate between that indicated in the 1921 and 1931 Census.

3.4 Information on Geographic Distribution of the Industry from Location of Mines and Bings

A third means of establishing the geographic location of the industry within West Lothian and Midlothian counties has been possible through the assistance of the Lothian Regional Council. Both the location of the shale bings and a listing of the shale mines for which abandonment plans had been filed including their location on 6-inch Ordnance Survey maps was available. Location of 67 of the approximately 100 mines on the list was confirmed independently by review of Ordnance Survey maps and plotted by civil parish in Figure 2. The 24 mines that were active after 1925 are circled. The 27 shale bings are indicated by letter (the letters Q and U not used). Bings establish the location of the retorts where the shale was heated for release of oil from the kerogen. The spent shale was then disposed of in bings. The names of the mines by number, and the bings by letter are found in Tables 3 and 4 respectively. The retorted shale from many of these bings has found other commercial uses - the major ones being use as roadbed for highways and use for making brick. During the last 40 years of the industry, three of the refineries were located in Uphall Civil Parish and one in Kirknewton. The information in Figure 2 is summarised by civil parish of location in Table 5. They include all but three of the civil parishes listed in Table 2 and based on the number of mines and bings can be easily grouped into six civil parishes. designated "Heavy Shale Area" and five designated "Light Shale Area". Only 2 mines and 2 bings are located outside these civil parishes with Mine No. 22 and Bing AA located in the village of Tarbrax in Lanarkshire just outside Midlothian, and Mine No. 56 and Bing CC located in Pentland, a suburb of Edinburgh city.

While the designation of Heavy and Light Shale Areas is somewhat arbitrary, it is the most reasonable division based on all the data taken together. Table 6 shows the 1961 Census population of the two counties broken into these areas. The Heavy Shale Area contains

30482 persons - 15% of the total population of the two counties. The Light Shale Area contains 17149 persons (8% of the population) or 43429 persons (21% of the population), depending upon whether the small burghs of Bathgate, Armadale, Linlithgow and Queensferry are included. When the location of the approximately 6000 former shale workers under study by the Institute of Occupational Medicine is known, a final decision on designation of the shale areas can be made.

4. CAUSE OF DEATH INFORMATION

4.1 Sources of Data

Health officials were contacted on the national level at the Common Services Agency and on the regional level at the West Lothian District Health Office. The latter identified key consultants, family practitioners and former shale workers who could provide both an orientation to the health practices in the area and comment specifically on the health status of the shale workers. Extensive meetings with the Registrar General of Scotland's staff provided the necessary information on published and computerised vital statistics (personal communication - MR. DAVID ORR).

4.2 Quality of Medical Care

There were no hospitals in West Lothian and Midlothian Counties until after World War II. All laboratory tests, x-rays and hospitalisations occurred in Edinburgh. A significant step forward in the provision of medical care occurred when Bangour General Hospital became available as a regional civilian hospital after World War II. It is located in West Lothian in the heart of the eleven shale-area civil parishes. The second factor that affected medical care throughout the U.K. was the introduction of the National Health Service in 1946. Thus for both general and special reasons it can be assumed that there was improvement in availability as well as quality of medical care after World War II. Although the foregoing sections document an active workforce in

oil shale dating from before the turn of the century, the quality of the medical information including causes of death can be questioned prior to 1950.

4.3 Registrar General of Scotland Vital Statistics Records (REGISTRAR GENERAL SCOTLAND 1951-1970)

From the foregoing sections it is clear that the population at risk from the oil shale industry was found to be divided between two counties, West and Midlothian, with the Heavy Shale Area representing only 15% of the 1961 population of these counties. Thus, it would not be expected that county level vital statistics would reflect increased health risks even if they were present in this subpopulation. Furthermore, although causes of death by ICD code are available by age and sex for Scotland as a whole, the basic data about selected causes of death necessary for calculating age/sex/cause specific rates on the county level is available only from 1931. The Registrar General's Annual Report publishes no data on areas below the county level.

Table 7 lists some of the specific causes of death in which we would be especially interested, based on published occupational health studies on workers in oil refineries, coke ovens, coal mines and granite quarries and the data available on the county level for their estimation. Except for Bronchitis and Emphysema which is available throughout, no other causes of death of interest are identified except lung cancer beginning in 1958 and stomach cancer beginning in 1968.

At this point, it is apparent that published information on causes of death is insufficient for a proper study of mortality experience. The Registrar General has recorded on computer cancer deaths from 1953 and all deaths from 1971 so that most specific causes of interest in Table 7 can be obtained during this period and, most importantly, the deaths are coded by area of usual residence in small areas. The computer classification by the 27 small areas for West Lothian and

Midlothian together with the corresponding civil parish are shown in Table 8. Data on these same small areas are also available after the reorganisation of areas of Scotland from counties into districts in 1974, using the appropriate combination of postal zone codes.

4.4 Estimation of Number of Deaths by Cause

Table 9 contains a more complete list of causes of death, including the respective ICD three-digit codes for the 6th, 7th and 8th revisions, which would be of interest for a community mortality study. Table 9 also indicates a range of annual estimated deaths for the two county area based on the best available data from a combination of national and county vital statistics. Table 10 shows actual, where possible, and best estimates elsewhere of numbers of deaths by each five year period from 1951-1970, for these two counties. Whole numbers indicate actual observed deaths and decimal figures indicate estimates. Methods for deriving the figures for Table 10 are recorded in detail in Appendix I. When grouped by five-year periods, the number of estimated deaths are large enough to be able to establish reasonable confidence limits for all causes of interest except perhaps for the rare causes - brain, kidney and bladder cancer.

4.5 Comparison Areas

The best test of association with the shale industry will probably be gained by examination for a gradient of mortality from the Heavy Shale Area to the Light Shale Area, and to the Non-Shale Area of West Lothian and Midlothian counties. In addition, it would be desirable to have a non-mining population and a population where coal mining is the major mining activity for the period. The adjacent seven Borders counties to the south (combined 1951 male population of 79,239) fit the former and the county of Fife to the north fits the latter (1951 male population of 97,185, with 25% engaged in coal mining).

5. SEARCH FOR OTHER SOURCES OF INFORMATION ON HEALTH EFFECTS FROM SCOTTISH SHALE OIL INDUSTRY

5.1 Early History

In preparing this feasibility study, a thorough review was made of both published and unpublished sources describing the Scottish shale industry. This included search for dissertations in British universities relating to oil shale, reviewing archival material relating to the oil shale industry in possession of British Petroleum, and interviews with former employees, geologists, physicians, officials in government agencies with special emphasis on the National Health Service, and university researchers.

The best source of information on the early years of the industry comes from PROFESSOR JOHN BUTT'S Ph.D. THESIS (1964).

Wages were considerably better than for agricultural jobs at the time of the inception of the shale industry and the new industry took advantage of the decline in the numbers of employees needed for handloom weaving in the textile industry. However hours were quite long and a number of labour disputes in the early days were over the long hours of employment. Retort men, for example, worked 78 hours one week and 72 hours the next. By 1872, most of the trades in the oil shale industry were working 60 hours per week. James Young, the founder of the shale oil industry, had a relatively enlightened attitude towards labour and sought to eliminate potential health hazards. Water sprays were used beneath the shale crushers to reduce dust. He established a school for children of the workers and placed emphasis on good housing. As early as 1872, a physician was employed by the company. The paternalistic attitude towards the workforce found expression also in voluntary accident benefit paid to workers seriously injured and hospital expenses were paid at the Edinburgh Royal Infirmary! Boom town conditions existed in the area from 1850-1870 with a great deal of overcrowding despite industry's attempts to provide adequate housing. There was a great deal of social unrest due largely to the overcrowding and to the fact

that the newcomers were Irish immigrants coming into a historically protestant area.

5.2 Accidents

There were no reported fatal accidents in the industry from 1851-1862. A five year experience of accidents in the industry was reported at the first Oil Shale and Cannel Coal Conference (WINSTANLEY, 1938).

Over the period 1933-37 16 fatal, 53 serious and 2126 total accidents were reported, a reported accident being one that resulted in three or more days of disability. Assuming 8-hour shifts, average annual incidence was 0.15 fatal, 0.50 serious, and 20.0 total accidents per 200,000 man-hours (100 workers per year). At the time this was considered a good safety record, especially in the area of accidents caused by explosives. Despite the fact that over half a million shots were fired each year, only one fatal and four serious accidents were due to explosives.

The documents relating to specific accident incidents in the SOL archives were reviewed and are summarised as follows:

1. Report of fire at Ingliston Pit in 1917 (no loss of life)
2. Explosion of magazine at Duddingston 1921-22 (no loss of life)
3. Fire at Oakbank - 1921 (The fire was in the housing, not the mine)
4. Accident to Patrick O'Donnell - 1920 (probably caused by ignition of a mine lamp)

Anecdotally, the following reasons were given for why shale mining was safer than coal mining: the workings were larger, the roof was safer with less crumbling, and dust from coal can be itself explosive while shale dust is not. The hazard from methane was judged to be equal in this area (personal communication - DR. EAMON HYDE, 1982).

5.3 Dermatitis and Skin Cancer

Dermatitis and skin cancer are the best recognised health hazards from the industry. The problem was identified in the paraffin shed workers before the turn of the century and effective preventive measures introduced with virtual elimination of the problem by the 1920s (SCOTT, 1922 and 1923).

5.4 Environmental Pollution

The only indication that there were some problems from environmental pollution comes from items listed in the SOL archives:

1. Copy memorandum of agreement between J. Shairp of Houston, Uphall, and Young's Paraffin Light Company regarding damage caused by smoke (1905-1915). (Agreement was for the company to pay 80 pounds per year for 15 years.)
2. Midlothian County Council's Rivers Pollution (Prevention) Acts. Effluent from Addiewell Works 1937-1938 (Problem related to high temperature of water which was corrected).
3. Fumes from Uphall Works. Complaints from B. Ivory and J. Shairp - 1931 (Fumes were sulfurous and no settlement was made).

5.5 Pneumoconiosis and Lung Cancer

The recent report by SEATON et al (1981) documents the existence of pneumoconiosis among four former shale miners and because of the finding of lung cancer in two cases at post mortem raises the question of the association of lung cancer with shale mining. The latter possibility is currently the subject of a three year case/control study being funded by a U.S. DOE contract with the Institute of Occupational Medicine.

Bangour General Hospital has had a full-time pathologist since 1963. The same pathologist has been in charge from 1963 to the present. Data from Bangour provides a potential source of new information about frequency of pneumoconiosis. The over 300 post mortems with a pathological diagnosis of pneumoconiosis may permit a greater

assessment of this risk in shale miners and perhaps give some insight into the relative risk of shale vs. coal miners for pneumoconiosis (personal communication - DRS. W. M. MARINE and G. SCLARE).

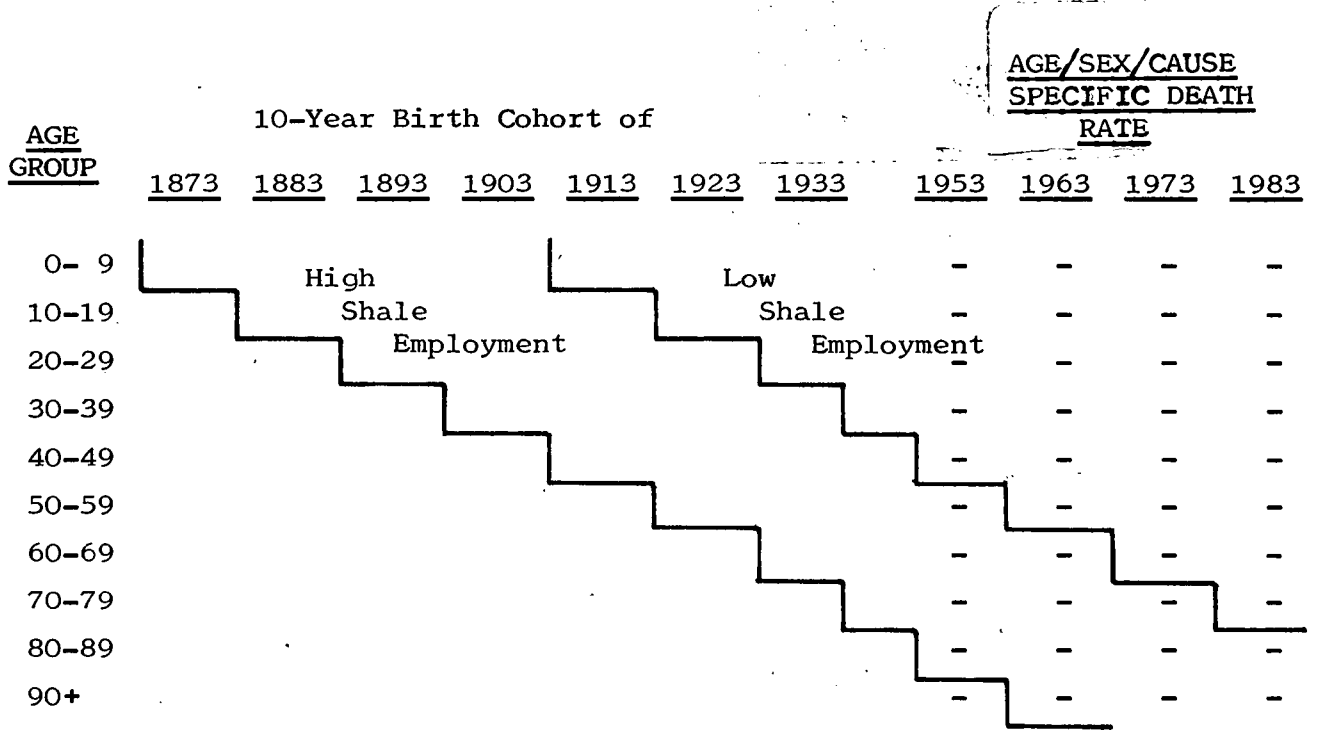
6. DISCUSSION AND CONCLUSION

This report has presented the kinds of information available that will make an intensive study of mortality in the shale area of Scotland possible. The goal has been to uncover any insurmountable obstacles that would render a study inadvisable, and to identify any additional reasons supporting a community study.

The shale area population appears well defined. Census information, Secretary of Mines information, and location of mines and bings all combine to identify the population of six civil parishes within West Lothian and Midlothian counties as the Heavy Shale Area.

The greatest advantage of being able to localise the industry so precisely is that a gradient of mortality from Heavy to Light to Non-Shale areas can be analysed to test the hypothesis that there may be a causal relationship between the shale industry and any excess cause of death observed.

Documentation of the size and location of the shale industry workforce from 1891-1962 suggests that mortality experience be studied over the entire period. A major constraint in the scope of a community mortality study is the unavailability of computerised vital records before 1953. While this means that cross-sectional age specific death rates are only available from 1953, we can still obtain a good indication of the major causes of mortality before 1953 by employment of the birth cohort analysis technique. This technique, first applied to the study of tuberculosis mortality has also been most useful in examining the lung cancer "epidemic" in developed countries. An illustration of how this technique can be applied to a community mortality analysis in the shale area is shown in the following table:



As noted above in the brackets, the mortality of four "high shale employment" 10-year birth cohorts from 1873-1903 will be reflected by the age/sex/cause specific rates for the population 50+ in 1953, 60+ in 1963, 70+ in 1973 and 80+ in 1983. The mortality of the "low shale employment" 10-year birth cohorts from 1913 and beyond will be reflected in the age/sex/cause specific rates of the population less than 50 in 1953, less than 60 in 1963, less than 70 in 1973 and less than 80 in 1983. The greatest differences should be expected in the Heavy Shale Area where employment was greatest. While examination of cross-sectional mortality prior to 1953 would have been desirable,

this limitation may not be as great as it seems at first when one considers the quality of medical care and records prior to 1950.

The coding of computerised death records by small area offers a strong methodological justification for undertaking a community study of mortality. First, the mortality statistics can be assembled by Heavy, Light and Non-Shale areas in order to test the hypothesis of occupationally-related exposure. Second, it will then be possible to examine the other major hypothesis of adverse health effects from the industry - that of environmental exposure. In addition to the obvious route of air pollution while the industry was active, there are the other possible routes of water and soil pollution. The presence of the bings and their environmental exposure constitutes an ongoing potential hazard to the population. The geochemical studies planned may uncover a source of continuing pollution for which the small area data may provide relevant health effects information. Conversely, unexpected health effects identified from small area analysis may provide a focus for geochemical studies. The search for other sources of information on health effects from this industry confirms the paucity of data and provides additional rationale for a comprehensive community approach. The archival information from SOL confirms that even during a period when public awareness of environmental pollution was not well developed, examples of air and water pollution from the shale industry came under public scrutiny.

This study has attempted to paint a picture of the Scottish shale oil industry from the standpoint of the group that made the industry possible - the employees and their families. The picture that emerges is one of a vigorous and dominant industry for the majority of men in the area until after World War I. It became a less dominant employer in the area after 1930, and soon after 1950 the industry

was eliminated in stages until it ceased altogether in 1962. Viewed within this scenario, the current IOM study is focused on a "remnant" workforce - rather small in size which worked at a time when the industry was most advanced technologically and when industrial exposures are likely to have been less than at earlier periods. Nevertheless it is the only purely occupational group available and will doubtless yield important results.

In conclusion, this report points out in some detail that a community study of the shale oil area offers unique research opportunities largely due to the fact that the entire industry was confined to a very small area where for many years it was a major employer. Perhaps most importantly a community study as outlined provides a way to capture the mortality experience of former shale workers or retired workers who still lived in the area in 1950 and are not part of the current IOM study group. A conservative estimate is that the number would at least equal the 6000 in the IOM'S study - thus doubling the number of employees under study. If indeed there are important health risks associated with shale mining and processing, then our ability to estimate the magnitude of that risk with reasonable confidence depends on -

- (a) the size of the risk-group available for study, and
- (b) the range of exposures represented by the risk-group.

A community study of the shale oil area would probably increase both (a) and (b) and thus provide a means of further exploiting the Scottish shale oil industry experience.

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TABLE 1

Census of Scotland
Data on
Occupation and Industry for West Lothian and Midlothian (excluding Edinburgh)

MALES

Census Year	<u>SHALE INDUSTRY</u>			<u>SHALE AND COAL INDUSTRY TOTAL</u>	<u>SHALE/COAL WORKER RATIO</u>	
	West Lothian	Mid Lothian	Total		West Lothian	Mid Lothian
1891	2036	2186	4222*	11548	.63	.53
	3410**	3662**	7072**		1.06	.89
1901				14678		
1911	6046	2342	8388	28215	.83	.19
1921	6356	2381	8737	26445	.81	.24
1931	4323	1524	5847	24096	.58	.14
1941		No Census				
1951	1883	1663	3546	20991	.26	.16
1961		10% Sample --- No County Data				

* 1891 Census counted shale miners only. Other Census data represents both shale miners and oil refinery workers.

** Estimated total employees in industry based on 1911 census that indicated 59.7% of all employees were miners.

Table 2

1921 Census Data on
Geographic Distributions of Shale Workers and Coal Miners within West Lothian and Midlothian

MALES

District of Co.	Civil Parish	Shale Workers	Coal Miners	Shale/Coal Worker Ratio
Calder (ML)	West Calder	2368)	667)	3.55
	Mid Calder			
	Kirknewton			
Linlithgow (WL)	Abercorn	1832)	551)	3.32
	Bo'ness Carriden *			
	Dalmeny			
	Ecclesmachan			
	Kirkliston			
Linlithgow	95%	32%		
Bathgate (WL)	Bathgate	4106)	4373)	.94
	Livingston			
	Torphichen*			
	Uphall			
Whitburn*))		
Elsewhere in West Lothian and Midlothian	431) 5%	12118) 68%	.04	
Total West Lothian and Midlothian		8737) 100%	17709) 100%	.49

* Non Shale CP

TABLE 3. SHALE MINES BY CODE NUMBER IN FIGURE 2, CIVIL PARISH, SEAMS WORKED AND DATE OF ABANDONMENT

Code No.	MINE	Civil Parish	Seams Worked	Date of last Abandonment Plan
1.	Philpstoun No. 1	Abercorn	Upper Broxburn; Broxburn; Dunnet	1962
2.	Philpstoun No. 6	Abercorn	Dunnet	1962
3.	Hopetoun, Fawns Park No. 41	Ecclesmachan	Broxburn Main; upper; Grey; Upper Grey.	1927
4.	Hopetoun Glendevon No. 5.	Uphall	Broxburn	1891
5.	Hopetoun No.35	Ecclesmachan	Broxburn Main; upper; Grey Upper Grey	1958
6.	Ochiltree No. 2.3	Linlithgow	Broxburn	1912
7.	Ochiltree	Linlithgow	Broxburn	1889
8.	Duddingston No. 3	Abercorn	Jubilee; Curly; Wee; Plain; Dunnet; Barracks	1956
9.	Duddingston No. 1. & 2	Abercorn	Dunnet; Barracks	1941
10.	Tottywells	Dalmeny	Broxburn; Main; Pumpherston Plain	1960
11.	Gavieside No. 40	West Calder	Dunnet; Under Dunnet;	1927
12.	Polbeth No. 26	West Calder	Dunnet	1947
13.	Polbeth No. 21	West Calder	Broxburn	1907
14.	Limefield No. 32	Mid Calder	Dunnet	1923
15.	Polbeth No. 11 and Westwood No. 30.	West Calder	Addiewells or Fells	1900
16.	H ermand No. 4	West Calder	Dunnet	1961
17.	Seafield No. 3	Livingston	Upper Dunnet; Dunnet; Barracks	1917
18.	Cobbinsbaw South	West Calder	Fells	1903
19.	Cobbinsbaw No. 5	West Calder	Fells	1926
20.	Tarbrax, Viewfield No. 5	West Calder	Fells	1926
21.	Tarbrax, No. 1 & 2	West Calder	Fells	1903
22.	Tarbrax No. 4. Viewfield		Fraser	1920

Code No.	MINE	Civil Parish	Seams Worked	Date of last Abandonment Plan
23.	Burngrange No. 39	West Calder	Broxburn or Under	1912
24.	Burngrange No. 1 & 2	West Calder	Dunnet	1958
25.	Westwood	Livingston	Fells; Broxburn; Dunnet	1962
26.	Ingliston No. 36 & 37	Kirkliston	Camps	1926
27.	Roman Camp No. 2	Mid Calder	Curly; Main; Under; Wee	1893
28.	Pumpherstons No. 4	Uphall	Camps	1927
29.	Loaninghill No. 4	Uphall	Curly; Dunnet	1930
30.	Pumpherstons No. 1 2 & 3	Mid Calder	No.1 Upper or Jubilee; No. 2 Maybrick; No. 3 Curly; No. 4 Plain; No. 5 Wee	1901
31.	Crossgreen No. 2 & 3	Uphall	Broxburn; Curly; Grey	1899
32.	Carledubs	Uphall	Curly; Grey; Upper Grey; Broxburn	1922
33.	Pyothall No. 5	Uphall	Curly; Grey; Broxburn	1919
34.	Hopetoun No. 3 Niddrie	Uphall	Broxburn	1884
35.	Greendykes South	Ecclesmachan	Broxburn; Curly; Grey	1915
36.	Haycraigs	Ecclesmachan	Curly; Broxburn; Grey	1919
37.	Greendykes North	Ecclesmachan		1874
38.	Dunnet Sandhole	Uphall	Dunnet	1927
39.	Stewartfield No. 1	Uphall	Broxburn; Curly; Grey; Fells; Dunnet	1923
40.	Stewartfield No. 2, 3 & 4	Uphall	Broxburn; Curly	1914
41.	Albyn	Uphall	Broxburn; Curly	1905
42.	Newliston No. 29	Kirkliston	Dunnet	1937
43.	Hut	Uphall	Grey; Curly; Broxburn	1912
44.	Drumshoreland Muir	Uphall	Lower Dunnet	1901
45.	Forkneuk No. 1	Uphall	Broxburn	1886
46.	Forkneuk No. 9, 10, & 38	Ecclesmachan	Broxburn; Upper Grey	1909
47.	Fivestanks	Uphall	Raeburn	1920

Table 3 (continued)

Code No.	MINE	Civil Parish	Seams Worked	Date of last Abandonment Plan
48.	Stankards No. 1 & 45	Uphall	Upper Broxburn; Broxburn; Grey	1912
49.	Mid-Briech	Livingston	Broxburn; Dunnet	1961
50.	Briech No. 1 2 & 3	Livingston	Broxburn	1927
51.	Dean No. 1, 2 & 4 Capithall	Bathgate	Stanley; Dunnet; Pattison	1938
52.	Rosshill No. 1 & 2	Dalmeny	Upper; Mid; Lower	1921
53.	Dalmeny No. 2 & 3 Railway	<i>Dalmeny</i>	Main or Broxburn; Curly; New Brushing	1914
54.	Fraser	West Calder	Fraser	1951
55.	Baads	West Calder	Dam	1873
56.	Mortonhall No. 9 & 10 Straiton No. 3, 4, 7 & 8; Pentland No. 1 & 2		Dunnet; Broxburn; Fells	1900
57.	Boghall No. 4	Bathgate	Fells	1871
58.	Cousland No. 1	Bathgate	Broxburn	1912
59.	Alderstone No. 43	Mid Calder	Pumpherstoun	1921
60.	Newfarm No. 3 & 4	Mid Calder	Fells; Lower Big; Curly; Broxburn	1919
61.	Deans No. 6 & 7	Bathgate	Fells; Broxburn	1931
62.	Hopetoun No. 6	Ecclesmachan	Broxburn; Main; Upper Grey	1957
63.	Philpstoun No. 7	Abercorn	Champfleurie; Dunnet	1931
64.	Pumpherstoun No. 5	Mid Calder	No. 1 Upper Dunnet; No. 2 Gavin; No. 3 Lower	1925
65.	Roman Camp No. 5	Uphall	Camps	1934
66.	Dean No. 5	Bathgate	Jubilee	1931
67.	Roman Camp No. 3	Uphall	Wee; Jubilee; Curly; Plain; Maybrick	1938

TABLE 4

SHALE BINGS IN FIGURE 2 BY CODE LETTER
AND CIVIL PARISH

Code Letter	Name	Location by Civil Parish
A	Dalmeny	Dalmeny
B	Philpstoun North	Abercorn
C	Philpstoun South	Abercorn
C	Niddrie Castle	Uphall
E	Faucheldean	Uphall
F	Green Dykes	Uphall
G	Albyn	Uphall
H	Stewartfield	Uphall
I	Uphall East	Uphall
J	Uphall West	Uphall
K	Green Bing	Uphall
L	Drumshoreland	Uphall
M	Clapperston	Uphall
N	Pumpherstoun	Mid Calder
O	Deans	Bathgate
P	Oakbank	Kirknewton
R	Contentibus	Mid Calder
S	Seafield	Livingston
T	Mid Brieche	Livingston
V	Gavieside	West Calder
W	Five Sisters (Westwood)	Livingston
X	Hermant	West Calder
Y	Addiewell South	West Calder
Z	Shuttlehall	West Calder
AA	Tarbrax	Tarbrax
BB	Bridgend	Linlithgow
CC	Pentland	Edinburgh

TABLE 5

Distribution of Shale Mines and Bings in Scotland

Civil Parish (CO)	SHALE MINES Active since 1925		SHALE BINGS	
	Total			
Uphall WL	18	5	10)	53 Mines 21 Bings H*
West Calder ML	13	4	4)	
Ecclesmachan WL	7	3	0)	
Mid Calder ML	6	1	2)	
Livingston WL	4	1	3)	
Abercorn WL	5	5	2)	
Bathgate WL	5	2	1)	12 Mines 4 Bings L**
Linlithgow WL	2	0	1)	
Dalmeny WL	3	1	1)	
Kirkliston WL + ML	2	2	0)	
Kirknewton ML	0	0	1)	
Total Shale Area	65	24	25	
Other Areas - Scotland	2	0	2	
Total Scotland	67	24	27	

H* Heavy Shale Area

L** Light Shale Area

TABLE 6

1961 Census Data

Selected Areas of West Lothian and Midlothian

Area	1961 Census		
	Males	Females	Total
Heavy Shale Area (6 Civil Parishes)	15037	15445	30482
Light Shale Area (5 Civil Parishes)	8759	8390	17149
NoneShale Areas of West Lothian and Midlothian	76953	80152	157105*
Total Population, West Lothian and Midlothian	100749	103987	204736

*Includes 26280 persons (12847 Males and 13453 Females) living in small burghs of Bathgate, Armadale, Linlithgow and Queensferry in light shale area.

TABLE 7

DATA AVAILABLE ON PUBLISHED COUNTY DEATH STATISTICS OF INTEREST

1.	Lung Cancer	None before 1958. In 1958-1967 Malignant Neoplasm of Respiratory System (160-165). Beginning in 1968, 162 code used on county level.
2.	Stomach Cancer	None before 1968. In 1968, 151 code used.
3.	Cancers of Digestive Organs (excluding stomach)	None
4.	Brain Cancer	None
5.	Kidney Cancer	None
6.	Bladder Cancer	None
7.	Other Cancers	None relevant.
8.	Bronchitis & Emphysema	Recorded 500-502 until 1968, when 490-493 used which includes Asthma (493)
9.	Pneumoconiosis	None
10.	Other Respiratory Diseases	None relevant.

TABLE 8

GENERAL REGISTER OFFICE

Computer Classification of Deaths by Small
Areas of Usual Residence for West Lothian
and Midlothian Counties 1953 - 1973.

<u>Computer Classification:</u>	<u>Civil Parishes included:</u>
<p>A. <u>West Lothian County</u> <u>District of County</u> Bo'ness Kirkliston and Winchburgh Linlithgow Torphichen & Bathgate Uphall Whitburn and Livingston</p> <p>Small Burghs</p> <p>Armadale Bathgate Bo'ness Linlithgow Queensferry Whitburn Livingston N.T.</p>	<p>Bo'ness and Carriden Abercorn*, Kirkliston*, Dalmeny Linlithgow* Bathgate*, Torphichen Ecclesmachan*, Uphall* Livingston*, Whitburn</p> <p>Bathgate Bathgate Bo'ness and Carriden Linlithgow Dalmeny Whitburn Bathgate, Uphall, Livingston</p>
<p>B. <u>Midlothian County</u> <u>District of County</u> Currie East Calder Gala Water</p> <p>Lasswade</p> <p>Musselburgh Newbattle Penicuik West Calder Livingston N.T.</p> <p>Small Burghs</p> <p>Bonnyrigg & Lasswade Dalkeith Loanhead Musselburgh Penicuik</p>	<p>Currie, Ratho, Kirkliston* Mid Calder* Kirknewton* Borthwick, Temple, Cockpen, Newbattle, Stow, Crichton, Heriot, Granston, Fala and Soutra Lasswade, Carrington, Cockpen Dalkeith Newton, Inveresk, Dalkeith Dalkeith, Cockpen, Newbattle Glencorse, Penicuik, Lasswade West Calder* Mid Calder*, West Calder*</p> <p>Cockpen, Newbattle Dalkeith, Newbattle Lasswade Inveresk Glencorse, Penicuik</p>

*Civil Parishes within the Heavy and Light Shale Areas

TABLE 9

DEFINITIONS OF GROUPS OF CAUSES, ICD CLASSIFICATION, AND RANGE OF ESTIMATED ANNUAL DEATHS FOR WEST LOTHIAN AND MIDLOTHIAN 1951-1970

Cause Group	ICD Three-digit Codes		Estimated Annual Death by Sex Range 1951-1970	
	6th & 7th Revisions	8th Revision	Male	Female
1. Lung Cancer	162, 163	162	40-125	6-17
2. Stomach Cancer	151	151	33-27	27-13
3. Cancers of Digestive Organs (excl	150; (152 .. 159)	150; (152 .. 159)	45-66	41-59
4. Brain Cancer	193	191	2.8-5.1	1.3-3.4
5. Kidney Cancer	180	189	2.1-5.2	1.4-3.6
6. Bladder Cancer	181	188	5.6-120	1.8-5.1
7. Other Cancers	(140 .. 205) - (162,163) -(150 ..159) - 193-180-181	(140 ..269) - 162 -(150 ..159) -191-189-188	-	-
8. Bronchitis and Emphysema	(500 .. 502)	(490 .. 492)	31-80	12-26
9. Pneumoconiosis	001, 523, 524	010, 515, 516	-	-
10. Other Resp. Diseases	(470 ..527) +241 - (500 ..502) -(523,524)	(460 ..519) -(490-492) -(515, 516)	-	-
11. Ischemic Heart Disease	420,422	(410 .. 414)	-	-
12. Other Cardiovascular Disease	(400 .. 468) -420-422	(390 ..458) -(410 ..414)	-	-
13. Other internal cause	(All Internal Causes) -(Cause Groups 1-12)		-	-
14. All Internal Causes	(001 .. 799)	(000 .. 799)	907-1274	875-1018
15. All External Causes	(800 .. 999)	(800 .. 999)	50-76	23-49
ALL CAUSES	(001 .. 999)	(000 .. 999)	961-1324	845-1067

TABLE 10.

ACTUAL AND ESTIMATED DEATHS BY SELECTED CAUSES BY SEX FOR MIDLOTHIAN AND WEST LOTHIAN 1951-1970

Years	Lung Cancer		Stomach Cancer		Cancer of other digestive organs		Brain Cancer		Kidney Cancer		Bladder Cancer		All other malignant neoplasms		All malignant neoplasms	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1951-55	181.3	41.1	158.9	119.9	249.9	217.2	17.1	9.6	14.6	9.6	28.3	11.8	254.9	307.8	905	717
1956-60	357.0	34.1	153.0	128.5	244.2	249.9	19.3	12.9	20.5	10.5	35.2	14.8	149.8	360.3	979	811
1961-65	348.7	44.4	158.8	121.8	270.0	263.5	21.8	16.2	22.4	12.8	42.1	19.4	226.2	415.9	1090	894
1966-70	544.7	70.5	146.4	93.0	270.8	277.4	19.0	14.0	22.9	15.2	49.2	20.7	233.0	455.2	1286	946
Total	1431.7	190.1	617.1	436.2	1034.9	1008.0	77.2	52.7	80.4	48.1	154.8	66.7	863.9	1539.2	4260	3368
Years	Bronchitis & Emphysema		All Internal Causes		All External Causes		All Causes									
	M.	F.	M.	F.	M.	F.	M.	F.								
1951-55	182	81	4957	4369	318	131	5272	4500								
1956-60	246	89	5277	4534	329	176	5606	4710								
1961-65	288	102	5565	4679	352	186	5917	4865								
1966-70	329.3	87.7	5829	4955	312	189	6141	5144								
Total	1045.3	359.7	21628	18537	1311	682	22936	19219								

West Lothian and Midlothian

	Males	Females
1951 Population	93373	94178
1961 Population	100749	103987
1971 Population	123325	127365

Totals

187551
204736
250690

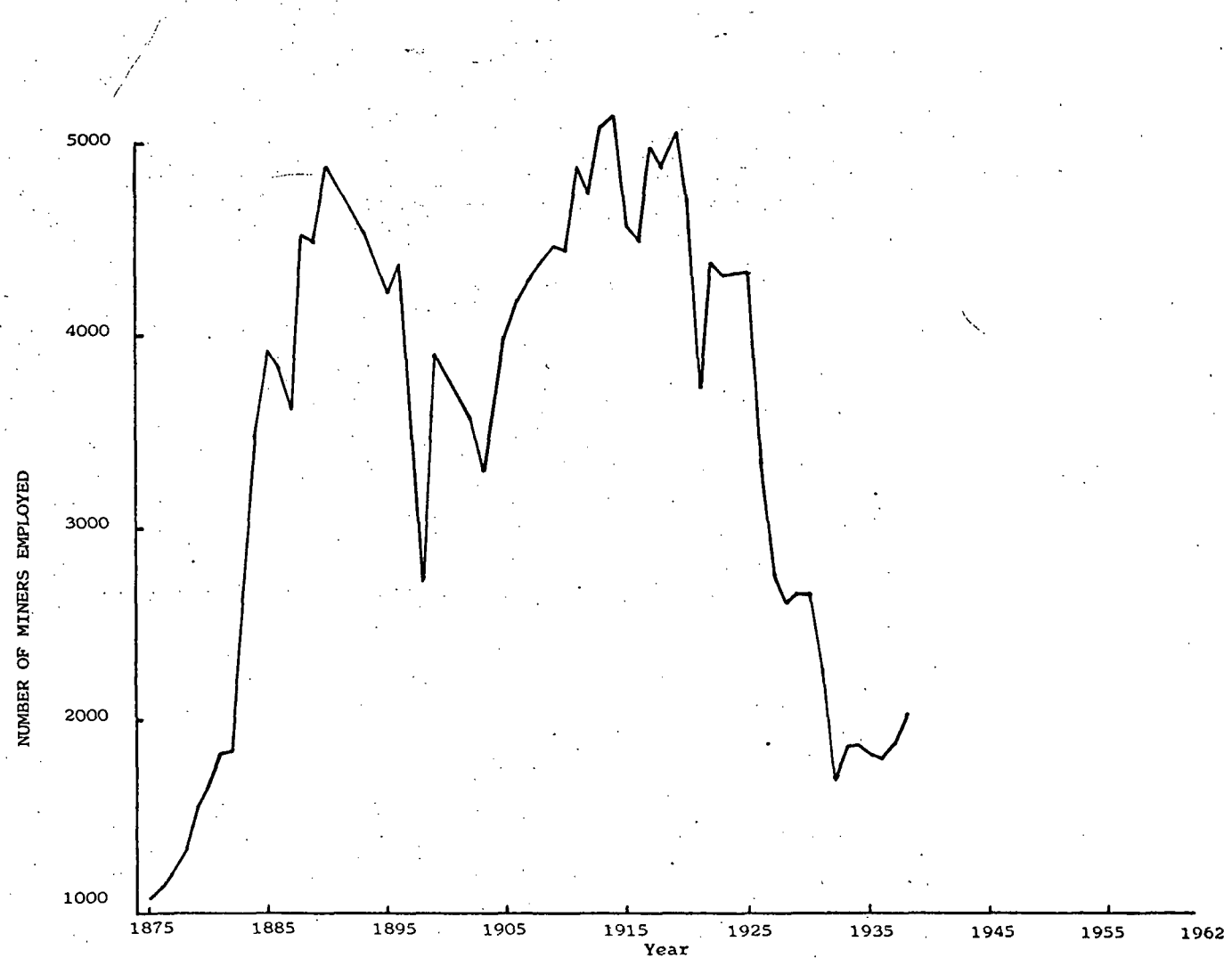
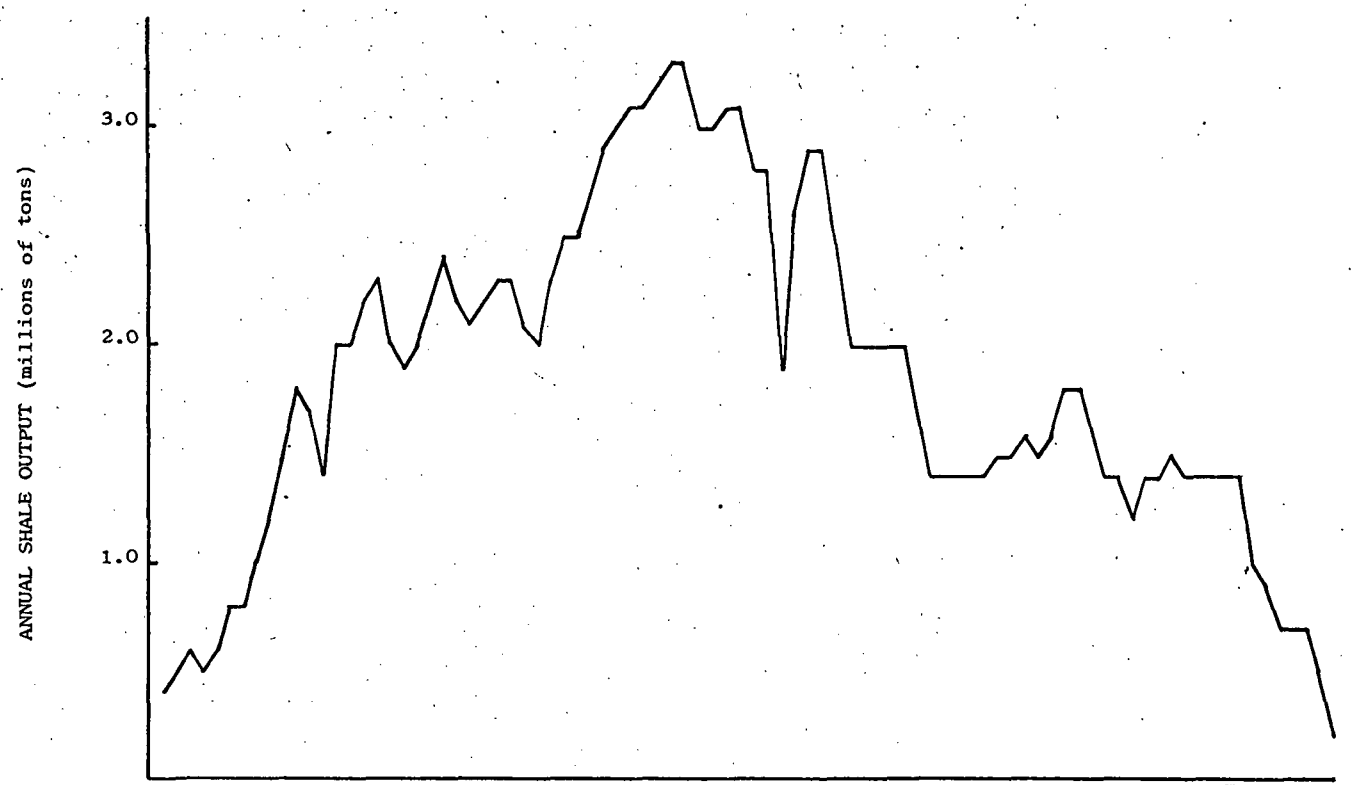
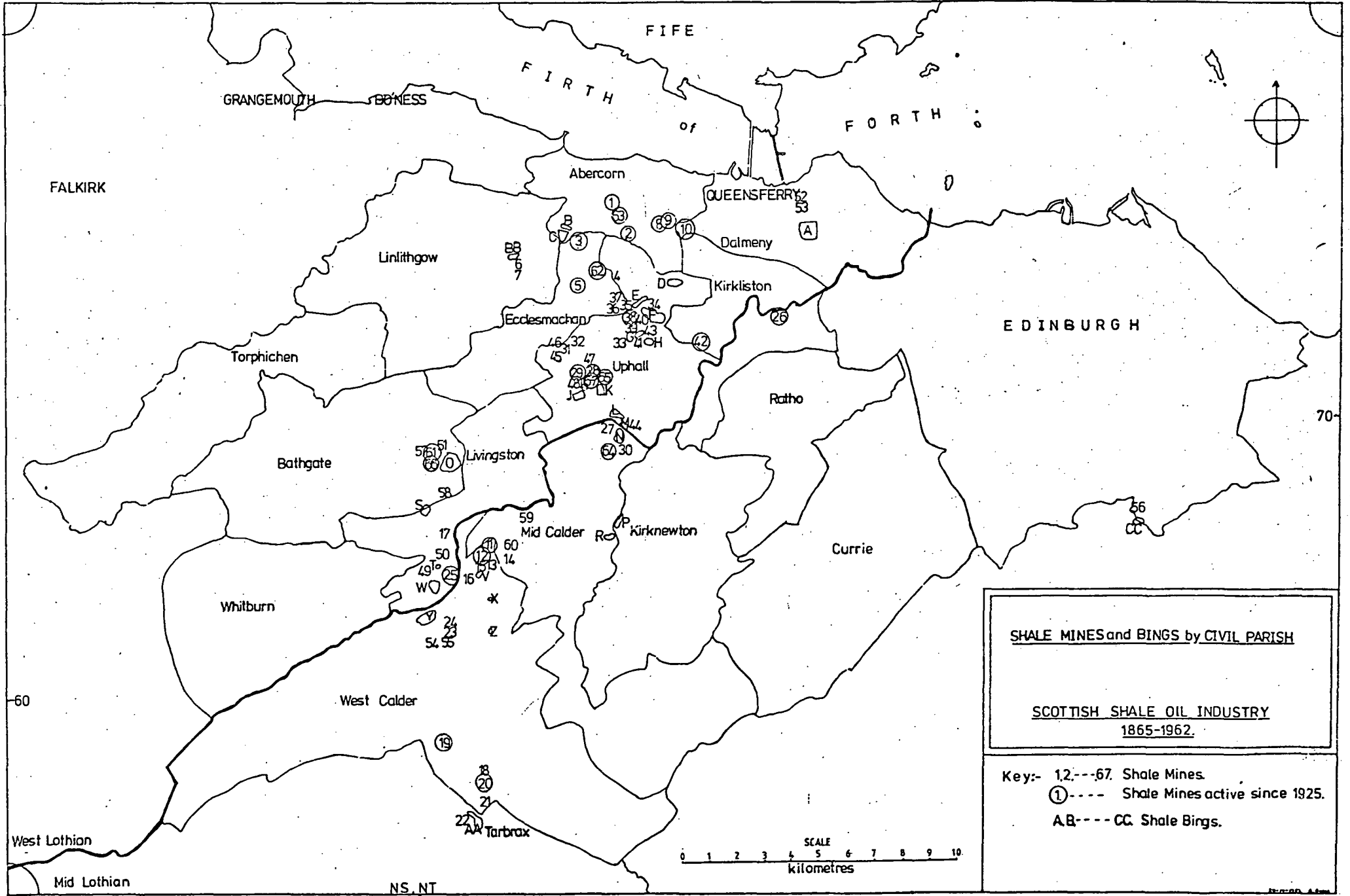


Figure 1: ANNUAL SHALE OUTPUT AND NUMBER OF MINERS EMPLOYED - 1875-1962 FROM SECRETARY OF MINES REPORTS

Figure 2



39

70

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APPENDIX 1

METHODS OF ESTIMATES OF MIDLOTHIAN AND
WEST LoTHIAN DEATHS 1951-1970

1. Lung Cancer: From 1951-57 Malignant Neoplasms of the Respiratory System (ICD 160 ... 165) estimated from each county's All Malignant Neoplasm deaths (ICD 140 ... 205) by use of ratio of Scotland deaths by sex 160-165/140-205.

From 1951-57, estimates of Lung Cancer obtained by ratio of Scotland deaths by sex 162 + 163/160-165 times estimate of Malignant Neoplasms of Respiratory System above.

From 1958-67 estimates of 162 + 163 obtained by use of ratio of Scotland deaths by sex 162+163/160 .. 165 times reported deaths for each county ICD 160 ... 165.

From 1968-70 Lung Cancer (ICD 162) reported by county.

2. For other cancers an intermediate step was the use of the number of deaths from all other malignant neoplasms, excluding death from respiratory neoplasms. Thus from 1951-57 this figure found by subtracting estimates of 160 ... 165 from reported all malignant neoplasms. From 1958-67, all other malignant neoplasms were obtained from county deaths by subtracting (140 ... 205) - 160 ... 165). From 1968-70 the subtraction was as follows: (140 ... 209) - (160 ... 163).

3. Stomach Cancer: From 1951-67 estimates of stomach cancer (ICD 151) obtained by use of ratio of Scotland deaths by sex 151/(140 ... 205) - (160 ... 165) times estimated (1951-57) or reported all other malignant neoplasms at county level.

From 1968-70, stomach cancer reported on county level.

4. For Cancers of Digestive Organs (excluding stomach), Brain, Kidney and Bladder, the ratio of deaths by sex by each cause for Scotland to All Other Malignant Neoplasms deaths for Scotland was multiplied by the combined Midlothian and West Lothian All Other Malignant Neoplasm deaths (140 ... 205) - (160 ... 165) from 1951-67 and (140 ... 209) - (160 ... 163) from 1968-70.

5. For All Other Malignant Neoplasms, the sum of the specific causes estimated was subtracted from the reported All Malignant Neoplasm deaths (140 ... 205) from 1951-67 and (140 ... 209) from 1968-70.

6. All Malignant Neoplasms, All External Causes and All Causes were obtained from actual reported deaths on county level. The All Internal Causes was obtained by subtraction of All External Causes from All Causes.

7. Bronchitis and Emphysema deaths were reported on the county level from 1951-57. Beginning in 1968 estimates of Bronchitis and Emphysema (490 ... 492) were made by the ratio of Scotland deaths by sex $490 \dots 492/490 \dots 493$.

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