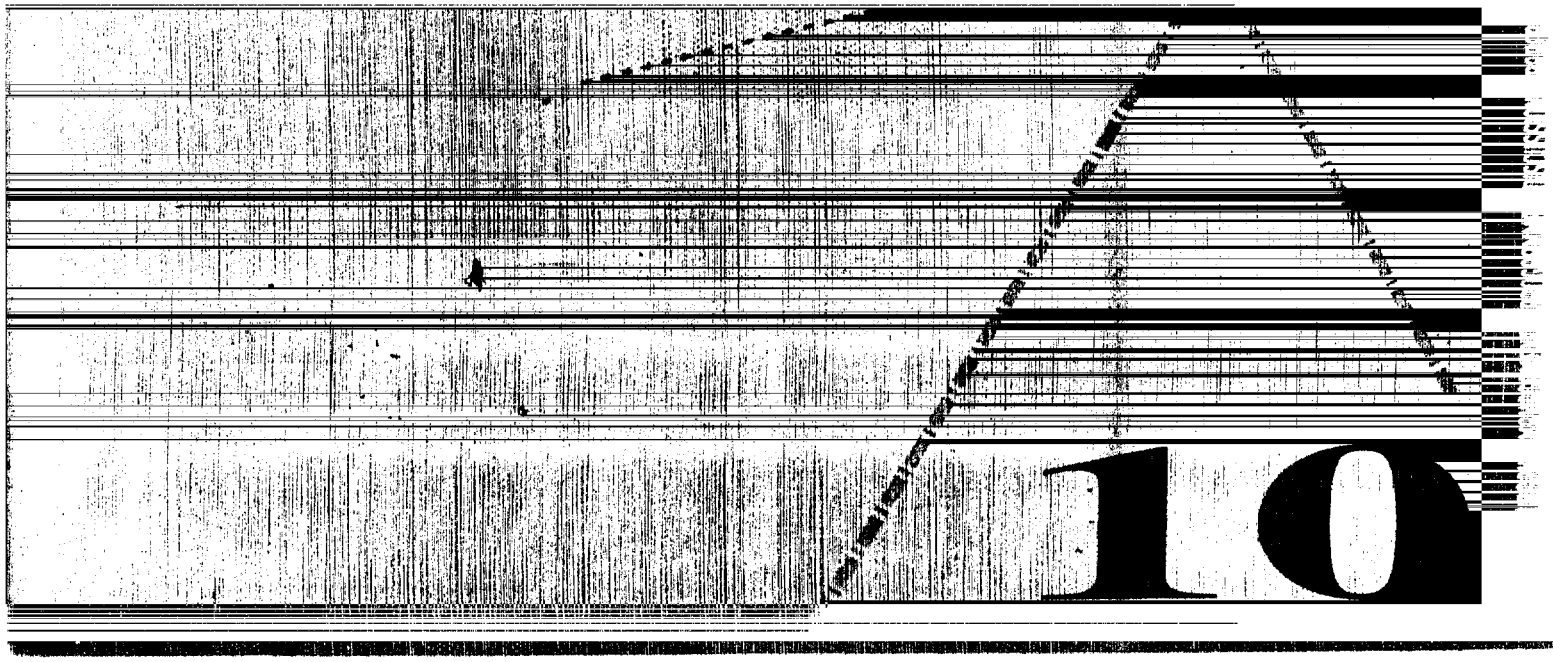
Urban Management Programme

Utility Mapping and Record Keeping for Infrastructure



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Utility Mapping and Record Keeping for Infrastructure

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The Urban Management Programme (UMP) represents a major approach by the United Nations family of organizations, together with external support agencies (ESAs), to strengthen the contribution that cities and towns in developing countries make towards economic growth, social development, and the alleviation of poverty. The program seeks to develop and promote appropriate policies and tools for municipal finance and administration, land management, infrastructure management, and evnironmental management. Through a capacity building component, the UMP plans to establish an effective partnership with national, regional, and global networks and ESAs in applied research, dissemination of information, and experiences of best practices and promising options.

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ABSTRACT

Any attempt to improve, or even maintain, the standard of living in rapidly developing urban areas cannot go forward without adequate municipal infrastructure and utility services. Inadequate or poorly managed services limit urban economic development in several ways;

- exposing segments of the urban population to health risks;
- limiting economic productivity when services are cut-off or unreliable;
- adding financial costs to individuals and enterprises through unnecessary property damage, and;
- creating additional economic costs from congestion of transportation and communications systems.

The economic and efficient delivery of infrastructure services in turn, depends on effective planning and management. Without proper information, spatial and otherwise, the quality of service delivery, financial performance, and the ability to plan can be eroded. Information from maps, and records, based largely on records of utilities and infrastructure facilities, contributes not only to efficient services, but also to the operation and maintenance of assets, and to the sensible planning of extensions and new works. Any serious lack of such information can adversely affect the economy, the quality of life, public health, and the environment.

This discussion paper reviews recent developments in the field of urban infrastructure recording and mapping, a number of issues that need to be addressed, and some actions that could be taken to improve recordkeeping systems. Although the emphasis here is on map and records for utilities basic municipal infrastructure services, particularly those with underground networks, some aspects of the discussion apply to urban management information systems in general. The central point is that the standards of records and information systems in municipalities and utilities often fails to meet the needs outlined above. Any organization that expects to run an efficient day-to-day operation and to manage and develop its services effectively must know what assets it has, where they are, their condition, how they are performing, and how much it costs to provide the service.

As the discussion makes clear, adequate records are essential not only for infrastructure management, but to assess deficiencies and to engage in forward planning. As the need for satisfactory recorded information continues to grow, countries must decide how to deal with a number of related institutional, organizational, and technological issues, including questions of awareness and responsibility. This discussion paper examines those issues and some options for addressing them. The options range from national initiatives to measures that could be taken by municipal departments and utilities on their own or in cooperation with other local bodies.

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FOREWORD

This discussion paper has been prepared for the infrastructure management component of the Urban Management Programme (UMP). Since its inception in 1986, the UMP has become an important member of the UN family of organizations and other external support agencies. It works to strengthen the contribution that cities and towns in developing countries can make toward economic growth, social development, and the alleviation of poverty.

Phase 2 of the UMP (1992-96) is concerned with capacity building at both the country and regional levels and with facilitating national and municipal dialogue on policy and program options. It emphasizes a participatory structure that draws on the strengths of developing country experts and expedites the dissemination of that expertise at the local, national, regional, and global levels.

The main goal of the UMP in Phase 2 is to build the capacity for infrastructure management, municipal finance and administration, land management, urban environmental management, and poverty alleviation by means of three interactive processes:

- City and country consultations. The UMP brings together national and local authorities, private-sector networks, community representatives, and other actors to discuss specific problems within the UMP's subject areas and to propose reasoned solutions.

- Regional panels and technical cooperation. To ensure sustained and effective support for the activities to follow country consultations, the UMP is establishing regional offices, each headed by a regional coordinator, in Kuala Lumpur for the Asia and Pacific region, in Accra for Africa, in Quito for Latin America and the Caribbean, and in Cairo for the Arab States. From 1993 to 1996 the UMP will gradually build up regional panels of urban management expertise for each of the program's five areas of concern, which will provide the structure needed to institutionalize the UMP's capacity-building objective over the long term. Developing countries will be able to draw on this pool of expertise for technical advice on a sustained basis.

- Global support and synthesis. Nucleus teams in Nairobi and Washington, D.C., support the regional panels and national institutions by synthesizing lessons learned, conducting state-of-the-art research, identifying best practices, and disseminating program-related materials. The present paper is part of a series of management tools produced by the UMP.

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i. Any attempt to improve, or even maintain, the standard of living in rapidly developing urban areas cannot go forward without adequate municipal infrastructure and utility services. Inadequate or poorly managed services limit urban economic development in several ways:

- exposing segments of the urban population to **health risks**;
- limiting **economic productivity** when services are cut off or unreliable;
- adding **financial costs** to individuals and enterprises through unnecessary property damage; and
- creating additional **economic costs from congestion** of transportation and communications systems.

ii. The economic and efficient delivery of infrastructure services, in turn, depends on effective planning and management. Without proper information—spatial and otherwise—the quality of service delivery, financial performance, and ability to plan can be eroded. Information from maps and records, based largely on records of utilities and infrastructure facilities, contributes not only to efficient services, but also to the operation and maintenance of assets, and to the sensible planning of extensions and new works. Any serious lack of such information can adversely affect the economy, the quality of life, public health, and the environment.

iii. This discussion paper reviews recent developments in the field of urban infrastructure recording and mapping, a number of issues that need to be addressed, and some actions that could be taken to improve recordkeeping systems. Although the emphasis here is on maps and records for utilities and basic municipal infrastructure services, particularly those with underground networks, some aspects of the discussion apply to urban management information systems in general. The central point is that the standard of records and information systems in municipalities and utilities often fails to meet the needs outlined above. Any organization that expects to run an efficient day-to-day operation and to manage and develop its services effectively must know what assets it has, where they are, their condition, how they are performing, and how much it costs to provide the service.

iv. As the discussion makes clear, adequate records are essential not only for infrastructure management, but to assess deficiencies and to engage in forward planning. As the need for satisfactory recorded information continues to grow, countries must decide how to deal with a number of related institutional, organizational, and technological issues, including questions of awareness and responsibility. This discussion paper examines those issues and some options for addressing them. The options range from national initiatives to measure that could be taken by municipal departments and utilities on their own or in cooperation with other local bodies.

Creating an Awareness of Record Keeping

v. A key issue identified in this discussion is the need for greater awareness of what is required to create and maintain up-to-date and accurate records. This need is evident at all levels of government, from the national through the municipal, down to individual managers in municipalities and utilities. Adequate and appropriate records are required by all levels of management in a utility if it is to provide an effective and economic service and to adequately maintain its asset base.

vi. Two means of increasing awareness of the importance of record-keeping are briefings and training sessions among staff. Such sessions can be used to explain why records are important for planning purposes and for countless other tasks of urban management. For example, senior managers need data to guide investment planning and asset management; they are needed to monitor the amount and quality of information on which applications for funding of infrastructure projects are based. Records are crucial to satisfying customer needs and have a direct connection to the quality of service provided. Utility mapping also effects safety, particularly in cases in which the utility handles an inherently dangerous product (such as gas or power) or because the service, if compromised, may affect public health (for example, if water is contaminated).

vii. In many developing countries, resources, especially skilled staff, are in short supply. It often happens that persons in one utility who have few if any reliable plans will recognize the need for them, whereas those in another utility, although they have good plans will play down the need for them, not recognizing their value. A possible solution is for municipalities or utilities to work together to promote awareness by nominating one of their members to coordinate and encourage activities in this direction. Within the utility or municipal department, a staff member may be encouraged to champion this cause. What is most important, however, is that management recognizes the need to maintain and up-date records and that adequate resources and attention are devoted to these tasks.

Institutional and Legal Issues

viii. Many urban areas lack the legal framework to encourage utilities to establish recording systems. Even where such a framework exists, it often applies to a single service or utility; therefore the systems used by different services and utilities are not compatible. Furthermore, few mechanisms have been established for the exchange of information between utilities and municipal organizations before excavations are started. As a result, underground installations and streets suffer greater damage from such excavations than would otherwise be the case.

ix. Proposals have been put forth in some countries to develop a legal framework for making records more compatible across municipal and utility boundaries and services. Even where legal requirements have been enacted, however, they vary between the different utilities and services. There is little consistency as to scale, although boundaries between utilities and other services often overlap. The main reason for lack of uniformity is that each utility has developed within the legislative framework for its own function with little thought being given to compatibility with

others. At the least, authorities should consider introducing common map scales, location referencing, and standard symbols.

x. To promote the exchange of information before excavations start, governments might consider introducing legislation that would permit all the municipal services and utilities that work in an urban area to establish and operate a single information system. Another option for municipalities might be to set up a common clearinghouse for inquiries and to issue digging licenses. Such licenses might also be an effective way of controlling digging activities, particularly in big cities. A partial mechanism is already in place in some cases. For example, a municipal authority may require a utility to inform it of any work being planned on highways. Such a requirement is mainly a regulatory measure designed to keep the authority abreast of what is happening within its sphere of influence. Such a measure, however, can only be of real use if the notification is passed on, or when suitable records are available and comparable.

Organizational Issues

xi. Of the organizational issues identified in this discussion, one requiring immediate attention concerns the allocation of responsibility for records within the individual utility or municipal department. Who is responsible for collecting and processing data and the methods to be used are often unclear. Where the tasks are defined, they are often given low priority, and the responsible unit is rarely provided with sufficient staff and financial resources to carry them out.

xii. One solution would be for the responsibility for records and information systems to be assigned to an existing department such as operations, planning, or new works; or to a separate department created specifically for this purpose. The difficulty is in persuading utility organizations to disregard financial and personal interests and work together in this regard. Because the municipality represents some legal power within the municipal boundaries, it might be the only official body that can encourage all the concerned parties to agree on how to solve the matter according to local circumstances.

xiii. Where the responsibility for overall control has been allocated, decisions must be made concerning who is to carry out each aspect of the work involved. These tasks can be grouped into the following categories:

- obtaining, collecting, and processing the information;
- building up and maintaining the data base; and
- disseminating the information to the people and organizations that need it.

xiv. The responsible department may be fully involved (that is, it may send its own staff into the field to measure up and gather information), or it may delegate the various tasks to other sections or staff members. In the latter case, the central department would simply coordinate the activities and monitor the completeness and accuracy of the input. Even if the department is fully involved,

it could appoint another section, or even an outside body, to carry out the auditing and quality control.

Technical Issues

xv. As this discussion makes clear, readily available maps and coordinated reference systems are vital components of municipal and utility information systems, particularly for service and asset data. A fundamental rule for urban planning in general is that strategic decisions can only be as good as the maps and information on which they are based.

xvi. **Base Maps**. Two types of base maps are in common use, topographic and cadastral maps. Cadastral maps show details such as property boundaries and are generally most useful for land information and registry. Geographical detail tends to be limited, and features such as buildings are often not shown. The value of such maps to utilities is not great. Topographic maps have much more geographic detail, usually including roads and buildings, and hence are of more value to utilities. Certainly, the utilities that lay pipes and cables along streets and make connections to buildings rely on such maps as the background for their records. However, a single set of topographic maps cannot possibly meet the requirements for all the utilities.

xvii. Several questions need to be considered where base maps are concerned, beginning with who should provide them. This responsibility may be placed with a central government ministry or department, a national agency, or even an outside contractor. If a national approach is not chosen, then a municipality may have to make its own arrangements. It can either seek a solution alone or work in association with other bodies. The cooperating bodies may work in the same areas or have other common interests.

xviii. Decisions will also have to be made on matters such as the preferred scales for maps, the features and level of detail to be shown at each scale, and the manner of production (from ground survey, aerial photography, or a combination of the two). Map updating will be another concern, as is how often updating will need to be done and how these updates should be presented and distributed. Also important is the question of how costs will be met and whether a subsidy from the center is appropriate.

xix. **Record Maps**. The record situation in developing countries varies from one city to another and from utility to utility. Where record systems do exist, they should be checked for completeness, quality, and usefulness.

xx. **Data Sources and Collection**. Whether supplementing existing systems or starting from first principles, authorities must address technical issues such as how to identify and collect the data. In building up the record data base, they will have to obtain the relevant data in various ways. These are likely to include actual measurements of locations and possible levels of assets in the field, abstraction of details from "as-built drawings," and the gathering of further information from ad hoc sources such as random drawings, archived material, and local knowledge.

xxi. In summary, however, it is now widely recognized that technology alone will not guarantee a better information system. A technology cannot be applied successfully without a sound management policy. Such a policy would deal with institutional and organizational matters such as mandates and linkages, legal frameworks, technology strategies, human skills development, and financial management. Although in this paper the issues identified and the options put forward are grouped under separate headings, in practice these issues overlap and solutions interact. For example, training is a key issue on which many options, if selected, are likely to have an impact.

Strategic Options

xxii. The paper explores such options for improving the management of infrastructure information, records, and mapping. Such options include those for determining the best institutional structure for record keeping and mapping, how to develop human resources, and frameworks for making best use of the technology available. The discussion is based on practical solutions that have been tried in the past, as well as how to assign tasks, conduct training, and create record systems. Finally, a sampling of maps and case studies of work undertaken in several developing country cities are included as illustrative material.

xxiii. In summary the paper concludes that there is little doubt that improvements in utility mapping and record keeping are cost effective, improve the efficiency of the utility concerned, and indirectly raise the quality of life of those living in urban areas.

I. INTRODUCTION AND DEFINITIONS

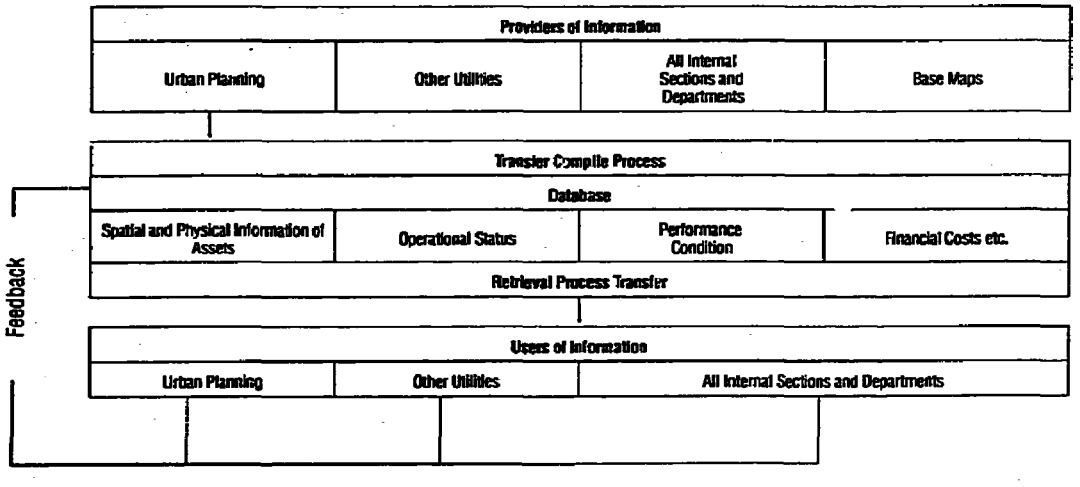
1.1 The infrastructure and services needed to support urban areas, both established and developing, may be provided by a variety of organizations, depending on the arrangements in place. Those arrangements will have been influenced by the country's history and its more recent policies. In some countries the infrastructure and local services may be the responsibility of the municipality, whereas in others they may be handled by separate utility companies or by state or national agencies or boards. Often a combination of such bodies is involved, and in many cases their operational boundaries do not coincide. In this paper, all such relevant bodies are alluded to, even where reference is made only to municipalities, utilities, or services.

1.2 Staff at all levels of a municipality or utility require accurate information to enable them to develop the infrastructure and provide the services that urban populations require. As indicated below, the collection and processing of this information has to be managed properly.

1.3 Usually an organization will be required to call upon a variety of providers and sources of information in order to manage its affairs efficiently. It will have to arrange to collect and sort this information so as to build up and maintain an effective data base. Facilities will have to be established for this purpose, so that anyone requiring information will know that it is available and can readily be abstracted in a usable format. Because the data base will have to be kept up to date, arrangements need to be in place to allow users to feed information back into the system. For example, if when excavating down to a sewer authorities find its diameter differs from that indicated in the records, then a correction should be fed back to the information system. Similarly, if a water consumer moves from one house to another, this information needs to be registered in the system so that bills can be issued correctly and on time.

1.4 Figure 1-1 shows such a record system. Here, only a few compartments are listed under each heading for the sake of clarity, but in reality, the system will be considerably more complex. For instance, it will also include the public and users of the service.

Figure 1–1. Schematic of a typical management information system



1.5 In setting up a records system, management will need to know where to obtain any given type of data that they may need to run their utility effectively. This means that a very large number of items will have to be entered into the system, and these may have to be gathered from a wide range of external organizations, utilities, and companies operating in the urban area concerned. In addition, a full store of information will have to be gathered from all sections of the utility itself. Various problems will also have to be addressed in maintaining these records, as indicated in the following extract from the record keeping manual of the Mexico City Water Authority:

1.6 A variety of infrastructure sectors are considered in this paper, and, as mentioned earlier, the exact scope covered by any one agency will differ from city to city and country to country. For purposes of discussion, however, it is possible to make some general observations on the basis of the core utilities and municipal services shown in Table 1-1.

Table 1–1. Service sectors considered in this paper

Drainage	surface water
Electricity	transmission and distribution
Gas	piped distribution
Public buildings	
Sewerage and low cost sanitation	
Telephone systems	
Urban roads, bridges and road furniture	
Waste collection and disposal	solid refuse
Water supply	distribution

1.7 Most of the utilities covered by this paper will have associated assets, networks, and route systems that enable them to provide their services to the public, commerce, and industry.

1.8 Table 1-2 indicates the great variety of records that utilities and municipal services may need (examples are included in Annex A) to manage infrastructure. Most of the information is related to "locations" (areas, zones, systems, buildings, and so on) and can be referenced spatially. Hence, it can be kept on map-based record systems. Whatever record system is used, it is vital to understand the interrelationship between the principal categories of information so that any single piece of information will only need to be collected and entered once.

1.9 The types of records included in Infrastructure Management have been identified. Table 1-3 indicates the wide range of departments that rely on these records.

1.10 In addition to using records for its own purposes, the staff of a municipal or utility office will need a store of information to respond to inquiries from the users of their services and from other outside organizations. Examples of such external communications are shown in Box 1. Staff should record these incoming complaints and inquiries in the information system together with details of any action taken. Although it need not be the case, complaints from users of the service

and the public may often be the first indication that all is not well with the utility's services or the operation or maintenance of its installations.

Table 1–2. Types of records

Category of record	Information
Maps to various scales	Annotated to show assets, networks
Schematics	How networks are configured/operate
Details	Plans/sketches of particular features, junctions, controls
Inventory of assets	Location, use, design
Standards and policies	Levels of services, environment, quality that should be provided
Conditions of assets	State of structures, pipes, cables
Performance of assets	Treatment/carrying capacities, quality of product, losses/leakage
Status	Assets in use, on stand-by, or stood down
Customer details	Connections to users of systems, consumptions, passengers carried
Expenditure	Accounts/costs of construction, purchases, operating, maintenance, renewals
Income/revenue	Sources of, charges, customer accounts
Maintenance	Details of preplanned (routine) and reactive (emergency) servicing, repairs, rehabilitation

Table 1–3. Users of records within a utility

Types of record	System operation	Maintenance	Revenue	Finance	Planning	Design	Construction
Maps	X	X			X	X	X
Schematics	X				X		X
Details	X	X				X	
Inventory of Assets		X		X	X		
Standards		X					
Condition	X	X					
Performance					X	X	
Status	X		X				
Customers	X		X		X		
Expenditure		X		X			X
Income	X		X	X			
Maintenance	X	X					
Complaints	X		X		X		

Box 1. Types of external inquiries requiring the use of records

How often should the refuse be collected from my house?

My gas bill is too high; the meter reading must be wrong.

The water pressure at my house is too low.

Why didn't the bus come yesterday morning?

Why is the electricity off and when is it coming back on?

When are you going to repair the road outside my hotel?

We are building 200 houses; please connect a water supply and tell us where to lay the drains.

I'm not paying your bill as my property is not connected to your sewer.

We are putting up a factory can you supply electricity and also extend bus route to bring in the workers.

Our contractor is laying cables underground, what pipes and cables have you in the street and where are they and how deep?

II. DISCUSSION OF KEY ISSUES

2.1 It is evident from the utility mapping and records component of infrastructure management information systems across developing countries that these countries face a number of the same issues. These issues can be grouped under the following headings: the need for utility maps and records, cost/benefit of map records, political/financial issues, institutional/organizational/staffing issues, and technical issues.

The Need for Utility Maps and Records for Infrastructure Management

2.2 The need for records in each infrastructure sector or utility can be addressed from three main points of view.

The Utility as Business

2.3 Irrespective of the ownership of a utility or service, or of the commercial/political environment in which it operates, the utility/service has to be managed and controlled in a way that ensures its present objectives are attained. Thus although the utility should operate as a business, it need not be one in which profit is of the utmost significance. Furthermore, each level within the utility will require information to manage its assets, plan extensions, design new works, and carry out systematic operations and maintenance. It will need sufficient data on its networks, for instance, to analyze such factors as capacity, performance, and condition. In addition, it will need full details on the properties and customers served to support its income base. Senior management will need data to guide its investment planning and asset management. Such data ensure that the best use is made of available funding and that cogent arguments are put forward for continued investment. Expenditure proposals cannot be justified without facts to illustrate their soundness; and continued investment cannot be justified without good records of the existing assets and their condition to indicate whether limited funds are being put to their most effective use. Investment priorities must also be considered. If a utility can put together a well-documented proposal, based on adequate record information, it is more likely to obtain funding for its project, because the investment can be more accurately quantified and programmed. The kind of information required includes both raw data and details concerning asset condition, and the quality and levels of service.

2.4 Because most systems operate smoothly for much of the time, the usefulness of good records does not usually become apparent until a problem arises. When a medium voltage power cable is damaged, or a trunk water main bursts, a great deal of time and money can be saved if information is readily available from a record plan that will make it possible to reconfigure the system quickly so as to restore supplies while the fault is repaired. It would also be important, from the point of view of informing the customers, to be able to identify areas in which supply cannot be restored immediately. Although good record plans do not automatically mean that everyone will understand how the system operates or that the necessary maintenance will be done, without them the system will be impossible to analyze systematically. Where management has become accustomed to working without good records, its primary concern will be to find the services, which will take precedence over any analysis of the problems.

2.5 Two aspects of records are of particular concern to urban management. One is the basic details of the physical layout of the system (that is, the actual locations of physical assets such as pipes, cables, meters, telephones, street lights, and so on). These records can be used to derive other information, such as the number of properties served, total asset value in terms of length of cable, square meters of office space, or number of vehicles, together with age and condition.

2.6 The second concern is the specific recording system used for each process. For instance, the billing system should have a standard system of invoicing and recording payment history, or of planning work, for example with job sheets and requisition forms. This paper concentrates on the underlying, spatially based information such as is stored on or referenced from utility maps. It is essential to understand not only how these records will be used and how information will be derived from them, but also what quality and quantity of data should be held on them.

2.7 The value of good record plans becomes even clearer when one considers all the minute details of urban management that depend on recorded information. Simple pieces of information—like knowing where to find the sluice valves to isolate an area, or which properties have connections from a particular telegraph pole—have to be looked up on the record plans. And if these are not correct, much time can be wasted or further problems caused. Operators who rely on their knowledge of the system and transmit this information verbally run the risk of making errors. This is especially true where underground services are concerned, for it may be many years before certain details need to be recalled. Another argument for keeping complete record plans is that small pieces of information may need to be retrieved on a regular basis.

2.8 Finally, it is essential for a utility to be able to identify all of its customers. Whether the information pertains to solid waste collection points or to meters that must be read, complete records are needed. If for lack of information all the solid waste is not collected, there may be adverse consequences for health and safety, not to mention consumer complaints. Customers are unlikely to complain if a meter is not read, but in this case the utility will be deprived of badly needed revenue. Note, too, that the information on the number and location of the utility's customers provides a macroeconomic picture of a city, which can be useful when analyzing the system. Records of the location of meters and their readings constitute the basic inputs into the billing system. Where the billing is assessed in other ways, such as per household, or per capita, the records showing the number of houses served and the total amount of water supplied needs to be recorded. Without such data, the utility would not be able to deliver an efficient service and hence would underperform as a business.

The Utility as Part of the Urban Infrastructure

2.9 Municipalities need to know what services are provided by all the utilities in the area. This information enables it to set charges for differing parts of the city, depending on the level of service, or to identify deprived areas that need assistance. Accordingly, planners may wish to refine their options for centers of development or meet the needs of existing unplanned settlements. To do so, they will need information on the utilities' strategic network—for example, on routes of high voltage cables and sites of transformers, trunk mains and service reservoirs for water supply, and trunk sewers and relative ground elevations. They will also need to be aware of

deficiencies or surplus capacities. Many a utility giving such an overview has been handicapped by its lack of maps. Although it may have detailed record plans of parts of the network, it is likely to have no map showing the complete system. Housing planners and potential developers will wish to know details of the local infrastructure before they prepare layouts and allocate space for housing, commerce, and industry.

2.10 In their daily operations, utilities find they need to exchange information regularly. The benefit of making accurate and good records available to other utilities i immeasurable with regard to reducing the risk of plant damage or accident. Not knowing what underground plant exists under the carriageway or footway or where it may be found is a serious disadvantage and a hindrance to all present and future authorities who may wish to work in this vicinity. If they ignore the existence of the plant they may cause damage for which they may be held responsible and if they take care to avoid it they are forced into expensive excavation methods for which they will also have to pay.

The Utility in the Wider Context of the City

2.11 Utilities exist primarily to provide a service to the community. Often, the service is fundamental to the quality of life, depending on the country, city, and utility. Functions such as water supply may be seen as a duty of the government, whereas the supply of gas may be viewed as a purely commercial activity. In either case, record maps of some form are needed to show the connection between the source of supply and each customer. Without such records, the quality of service to the customer will fall short of what is acceptable. Because infrastructure provision is often precariously balanced in rapidly expanding cities, inadequate records will have a negative effect on levels of service and hence on the quality of life enjoyed by the inhabitants of the cities.

2.12 Utility mapping is also required for reasons of safety, either because the utility involved handles an inherently dangerous product (such as gas or power) or because the product, if compromised, might reduce public health (such as results from contaminated potable water). Adequate mapping reduces the risk of accidental damage to utility apparatus and hence raises the level of safety, both to the general public and to the operations of the utility.

2.13 Thus the service users, too, have an interest in the existence of good records. They are the ones who will suffer if a rerouted supply cannot be arranged in the event of a cable failure or a sewer collapse through lack of information about its condition. The above factors must be kept in mind in any infrastructure considerations aimed at improving the living standards of a developing-country city. It is vital to know who is being served and to be able to ensure the security and safety of the service.

Costs and Benefits of Appropriate Maps and Records

2.14 The need for records can be discussed from three points of view, along with their benefits.

2.15 Adequate and appropriate records are required by all levels of management in a utility if

it is to provide an effective and economic service and to maintain its assets in a proper state. Where a utility has a large part of its investment in installations that are buried underground, it is even more important for its records to be complete and up to date. Although the economic benefits of having infrastructure management information systems are considerable, these benefits are not easy to quantify and sometimes are not even apparent to staff in the organizations concerned.

2.16 As already mentioned, records will be used by a wide variety of persons across the organization. The following list gives a few examples of financial, quality-of-service, and planning-related benefits that come from having sound management information record systems:

Financial

- Lower expenditure on capital schemes. Because the design of schemes is on a firmer basis, there is less likelihood of having to spend valuable resources on unforeseen items (contingencies).

- Savings in excavation and reinstatement costs. When it is necessary to dig down to cables or pipes for repairs or new connections, if the exact position is known, the size of the hole can be kept to the minimum.

- Reduction in likelihood of incorrect payment to the parties. When expenditure is checked against the inventory of assets, it is all too often found that certain payments should not have been made. City authorities may have been still paying electricity accounts for buildings they had sold and utilities paying municipal charges (rates) for works that were no longer needed and had been demolished.

- Fewer unnecessary site visits and trial hole excavations. When planning for new construction projects, less hit and miss investigation is involved.

Quality of Service

- Improved service to consumers and the public. With good records, inquiries from the public can be answered quickly and at minimum cost. Complaints can be fully investigated, and any necessary remedial work put in hand without delay.

- Improved use of outdoor staff time in day-to-day operations. Records allow managers to schedule maintenance efficiently, with meter reading rounds following the shortest route.

- Reduction in time spent locating underground installations. Control apparatus such as valves can readily be found even if the surface boxes have been covered over, perhaps by road resurfacing material.

Planning

- Savings in time in search for particular items of information. Without proper filing and indexing, many hours of office time can be wasted. A great deal of time can be wasted tracking down the possible location of information and then sorting through files, papers, drawings, and so on. This can entail visits to other buildings, possibly on the other side of the city.

- Less time spent on preparing information for outside bodies. This covers such matters as enquiries about where and what type of services are available, the location of pipes or cables, and the scale of charges.

- Improved management and control of the service. Knowledge of the location, condition, and performance of the network makes it possible to preplan most of the work and to operate installations such as pumps in the most energy-efficient way.

- Reduction in design preparation time. With detailed information on the criteria that new works have to meet and on the necessary design standard and material estimates, least-cost solutions can be developed.

- Provision of an accurate basis for network analysis. This means that "what if" types of inquiry can be answered with confidence and that extensions to the system can be designed economically.

2.17 In many developing countries, resources, especially skilled staff, are in short supply. Good-quality records allow staff to be used in the most efficient way possible and minimize skill shortages. Increased efficiency in an organization often helps boost staff morale, which in turn increases productivity and reduces the rate of turnover. No utility can afford excessive waste or abortive efforts, least of all those in developing countries, which are usually under great pressure to provide services. While most infrastructure investments are made by the countries themselves, a large number of infrastructure improvement projects in developing countries are funded in whole or part by external support agencies, which are becoming increasingly selective. Good records provide a strong basis from which to demonstrate need and hence increase the probability that the utility will attract funding for improvement projects.

Disadvantages of Not Having Records

2.18 As the preceding discussion makes clear, one obvious disadvantage of not possessing accurately prepared and maintained records is that it invites unnecessary expenditure.

2.19 The ability of a utility to provide third parties, in particular other utilities or construction agencies, with information on the location of its installations is vital for damage control. In any city, especially one that is growing rapidly, there is considerable risk that infrastructure assets will be affected by development and building work. The consequences of damaging the property of utilities must not be overlooked, as the following examples show:

- **Expense to the utility.** Cost of carrying out repairs, cost of any temporary service arrangements necessary, and the possible loss of "product." This latter loss may be serious, as in the case of the loss of water in times of drought or shortages.

- **Effect on the utility's customers.** Although the loss of service to domestic properties may be an inconvenience only in the case of commercial premises, business may be stopped and data lost, and for industrial properties production may be halted and machinery damaged.

- **Risk to public health.** Hygiene problems may arise because of water supplies being contaminated, sewage backing up, or flooding and storm water inundation.

- **Highway repercussions.** Where highways are affected, there can be traffic holdups or need for diversions and damage to the road base and structures.

- **Damage to property of other parties.** Typical examples of how others may be affected include the loss of the contents of a warehouse through flooding, the spoiling of food because of refrigeration failure, and damage to houses or other buildings by undermining.

2.20 At first glance it would appear the costs associated with records are incurred by the public and all the savings by the utility. On the contrary, the public will benefit from improved service from the utilities with good management systems, and this should also be reflected in lower charges.

Political/Financial Issues

2.21 Although the reasons for keeping records should be clear, shortcomings continue to create problems. There are indications that political decisionmakers and management, particularly at a senior level, sometimes fail to appreciate the importance of having utilities maintain accurate, up-to-date, map-based records of their assets. When decisions have to be made about reducing or redeploying resources, be it manpower or financial resources, records are often considered nonproductive and hence are given low priority, although such an approach is never desirable. Yet a rapidly expanding town or city might well find it impractical and certainly costly to retrieve such records.

Awareness of the Need for Records

2.22 As already mentioned, the information from record maps can be put to a wide variety of uses. On the one hand, it can provide an overview of the whole system and indicate where expansion can take place or where additional capacity is required. On the other hand, it offers detailed information of the exact location of a particular service. Although a single set of drawings cannot provide this range, staff members at every level must recognize that there is a need for information other than what they require personally. It is unfortunate, indeed, when an individual

who is responsible for a set of records allows the information in which he or she has no direct interest to deteriorate through the lack of maintenance.

2.23 It often happens that persons in one utility who have few if any reliable plans will recognize the need for them, whereas those in another, although they have good plans, will play down the need for them, not recognizing their value. Because the plans are there, their importance in the smooth operation of the service is not appreciated. In this situation, both utilities are sinking to the same low standard of services, although they may have started from different standpoints. The deterioration of the records may go unnoticed until there is a call for current information. Then one of two things can happen. People may see that the records are not up to date and hence there is insufficient time to correct matters. Alternatively, they may not see that the information is wrong, in which case incorrect answers may be formulated to important planning questions concerning, say, the future capacity of the system. Even if some individual omissions are not significant, the long-term, cumulative effects of poor record keeping can be highly damaging.

Constraints on Record Keeping

2.24 A major problem is that updating of records is seldom considered an important task. There may appear to be little urgency about recording the details on a new system that has just been constructed. Everyone knows where it is, and where it is likely that things are to go wrong. Furthermore, there is often no direct benefit to the individuals who update the records. It is an unending task, and if the records are already in bad condition there seems to be no way of coming to grips with the problem.

2.25 At higher levels, there often is little incentive for an ambitious engineer or administrator to get involved in record keeping. Not only does it look like a clerical task, but it has none of the glamour or prestige of a new capital works project. Even those who are aware of the usefulness of a good set of records are unlikely to become engaged in the repetitive task of keeping them useful. To add to these constraints, budgets seldom allocate substantial sums for record keeping.

Organizational Issues

2.26 **Legal Requirements.** Many areas lack the legal framework needed to set up a system of utility records. As a result, the systems that they do devise are not compatible across geographic and functional boundaries, and utilities are unable to exchange the information gleaned from them. Even where utilities fully recognize the advantages of cooperating in this area, they may not have the powers to set up a central information bureau because of all their underground apparatus in the city. Where legal requirements have been enacted, they vary between the different utilities and services. There is little consistency as to content or scale, although boundaries between utilities and other service authorities often overlap. The main reason for lack of uniformity is that each utility has developed within the legislative framework for its own function with little thought being given to compatibility with others.

2.27 Although not strictly a mapping or record question, another important issue for utilities is the possibility of laying down preferred positions for its highway installations, in relation to those of other utilities, and the identification of different underground services by color-coded pipes and cables or their markers. Another concern is the registration of excavators and the issuing of digging licenses.

2.28 **Security of Information.** If it is to be available to outside parties, any request for information creates security problems for the utility. A balance needs to be struck between the risk of having outsiders interfere with the utility's system and the need for them to know the location of apparatus so they can avoid damaging it.

2.29 A security-related problem may arise when the military is responsible for providing base maps or is required to provide security clearance for the production of such maps. In many cases, such security restrictions have prevented civilian utilities from obtaining up-to-date topographic maps. Consequently, they have had to either settle for inadequate or incomplete material or undertake extensive survey work to obtain the necessary data. In some countries, the military itself has underground services, such as communications lines, about which it will not release information to the utilities.

2.30 Although probably counterproductive, the military thinking in the above case is easy to understand. However, when considering the transfer of information between civilian utilities, the need for national security restrictions should not arise. Yet services do get damaged or disrupted through the lack of adequate information.

2.31 **Mechanism for advising other utilities.** Ideally, anybody who is about to carry out excavation work should be able to check with the utilities before starting work that might adversely affect their installations. For instance, before excavating in a highway, it would be important to know if there are other services in the same area. Two factors tend to prevent this from happening. First, it may be that a utility's records are not accurate enough to give more than a general idea of their services in the area under consideration. Second, the mechanism established to allow such cross-communication is either so slow or encumbered with paperwork that it is ineffective. It might seem simpler, quicker, and cheaper to go ahead with the proposed work and pay for any repairs that might be needed to other utilities if and when damage is detected. Such an argument might carry some weight when one is comparing the cost of repairs with the costs of delays and preliminary paperwork. However, as already explained, other factors should be taken into account, particularly the consequential damage to third parties and customers of the utility, along with safety and health implications.

2.32 A partial mechanism is in place in some cases. The municipal authority, as the senior body, may require a utility to inform it of any work being planned in the highway. Such a requirement is mainly a regulatory measure designed to keep the authority abreast of what is happening within its sphere of influence. However such a measure can only be of real use if the notification is passed on, or when suitable records are available and comparable. All too often, even when the benefits to be obtained are recognized, the problems to be overcome on an organizational and intersectoral basis appear daunting.

2.33 **Responsibility for Records.** Within municipal services and utilities organizations, the responsibility for collecting data and processing information on infrastructure management is often undefined. Furthermore, the staff may not have been trained in record keeping duties and thus it may be difficult tc obtain satisfactory performance at the level required. A prerequisite for the efficient upkeep of utility maps is the clear assignment of responsibility. All too often record maps are not seen as a separate item requiring special attention. It may be left to technical staff at varying levels to produce maps as required. Possibly a set of maps was produced at some time in the past, but if no one has clear responsibility for maintenance, it will simply become out of date and hence be used less and less. The same can happen if responsibility is assigned, but no budget allowed or staff nominated for the job. There will always seem to be more urgent tasks to be done unless the primary job of nominated staff members is stated to be the upkeep of the record maps. As discussed earlier, if the upkeep of records is seen as a secondary task to be done by the drawing office, when it is not too busy with other tasks, then the records will in all probability not be kept up to date.

2.34 Some utilities retain mapping as part of the planning process while others hand on the responsibility to operations. Both can work, but only if there is some mechanism to ensure that new information is handed across from one division to another. Furthermore, when the needs relationship is not understood, duplication of effort often occurs, or worse still, there may be gaps in the coverage because one section assumes that another is keeping the relevant records. This is often the case when the task of running a utility is spread among several agencies.

2.35 **Excessive Bureaucracy.** In some cases, rules and regulations have been set up to govern all aspects of the administration of a utility, including record plans. Every detail is recorded carefully and a great deal of paperwork produced. This system can work as long as the reasons for the bureaucracy continue to be understood, each part of the system is followed, and people know where to find and how to use the information. Although the cost of running such a system may be high, if it works it can be justified in terms of the continued maintenance and development of the utility.

2.36 Such a system has two drawbacks, however. First, if managers change, the reasons for continuing to keep records, especially those parts relating to forward planning, may be overlooked. As a result, part of the system will be bypassed and the records will deteriorate. Other reasons for curtailment include cost-cutting exercises—if no direct or immediate benefit can be seen from one set of records, then that part of the system will be deleted. Much of the remaining paperwork can then become a routine exercise with little or no practical use. The second situation can occur as the size of a utility increases. The sheer volume of paperwork increases, and filing space becomes limited. Either the information becomes difficult to access, mainly because of the sheer quantity of information, or large numbers of old files are "archived," never to be seen again. The problem can be compounded where the number of staff required to process information is not increased to keep pace with the volume or, as is frequently the case, they are used to help out with what are seen as more immediate tasks. A record system set up perhaps twenty years ago for a city of 200,000 people is almost certainly inappropriate for the same city with a population of 1,000,000 today.

Staffing

2.37 **Training Issues.** Many municipalities and utilities are short of appropriately trained staff at all levels. As a result, they turn to staff training to expand the capabilities of their employees. In the area of records, training should encompass the rationale for mapping as well as technical and organizational skills.

2.38 Although it is assumed that engineers will be able to read plans and maps, they may not understand the methodology and information needed to create good records. Staff often have a variety of backgrounds and have to meet differing standards and formats. In such cases, training will be required to ensure that employees are consistent both in their contribution to the records and in their interpretation of the records that exist. This assumes that there are accepted standards. Often the reason that operational employees fail to use maps is that they are unable to understand them.

Technical Issues

2.39 The technical issues are divided into the following topics: base maps (their type, availability, format, spatial referencing); record maps (data sources and collection, format, level of detail); drafting facilities; and storage, use, and up-keep of records.

Base maps

2.40 Up-to-date base maps to the scale and detail required are often difficult to obtain or even nonexistent. Ground control points and level reference marks may be few and far between.

2.41 **Types.** Two types of base map are in common use, topographic and cadastral maps. Cadastral maps show details such as property boundaries and are generally most useful for land information and registry. Geographical detail tends to be limited, and features such as buildings are often not shown. The value of such maps to utilities is not great. Topographic maps have much more geographic detail, usually including roads and buildings, and hence are of more value to utilities. Certainly, the utilities that lay pipes or cables along streets and make connections to buildings rely on such maps as the background for their records. However, a single set of topographic maps cannot possibly meet the requirements for all the utilities.

2.42 Topographic maps are produced to many different scales, of which the larger scales, which provide more detail, are generally used by the utilities. The choice partly depends on the resolution of detail required and on the ability to put a usable amount of information on each record map. At 1:2,500 scale, a 1-millimeter-thick pen line will represent 2.5 meters width "on the ground," which may be accurate enough for the location of a water pipe, but unacceptable for, say, power or telephone system ductwork. However, a frequently used size of 1:2,500 map can cover an area of 1 square kilometer, while at 1:500 the same size plan covers only 200 square meters. Clearly, many more sheets will be needed to cover the same area at the latter scale. A decision will have to be made that balances the level of detail with the coverage of each sheet.

2.43 **Availability.** In some countries, a standard set of topographic maps may be produced by a national survey department or by an outside agency. Even so, the maps will need to be updated—frequently in the case of rapidly developing cities—and the job may not always be done. The problem may be compounded where a utility makes use of base maps supplied by others and marks its own installations directly onto a transparency of the base map. Even if source base maps are regularly updated, it is by no means certain that the utility will acquire these new maps. It is more likely to add the details of new developments to its existing maps, often based on the developer's plans rather than the official topographic base map. Each utility may follow its own practices, with the result that over the years their map-based information can diverge considerably. This will make the process of copying or transferring information between utilities increasingly difficult.

2.44 Where there is no standard base map the situation is worse. Record maps can be based on planning or construction drawings, accepted in whatever form they arrive. There may be little or no consistency between the individual plans within the complete set of records.

2.45 **Format.** The scale and format of the base maps required by each utility can lead to further problems. Each will require a different level of topographic detail or scale. Although digital mapping techniques can allow for these options to a certain extent, a national survey department will want to standardize certain scales and the level of detail for its published maps. Where facilities are available for reducing or enlarging the standard base maps, it should be possible to accommodate most of the utilities' requirements for variations in scale.

2.46 **Spatial Referencing.** Another scale-related question is what reference detail should be included on the base maps. Street names and house numbers can be used as a reference to help locate a feature. As smaller scales are used, first the house numbers and then many of the street names must be left off the map. At that stage, a grid referencing system becomes more applicable. For overall recording purposes it may be convenient to refer to a valve on a water distribution system by its grid reference or some numbering system based on that. An operator in the field, however, would need to refer to local features on the ground to determine location, for example, if it is opposite a certain house in a certain street. Both systems have value and need to be suitably correlated.

2.47 It may not be possible, however, to use either of these referencing methods. Some developing cities do not have a generally accepted name for every street, or a universal house-numbering system. (The developing world is not alone in this respect.) Even if there are numbers, a major redevelopment may necessitate a new numbering system, which may exist alongside the old one. This can lead not just to confusion, but also to errors in identifying parts of a utility's network. Equally, there may be no generally accepted grid to coordinate the system in use. Unless the national mapping agency has established such a system and it is widely used by others, particularly the developers, many of the utilities will in all likelihood use either their own referencing system or none at all. Even when a grid system does exist, a later upgrading may reveal errors in the original calculations, or a decision may be made to adjust a series of city-based coordinate systems to match a national system. Algorithms can be written to allow one set of grid

references to be transformed to another, but this can be an awkward, time-consuming endeavor and may never get done.

Record maps

2.48 The record situation in developing countries varies from one city to another and from utility to utility. Where record systems do exist, they should be checked for completeness, quality, and usefulness. For utility mapping, it is convenient to differentiate between the base topographic map and the mapping of the details relevant to a particular utility. Base maps at certain scales may include some of the features that form part of a utility's assets, such as municipal buildings, electricity poles, or bus stops. However, these items are generally included as topographic features, rather than as elements of utility. As such, they may be of relevance to any of the utilities as additional referencing points when recording the location of their own assets.

2.49 In built-up areas, utility mapping should not need to resort to first-order survey techniques. If there are adequate ground control points, level bench marks, and a topographic map is available, each utility will use these to locate all its assets by measuring off from marked features, or by simple short-distance triangulation. In some instances, it will be even simpler than that; for example, when recording bus routes or indicating the location of municipal buildings. In these cases it will be a matter of identifying which roads or what buildings are relevant and finding their geographic location, which will already be shown as part of the base map.

Data sources and collection

2.50 Whether supplementing existing systems or starting from first principles, authorities must address technical issues such as how to identify and collect the data. In building up the record data base, they will have to obtain the relevant data in various ways. These are likely to include actual measurements of locations and possible levels of assets in the field, abstraction of details from any "as-built drawings," and the gathering of further information from ad hoc sources such as random drawings, archived material, and local knowledge.

2.51 **Fieldwork.** Everything that is to appear on a record plan actually exists on the ground. Therefore, it should be possible to create a record plan by field survey, although it may not be possible to find all the details. The exercise can be particularly difficult for underground assets.

2.52 Several methods can be used to locate and trace underground services, but all have their drawbacks. The most straightforward is to dig trial holes to locate the pipes or cables. This assumes that the worker has some idea of where to start looking. A trial hole can all too quickly be enlarged in the elusive hunt for a service that is not there. In addition, depending on the location, the cost of actually digging the trial hole may be quite high, it may disrupt traffic, and the cost of reinstatement is another factor to take into account.

2.53 Alternatively, there are various electronic devices for locating underground items. These work in a variety of ways, but most can only detect metallic items. More and more gas, water, and sewerage systems are now using nonmetallic pipes, particularly those made from types of plastics,

while telephone utilities use fiber optics. Equipment for detecting such services is under development but has not yet proved satisfactory.

2.54 In any case, all of these methods need to be backed up by local knowledge. No amount of high technology can entirely replace such knowledge. It is not uncommon for a utility that is upgrading its records to bring back, possibly on a consultancy basis, some of its retired field staff to assist in locating services.

2.55 **As-Built Drawings.** Often a considerable amount of information can be obtained initially from as-built drawings when a new set of traffic lights is being constructed, or from management decisions, for example, when a new transport route is being decided on. If the base maps are adequate and a methodology for recording the information has been set up, such records are created as a matter of course. Unfortunately, this does not always happen. In the case of underground services or overhead telephone or electricity lines, it will not always be easy to retrieve the required information at a later stage. Furthermore, the information included on as-built drawings is not always reliable.

2.56 As-built drawings are undoubtedly an essential part of the records system but are frequently difficult to access. Each set is often numbered according to the contract number, and it is difficult to cross-relate the areas covered by successive contracts. The drawings may not follow a consistent format or standard and may be drawn on different base maps, or at times on strip plans of the streets. The plans are often held at a local office, and only local staff are able to find the correct plan for a given area. There is rarely an index map. Such drawings obviously provide details only of the project that has been undertaken, usually with little reference to the rest of the utilities system in the area.

2.57 Ideally information from as-built drawings should be transferred onto the utility's primary record plans at the time of completion, but this usually does not happen. Instead, the contractor is often allowed to record the network on his own plans and to his own standard. Although each of these plans may be adequate, contractors may vary in style and thus invite unnecessary complications, especially at the interface between contracts.

2.58 **Ad Hoc Record Information.** When record plans are known to be incorrect or incomplete, various other sources of information may be available. For one thing, the operational staff may have a large amount of local knowledge gained through their day-to-day operations. Individual plans may be marked up to show detailed local information that one person has gathered for his own use. There will also probably be a large number of old records archived for safe keeping. All of these sources could be used to supplement or indeed create a full set of record plans for a utility. All too often, however, many of these sources are inaccessible or difficult to retrieve.

2.59 Another problem can occur, often in isolated pockets, whenever the standard set of records is known on site to be poor or incorrect. The local staff may have deduced some of the correct information and either marked up their own copies of the records, or else relied on their

own memories. In either case the information is only accessible if the local staff are willing to divulge it.

Format of record maps

2.60 Utility record maps use a wide range of formats—different scales, different levels of detail, and topographical or diagrammatic presentations. A clear policy needs to be established governing the acceptable formats for each identified project. In many areas, the number of formats in use is far greater than needed. This occurs for several reasons. As-built drawings are often amended construction drawings and can vary from project to project. Unless a standard format has been specified for them, or for the information transferred immediately to the utilities own standard set of records, the number of styles multiply. This means that anyone in the utility who is using the records must be made aware of the variety of styles and of the danger of misinterpretation. It is also more difficult to ensure that all the expected detail is included.

2.61 Another complication may occur in countries that have changed or are changing from imperial to metric units of measurement. Many of the maps still in use will be drawn to imperial scales, such as 6 inches to the mile, 1 inch to 330 feet, or 1 inch to 100 feet. As metrication takes place, both ranges of scales may exist alongside each other. A new base map may be prepared to say 1:1,000 or multiples of that. Until all the old record information is transferred to the new scales, there is a danger the user will fail to recognize the correct scale of the map and take incorrect measurement from it.

Level of detail on record maps

2.62 In any system of record maps, a balance has to be achieved between the amount of detailed information that is included on the maps and the usefulness of that detail. The cost and effort to maintain that level of detail must also be taken into account.

2.63 There are three kinds of detail. First, the map may record purely the physical detail of the utility—such as the location, size, material, and age of assets like cables, pipes, or fittings. Next is the operational detail, which includes information about condition, number of failures, normal demand, and the usual status of valves or switches. Finally, there is the managerial detail, which includes the capacity of the system, its efficiency, and information on where and how it can be expanded. Each of these levels of information can draw on the others.

2.64 Close attention must be paid to the amount of detail required at each level, which varies from utility to utility. To some extent, it depends on the organization in each utility. Information needs will increase in complexity, from those of the foreman at ground level locating a cable or a house connection to a manager in his planning role deciding how to organize the public transport routes more efficiently.

Drafting facilities

2.65 Record plans cannot be maintained or updated without adequate drafting facilities.

Although the new works department of a utility may have its own, albeit limited, drafting capacity, the operations and maintenance department usually has none. Consequently, local engineers or technicians may be asked to maintain the records, a task for which they do not usually have the time nor the inclination. Inevitably the records deteriorate or if the work is done at all it is unlikely to meet common standards or be consistent between offices.

2.66 Utilities that have no drafting facilities often call on an outside agency to upgrade their records. The trouble with this procedure is that at the end of the project the utility may have an excellent set of plans but still no in-house facility for maintaining them. Within a relatively short period of time the records will again be in poor shape and the cost of the project will have been almost completely wasted. Before such a project is undertaken, the in-house resources for the maintenance of records should be reviewed and improved as needed. In the process of upgrading the records, the outside agency should be required to train the in-house staff so that they will be able to take over the upkeep of the records system once the project is completed.

Storage, use, and upkeep of records

2.67 Master records should be safely stored and copies provided to meet day-to-day requirements. One particularly vexing problem agencies must also face is how to keep their records up to date and reliable.

2.68 Record Storage. Decisions concerning storage must take the following factors into account: a) the information must be easy to obtain by the persons who will be using it, b) master records should be stored in a secure way to guard against physical deterioration and to ensure that they can be copied or restored in the event of loss, c) record plans need to be indexed for the sake of easy retrieval.

2.69 **Record Use.** As indicated above, whatever system of mapping and recording a utility uses, it should be readily available to the staff at all times. The facility for making copies is another important consideration. There will always be many users who need copies of some or all of the records. Even where advanced data storage and processing techniques are used, hard copies of records will still be needed and hence some thought will have to be given to reproducing and distributing them to the relevant users.

2.70 **Upkeep of Records.** Infrastructure is a dynamic entity. New services are constantly being added, and changes made to existing arrangements. There should be a prompt and accurate updating of the records to reflect such changes, but this much-needed activity is all too often neglected. Although the records of new construction, such as the newly developed areas of a city, may well be added to existing maps from as-built drawings, smaller changes are usually overlooked. Even where procedures exist to routinely update records, operational staff may well want to mark up their own copies if the time scale for updating is extended.

2.71 Records are particularly difficult to keep up to date where a multitude of types were created for specific uses but at the same time have a large amount of data in common. The same information needs to be entered into several records, or, as usually happens, most of the sets are

not kept current and eventually go out of date. Digital mapping techniques can help alleviate such problems but as long as different sets of records exist more updating will have to be done. Such practices soon become unmanageable. Careful planning is obviously vital to guard against such proliferation and to keep the number of different records to the absolute minimum. The holders of copies that will require updating or periodic replacement must be identified. At the same time, the system must not be too rigid.

2.72 Upkeep becomes even more problematic without a standard system of symbols. Unless these are clearly set down and used for all updating work, different styles and symbols can creep into the system. Over the years the records will become more and more confusing and information difficult to interpret. Such problems are serious enough when they occur within a single utility, but they increase manyfold when information needs to be transferred from one utility to another, especially if some physical components of its installations are similar—for instance, both gas and water are distributed through pipes with similar valves and fittings.

Geographic Information Systems

2.73 Map production and spatial data are increasingly being linked through computerized geographic information systems (GIS). This allows dynamic and flexible handling of spatial information in a manner comparable to the way word-processing systems deal with written information. GIS can be used to store, display, and plan utility networks and attributes. Combined with remotely-sensed data, GIS can also be an effective tool for siting new infrastructure, conducting site inventories, updating network information, and preparing base maps. For more detailed information on this technique, see Paulsson, Bengt. 1992. *Urban Applications of Satellite Remote Sensing and GIS Analysis*, UMP 9 (Tool), Washington, DC; Urban Management Programme/The World Bank.

III. STRATEGIC OPTIONS

3.1 Some options for improving the management of infrastructure information, records, and mapping are indicated in Figure 3-1.

Figure 3–1. Strategic option categories

Awareness Appraisal
Review Situation
Identity Needs
Programme/Priorities

Institutional Structure	**Human Resources**	**Technical Framework**
Legal	In-house Staff Capacity	Base Maps
Funding/Resources	Training	Creation/Format Detail
Organization/Responsibilities	External Assistance	Technology
		Use/Storage/Upkeep

3.2 A specific strategy should not be selected, however, until the following steps have been taken:

- Decide how to create or enhance decisionmakers' awareness of infrastructure management records.
- Assess the current state of records and management information across municipal services and public utilities, either comprehensively or at least on the basis of statistically representative samples.
- Identify needs, both in the immediate and long term, for establishing/improving records within and without each utility, making sure to take note of common requirements.
- Draw up an action plan, with a timetable and priorities, for the creation of coherent record systems that will include measures for dealing with any backlogs.
- Review the appropriateness of legal requirements or powers for infrastructure records and mapping and for the interchange of information between utilities.
- Identify the sources and methods of funding the program emanating from the action plan, together with the expenditure requirements of maintaining the systems once set up.

- Define institutional responsibilities and specify the supporting organization for the creation and upkeep of records.

- Examine options for building the human resource capacity to meet the demands of infrastructure management record systems, incorporating any opportunities to use outside bodies to help eliminate backlogs.

- Agree on the specifications for base maps, including spatial referencing, and assign responsibility for providing and updating them.

- Plan the means of identifying and collecting data and of creating records and their formats to meet requirements at various levels.

- Review alternative techniques and technologies to be used now and in the future.

- Study the options for accessing, distributing, and updating recorded information.

3.3 The specific options in several of these areas are discussed further in Section IV. At this stage, it may be useful for managers concerned with basic municipal infrastructure services to indicate the range of options that may be available in comparison with some common situations, as outlined below.

Institutional Structure

Situation:
- Inadequate institutional arrangements for interdepartmental sharing of geographical information.

Options:
- Go it alone, making the best use of existing systems.
- Seek cooperation between all municipal services providing departments (either voluntarily or by municipal policy decree).
- Seek cooperation between all municipal departments and all other infrastructure service providers in the municipality such as companies and agencies (either voluntarily or by municipal by-law).
- Press for the development of a state or national framework (either by code of practice or statute).

Human Resources

Situation:
- Staff/skill shortages at middle and higher management levels.

Options:
- Attempt training in department.
- Arrange in-house training covering all service departments in the municipality.
- Seek group training with similar municipalities/utilities.
- Seek training assistance from outside agencies such as colleges and universities.
- Second staff to other municipalities for training.

- Buy in staff on term contracts.
- Hire consultants to cover staff shortages but ask them to train up existing staff.

Technical Framework I

Situation:
- Outdated base maps and difficulties in obtaining updates.

Options:
- Go it alone, making best use of existing facilities.
- Work with other services or utilities in the municipality.
- Work with similar services across several municipalities.
- Follow state or national approach, making a single agency responsible such as a government department or ministry (if a single body carries out the work, then resources may be pooled and duplication of effort kept to a minimum).
- Use remotely-sensed data (satellite or aerial).

Technical Framework II

Situation:
- Limited map-based information and records of infrastructure, particularly for operations and maintenance.

Options:
- Arrange to call in and record information that is available (such as field books in local offices and knowledge of long serving employees).
- Record, in agreed format, information as repairs and maintenance are carried out.
- Ensure that all new works, extensions, and renewals are recorded as they are installed.
- Introduce a phased survey and investigation program to ascertain location and condition of infrastructure assets. Perhaps give priority to areas where service failure may have serious consequences or high repair costs.
- Develop full geographic and/or management information system.

IV. DISCUSSION OF SELECTED OPTIONS

Awareness Creation/Enhancement

4.1 It should be clear by now that records play a vital role in a wide range of utility activities. One question that remains, however, is who must be persuaded of the need for a comprehensive record system and who will have to do the persuading? Decisionmakers at senior levels are the ones who must be shown that resources should go into record keeping, along with all the other infrastructure activities they support. Also, the persons who use records, as well as the potential users, need to be made aware of the importance of records and the range of possible applications. For example, when funds are being allocated to new projects, steps could be taken to evaluate the suitability of the mapping and records that provided the information used to judge the appropriateness of the projects and their level of need. The project should also be examined to ascertain whether the records of the relevant utility are to be kept up to date on completion of the scheme.

4.2 An outside agent may present arguments for improving records, and these should be carefully considered, particularly if there is an accompanying offer of funding. However, greater effect can generally be achieved if the driving force comes from within the utility, from staff who already understand the importance of records and can champion the cause. The latter approach has been particularly effective when the improvement in utility mapping takes the form of a step toward computerization. However, the arguments hold true even for less advanced management information systems. Such a "champion" can push forward the initiative from inside. Without such persons, all the time, resources, and skills of an outside agency may simply come to nought, for the system is not likely to continue working effectively afterward. It will only be successful if staff within the organization have a personal interest in the proposed system and a sense of ownership. Such persons should be encouraged to take part in the development of the system and to contribute their own ideas. Even if the champion is not directly in control of the department responsible for records, he or she can act as an adviser at senior levels and so ensure successful implementation. Otherwise, there will be little interest in making the system succeed, and it will be all too easy to blame the outside consultant or the operatives at a lower level for its failure.

4.3 Management should take advantage of the opportunities to reinforce the message in the course of particular projects and during the day-to-day operation of the utility. During the preparation of a scheme, for example, it can ensure that the existing records are adequate for a full analysis of the relevant parts of the utility's existing system. Even where there is a statutory requirement for records to be kept, some managers may have difficulty justifying them or seeing their usefulness. In such cases, one option might be to ascertain the implication for the records whenever work is being done on any aspect of the infrastructure and to make allowance for the necessary work in the budget.

4.4 On the completion of a project, construction drawings should be revised to reflect what has actually been built, whereupon the information should be incorporated in the record system without delay. If work is done by outside agents, some provision needs to be made for handling

the record updating in the overall scheme, possibly by including suitable clauses in the specification or job description. If the work is done internally but funded externally, completion of the records must be part of the requirements.

4.5 For schemes funded and executed in-house, other ways may be considered for promoting interest in proper records. One approach is to first create a good set of records, even if management is initially daunted by the sheer scale of such a task. The entire task could be assigned to an outside agent who at the end of the project would be required to hand over a new set of records to the utility. The utility would then be prepared to maintain the system and keep it up to date. Such a project should be seen as an opportunity to promote interest in records and increase people's awareness of their importance. Local staff should be involved as much as possible, in order to learn not only how much work it takes to create good records, but also the reasons for such an investment. By gaining firsthand knowledge of the amount of information available in the records, they will be in a better position to judge the ways in which they can use the information and will be more interested in maintaining it correctly.

4.6 In recent years, digital mapping and geographic information systems have received close attention, with at least one salutary effect: there has been greater interest in record keeping in general. The questions of why keep records and what records should be kept have been investigated in great detail and the answers produced are equally applicable to traditional record keeping systems. The more streamlined an existing paper-based system can be made, the easier it will be to manage. Many of the powerful arguments used to justify digital mapping are only restatements of those put forth on behalf of the maintenance of records in the first instance.

Assignment of Responsibilities

4.7 When a utility assigns responsibility for mapping and records, it should look at the system as a whole. The purpose of this exercise is to identify all sources of data, the links by which the data are transferred to the office in charge of preparing and maintaining records, and the routes for passing the information on in an appropriate form to those who require it. Because records are an integral part of a utility the overall responsibility for mapping and records usually goes to one central department. The choice of department will depend on local circumstances and preferences, but it may be the planning department, the new works design department, one of the operations departments, or an entirely separate department. When a central department is put in charge of records, it does not necessarily need to undertake the task of gathering the basic information in the field itself. The utility may prefer to require the operating and construction employees, for example, to note details of asset location, condition, and performance and to transmit the information in a standard format to the central department. This option has been adopted in a number of utilities, and where each party understands and carries out their role it works satisfactorily.

4.8 Wherever any particular task or function happens to be allocated, the department concerned must be provided with the appropriate resources. The roles of gathering data, establishing and maintaining the records, and disseminating the information must be assigned high priority and not seen as an unimportant task only to be done when someone happens to be free.

Whatever arrangement is adopted for keeping records, the duplication of effort should be avoided and bureaucracy kept to a minimum. Procedures should be reviewed periodically to make sure they are still appropriate and that the information being produced is still needed.

Training

4.9 The training needed for utility mapping and records varies from one city and country to another. Even within a given city, the demand for training may change from utility to utility. Once an adequate awareness level has been established at senior levels, more general training can follow. Training at the management level should focus on questions such as how to assign responsibility for information flow and recording across the organization, how to decide on appropriate standards for mapping and records and for proper quality assessment and control, how to prepare action plans for the staged development of records systems, and how to budget for the mapping and records function.

4.10 Staff and employee training should cover a variety of skills. Some of these skills might already be present and merely need encouragement and development, whereas others might have to be taught from the very beginning. Individual needs will depend not only on the person's present accomplishments, but on the demands that may be placed on him or her as systems are developed and standards raised. Training programs must cover field staff, as well as those normally associated with record keeping such as draftsmen and others in the drawing office. The degree of skill required will vary from one task to another, but any program must recognize that some employees will have a desire to move upward through the organization, and such upward mobility should be encouraged wherever possible. The skills required will range from data collection to the application of the resulting information.

4.11 Having identified its training requirements, a utility must next consider how best to meet them. Some of its options might be to develop in-house training, use local schools or colleges, promote joint initiatives with other utilities, engage commercial firms or consultants, or call upon national or supranational agencies.

4.12 When outside expertise is called upon to assist with the mapping and records process, whether to overcome a work backlog or establish a system for the first time, the training of local staff must be a high priority. It will be important to transfer skills and experience from the consultant to the utility. This calls for close collaboration. Through careful guidance and reeducation, the old system can be replaced or improved. Problems will undoubtedly arise if the new system is set up without explaining the changes fully to the local staff. Training should therefore address not only the need for general skills but also any specific demands of the new system.

4.13 Staff members who are experienced in creating records should be encouraged to participate actively in maintaining them. If they know that they will be responsible for the records later, they will have an incentive to do a thorough job in the first place. Furthermore, if they created the records, they will understand the effort required and why they should be kept up to

date. In addition, they will be aware of the shortfalls in the records and will not be afraid to amend them when necessary.

4.14 Where appropriate, consultants and other outside experts should be used to full advantage to ensure that the utility will not have to experience all the lessons and pitfalls encountered by others. A good deal of expertise is available, and the emphasis should be on transferring this knowledge as effectively as possible to the organization or utility that is improving its own records. In particular, the persons who will have to maintain them afterward must learn these skills. It is little use just handing them a new set of records. Consultants might also act as advisers and provide additional assistance, as necessary, to a single utility. This agency could then become the "lead" body and center of excellence from which the other utilities could learn. Staff secondments might be possible, with the lead authority advising and assisting the others while accepting outside training assistance. In either case, costs need to be allocated carefully.

Base Maps

4.15 Base maps are used for many purposes and are therefore unlikely to meet all requirements in full. However, it is better to have too much detail, well laid out, than too little. The resulting maps are more likely to include information required by more users. When producing base maps, the specifications should allow for this variety of users. If created by a single utility, the specifications should coincide with those of the other utilities, assuming that they all expect to make use of the maps.

4.16 For example, decisions would have to be made whether to include ground levels on the base map, which are not important for electricity distribution, but are critical for stormwater drainage; or to include manholes, electricity posts, telephone poles, and other such features. If shown, they can often be used in addition to edges of buildings or wall lines as reference points for locating other services.

4.17 Utilities tend to use a variety of map scales in part because the base maps happen to be available or because a particular scale seems appropriate. Much depends on the density of the urban area under consideration, but the main set of records is generally held at scales of 1:500 to 1:2,500. As mentioned earlier, the choice of scale affects the amount of detail that can be included. One utility may only need the approximate width of a street, whereas others may need to show the presence of footpaths on either side and be able to ascertain their widths.

4.18 Such requirements imply that the base map will have to be derived from at least an aerial survey and probably a certain amount of ground survey. There is an order of magnitude difference between these maps and those based on satellite images, which can be used for many land information purposes (see also *Urban Applications of Satellite Remote Sensing and GIS Analysis.* UMP 9).

4.19 Utility base maps must have some spatial referencing system so that any item can be

identified in nongraphic form, and at the same time be located on other maps at perhaps other scales. It is not enough to simply use numbers keyed to an index sheet.

4.20 A number of cities have used a lead utility to make base maps with considerable success. Although different skills are required for the two types of mapping involved (base and utility records), a certain amount of overlap occurs, especially when the ground survey of details is included. Therefore it is useful to look into the possibility of combining the two surveys.

Creating Record Systems

4.21 A system for creating and keeping records can be developed in three stages. Depending on the current state of the utility's records, not all of these stages may be applicable. The first stage consists of creating or renewing the complete set of records. In-house resources may not be available for this task, and outside assistance may be sought. Local knowledge will still be essential, and whatever local staff can be made available must be used and involved to the extent possible. The objective is to have existing staff benefit from the training and transfer of skills from the outside project team. The second stage in record keeping consists of upgrading the existing records. This task often becomes necessary when good records have been allowed to deteriorate. Although this exercise does not require as much input as creating the records, it certainly takes considerable effort and resources. The third and ongoing stage consists of keeping up and maintaining the plans and records once they have been brought to the required standard. This work must be managed wholly by the utility. Whatever system a utility may have in place should be used as much as possible, with the appropriate modifications. Systems that the local staff understand and are familiar with should, wherever possible, be used in preference to a brand new set of systems.

4.22 As already pointed out, many methods can be used to collect the information needed to create good utility maps, and all have some drawbacks. Much time and effort can obviously be saved if the information is collected while a project is being carried out. Many of the cities in developing countries are growing very fast and there is a strong argument for putting a concerted effort into gathering information on the new installation. A city growing at the rate of 7 percent a year will double in size in ten years, and so will its utility mapping requirements. If the utility manages to record the expansion properly, however, then 50 percent of its assets will have been recorded by the end of the period. Furthermore, in the process much information can be gathered about the existing assets, either as connections are made, repairs carried out, or cables relaid. That is to say, the main emphasis should be on setting up systems to allow these new records to be created. The systems should be supported by a permanent section in the utility, rather than a team brought together for a short-term project of record creation.

4.23 Where a city is growing at a less dynamic rate, less effort will be required to keep up with new developments and the emphasis should perhaps be on getting the existing records into good shape.

4.24 The bulk of the work involved in either upgrading a records system or creating one in the first place consists of collecting data. To improve the records of existing assets, the records

department will have to glean information from a wide range of sources. As much use as possible should be made of information obtained in the course of other work, although this cannot completely eliminate the need for some research specifically planned for records improvement. For example, it is common practice in many countries when repairing bursts on a water main or a break in an electric cable for the foreman doing the repairs to make a note on the job sheet about the existing pipe or cable, even if this only amounts to recording its size and type. Some utilities have forms specifically created for recording the details found as a result of an excavation. Even so, there is the difficulty of ensuring that the forms are completed and handed on.

4.25 Such problems could be reduced if management was better aware of the need for good records and was encouraged to make sure that the corrected information was fed back to the users as soon as possible. Otherwise, users will see no direct benefit from what they may perceive to be additional work.

4.26 Creating a new set of records, or extensively revising existing records, is a monumental task. It may entail abstracting all the existing records, researching relevant files, and asking the staff on site for information and verifying the results. Where this approach proves to be inadequate or ineffective, an enormous amount of data will have to be collected in the field. The problem is that resources in the usual departmental budget are seldom readily available for such work. If at all possible, the task should be assigned to in-house staff. They will generally have a better knowledge of the existing system and will be able to apply what they have learned to maintaining the records in the future.

Technology

4.27 The use of technological aids such as computers, digital mapping, and GIS software rank high in any discussion of improvements. Such devices should be seen as a tools for improving utility mapping and record keeping rather than an end in themselves. The new technology can certainly simplify record keeping, but in itself cannot ensure good results. Without a clear understanding of why records need to be kept, and without an organization that is capable of maintaining those records, no amount of high technology will help. Superb records can be created and maintained by traditional methods. The choice of technology should be way down on the list of priorities.

4.28 If a utility decides to institute a records improvement scheme on its own by using conventional techniques, this should be encouraged, even though it may not entirely fit with plans for integrating the records systems of all the utilities in the city. The reasoning here is that the data collection and verification can represent up to 90 percent of the effort involved in record improvement. Thus, if the utility ultimately changes to the standardized system, any abortive cost will have been minimal. The utility will also have benefited from its improved records for the intervening period.

4.29 Several developing-country cities have set up computerized mapping systems or are investigating them in pilot projects. Some are merely digital maps, whereas others are highly developed geographic information systems capable of handling queries and analyzing the

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ANNEX A: EXAMPLES OF MAP-BASED RECORDS

A1.1 The following selection of map-based records illustrates the wide range of types and degrees of quality in use in different places and by different organizations. They have not been categorized as good or bad examples, because the appropriateness of any given map can only be fairly judged by its users.

A1.2 This selection serves two purposes. First, for those who do not widely use such records it indicates what can be included on a map-based record. Second, by showing examples from other countries or other utilities, it may provide food for thought about ways to improve existing records.

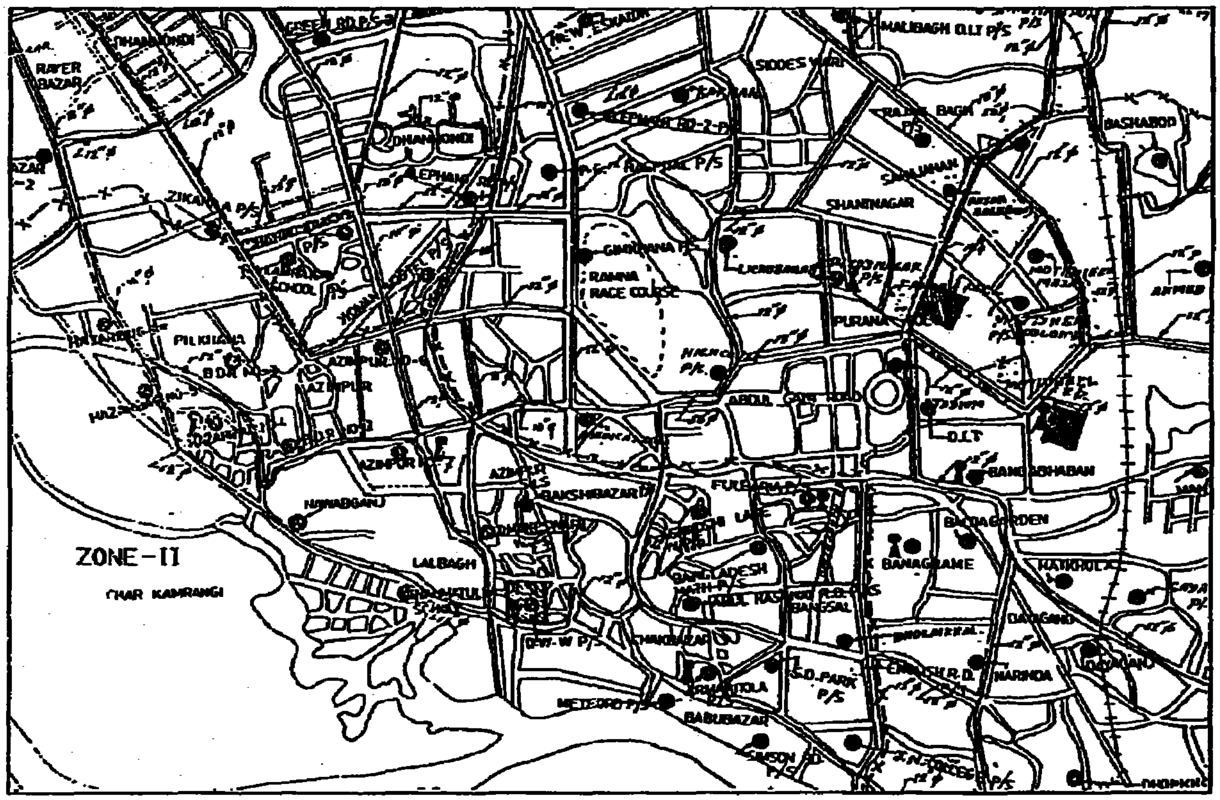
A1.3 Note that the majority of examples are from suppliers of water or electricity services. These are entities whose assets, the pipe or cable networks, are almost all underground and thus they have the greatest need for keeping an accurate record of the location. The material in all the examples has been retained at original size, with just a part of the record shown. The examples in this annex have kindly been provided by utilities and municipalities visited during the study (see Annex B).

A1.4 The following pages illustrate the wide variety of content, style, and quality in utilities mapping. Material has been obtained from Abidjan, Côte d'Ivoire, Dhaka, Bangladesh, Mexico City, Mexico, and elsewhere.

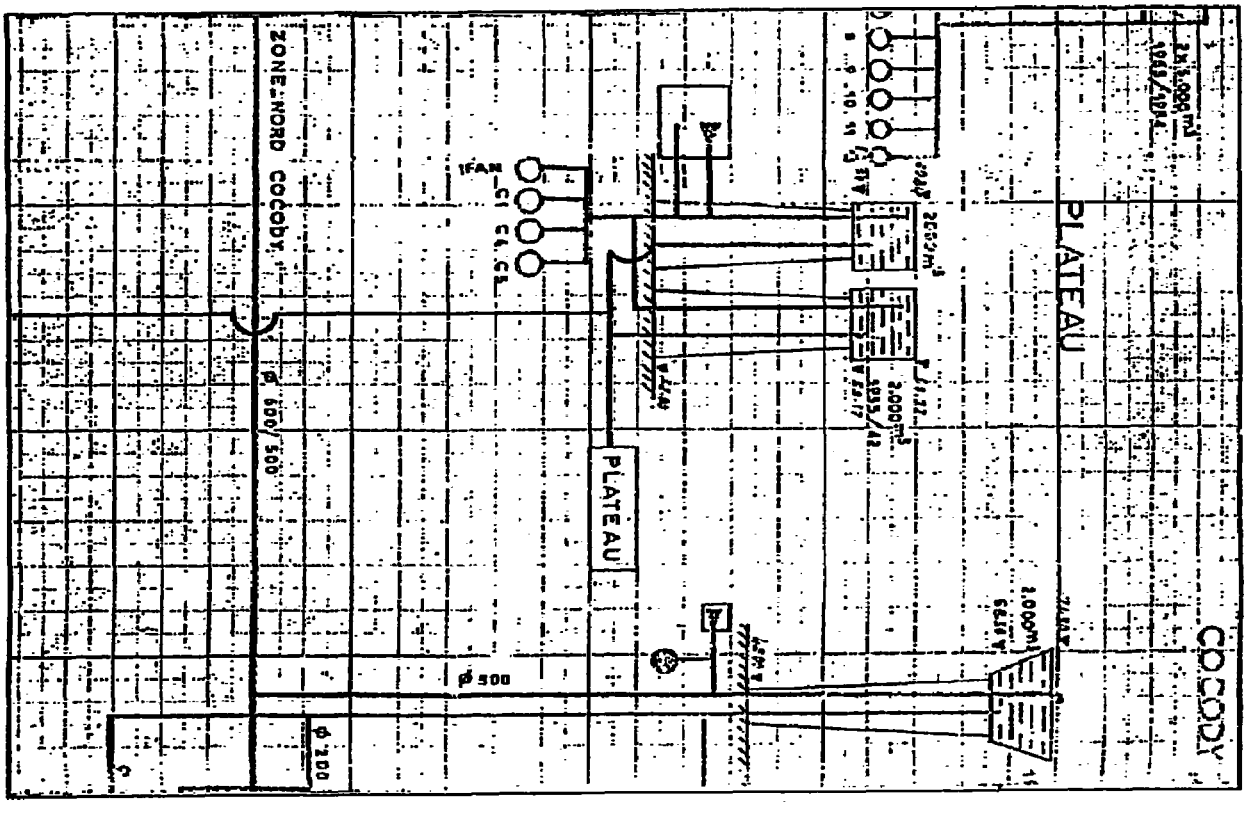
A1.5 The twenty-five examples included here can be divided into four categories:

Examples 1-8—Overview maps
Examples 9-12—Area maps
Examples 13-20—Detail maps
Examples 21-25—Details/as-built records.

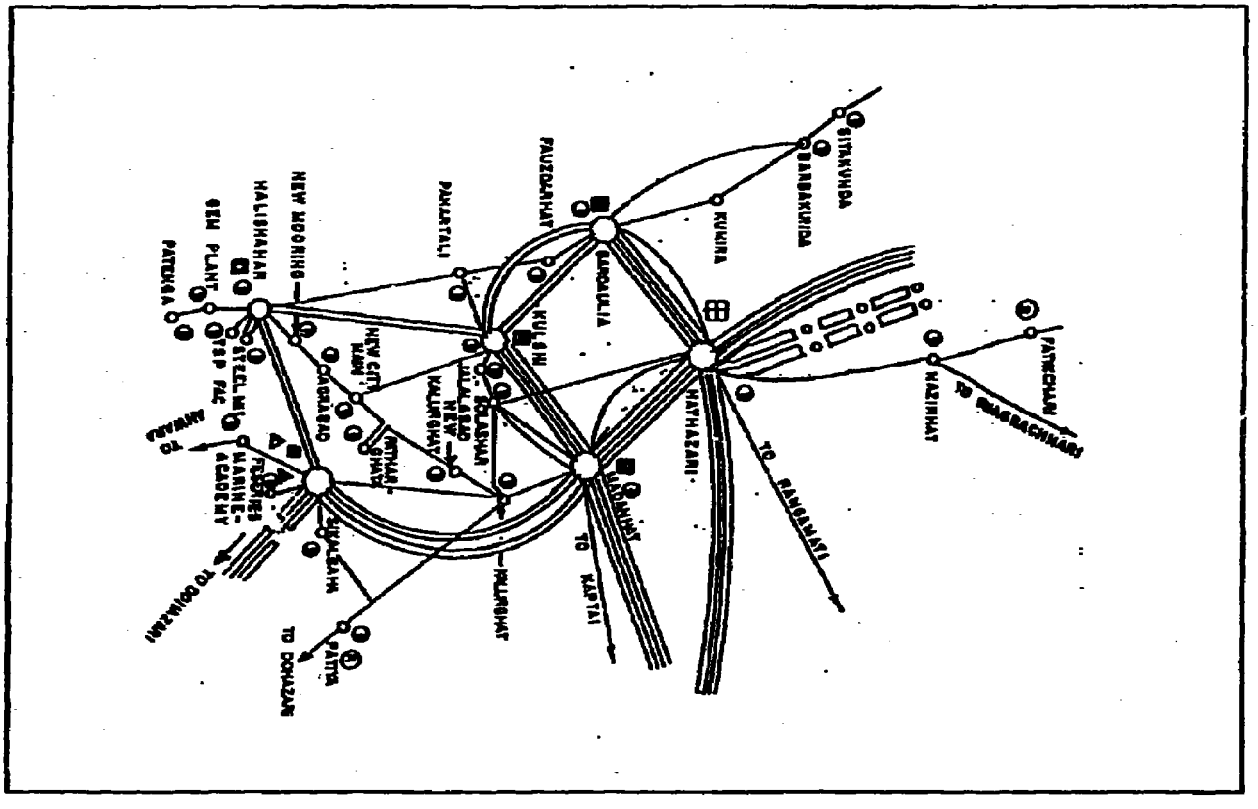
Map A-1. Water Supply—1:20,000



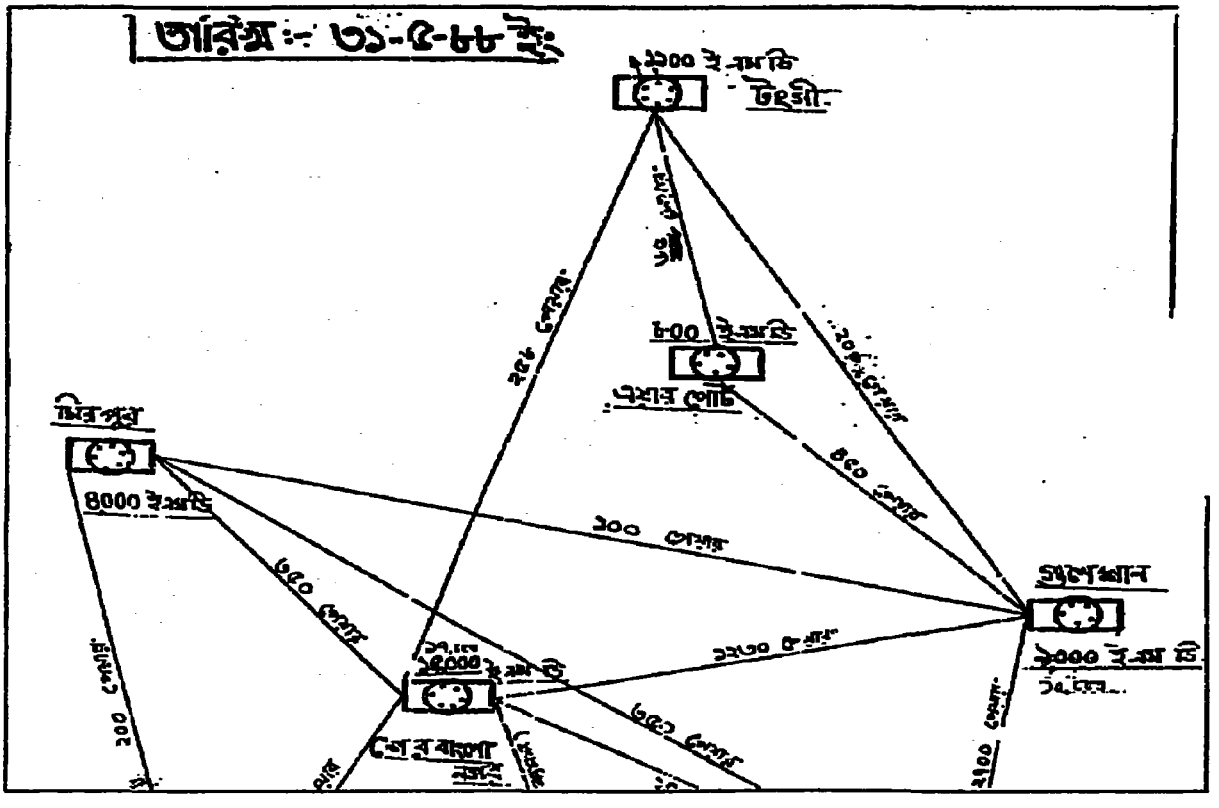
Map A–2. Water Supply—schematic



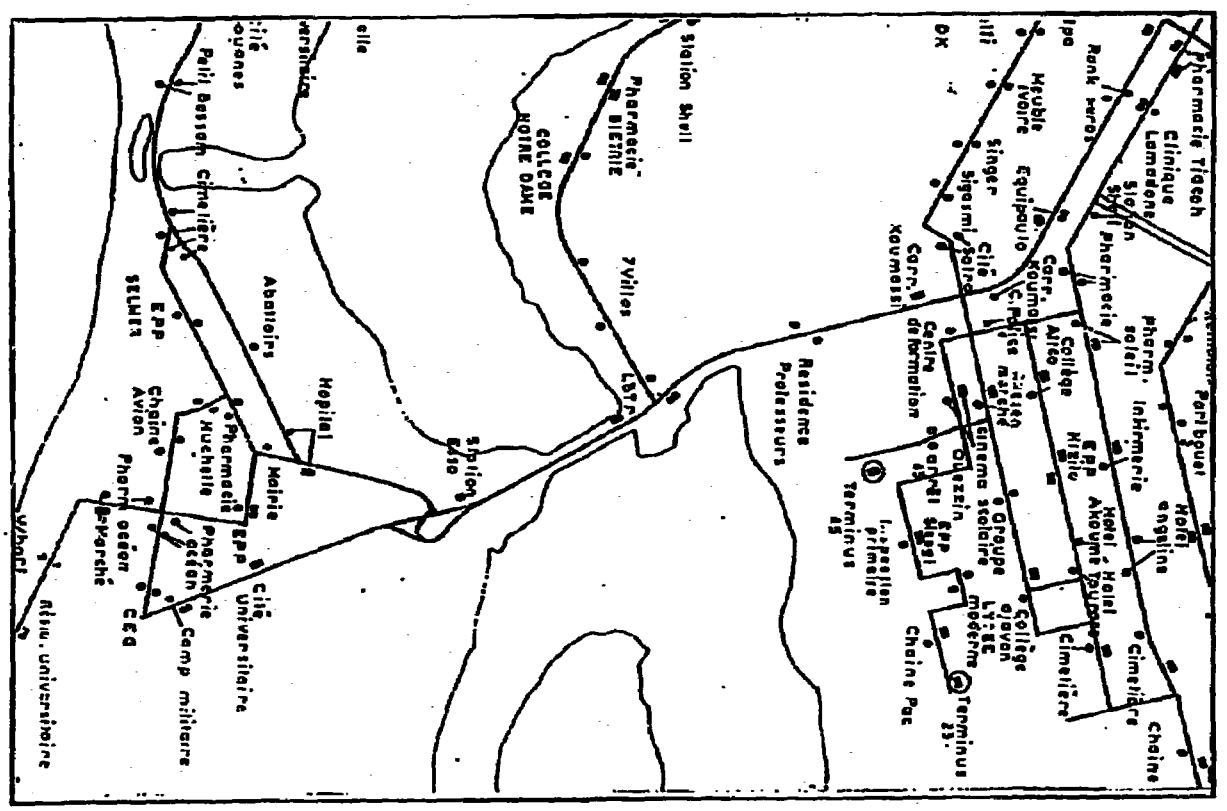
Map A–3. Electricity—schematic



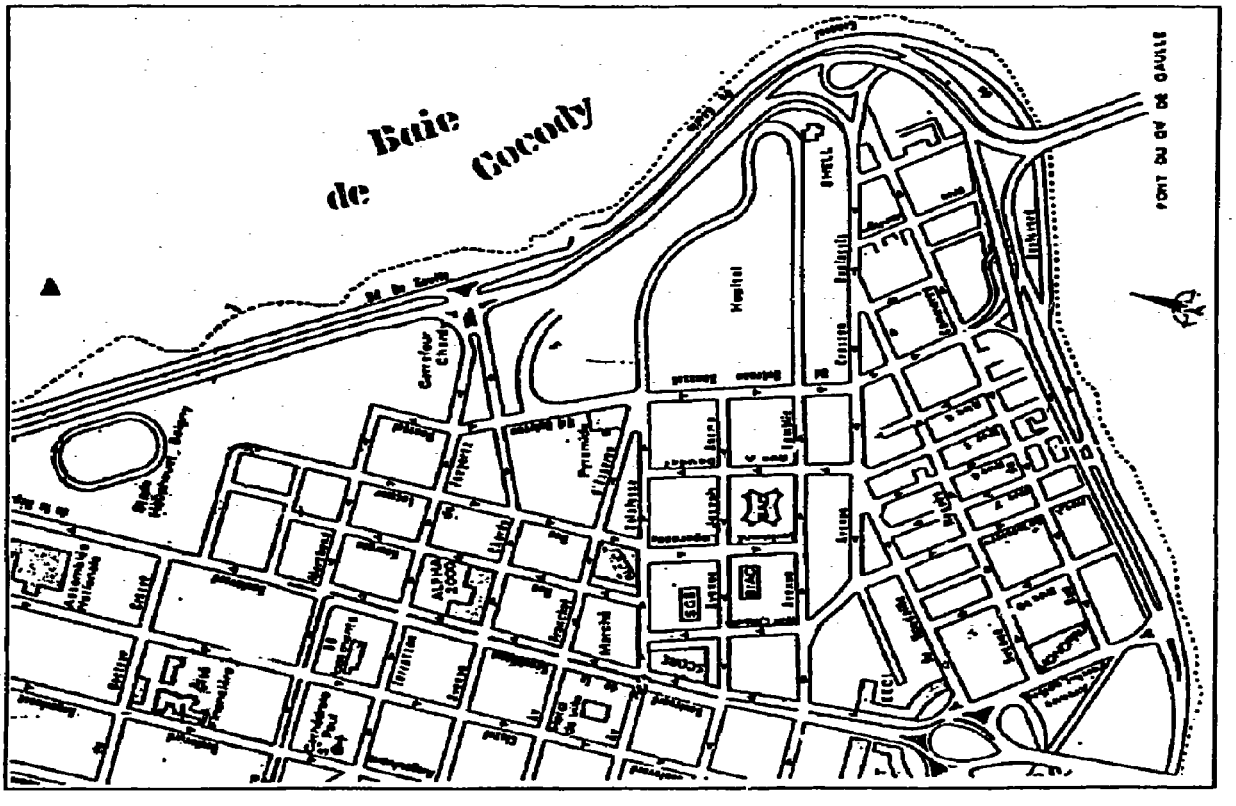
Map A–4. Telephones—schematic



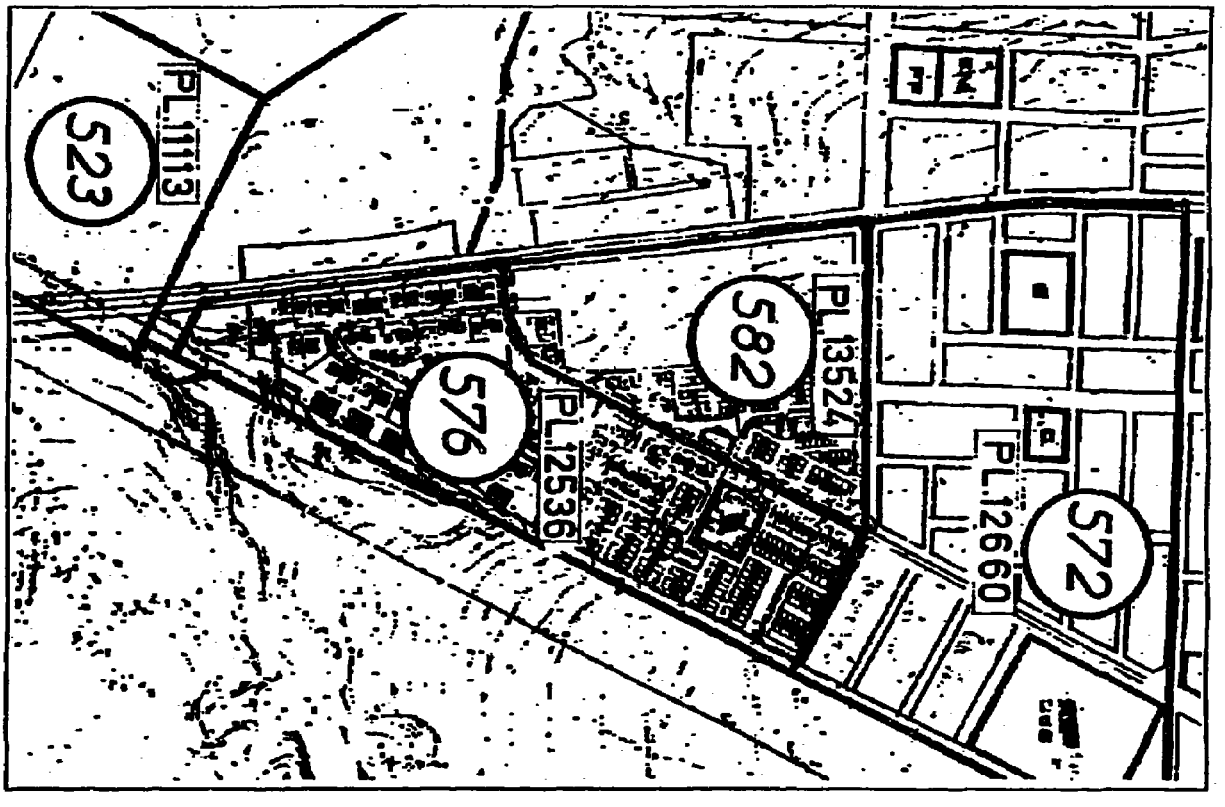
Map A–5. Public Transport—1:20,000



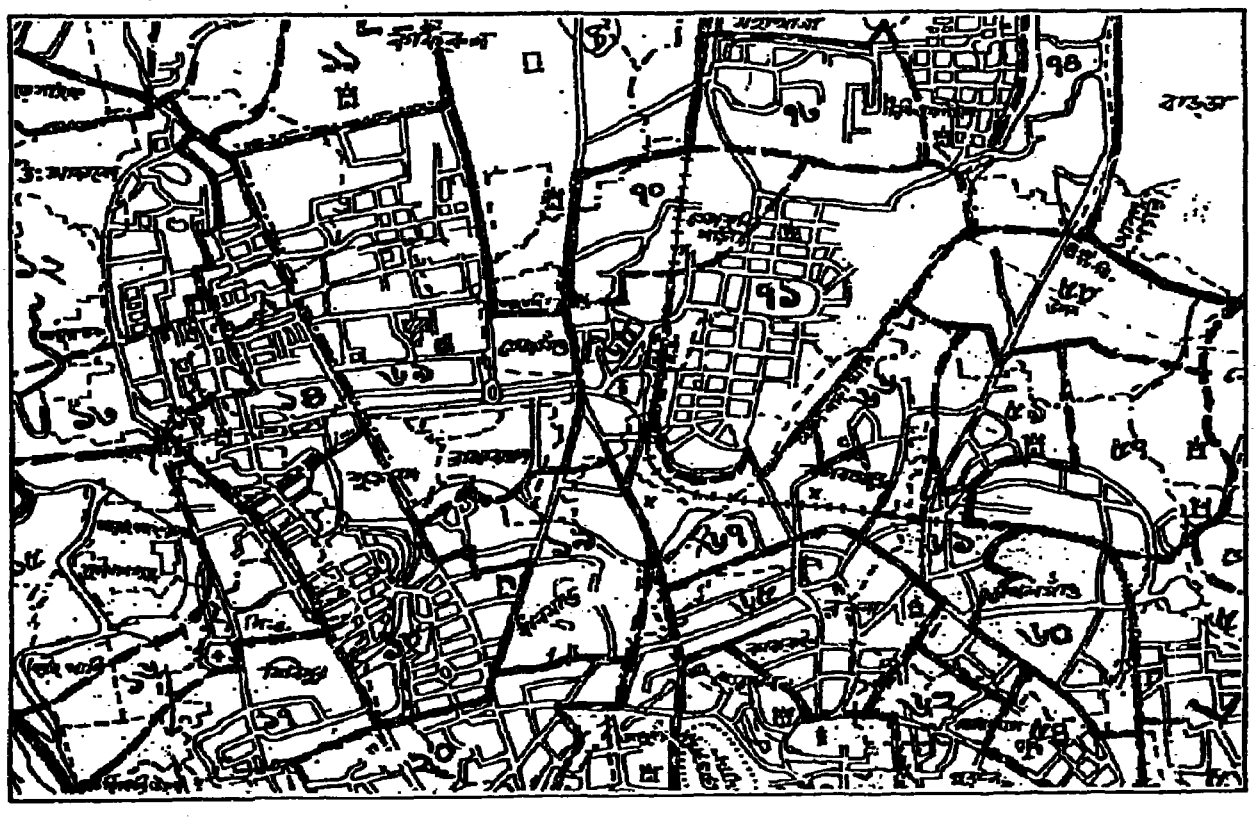
Map A–6. Traffic control—1:10,000



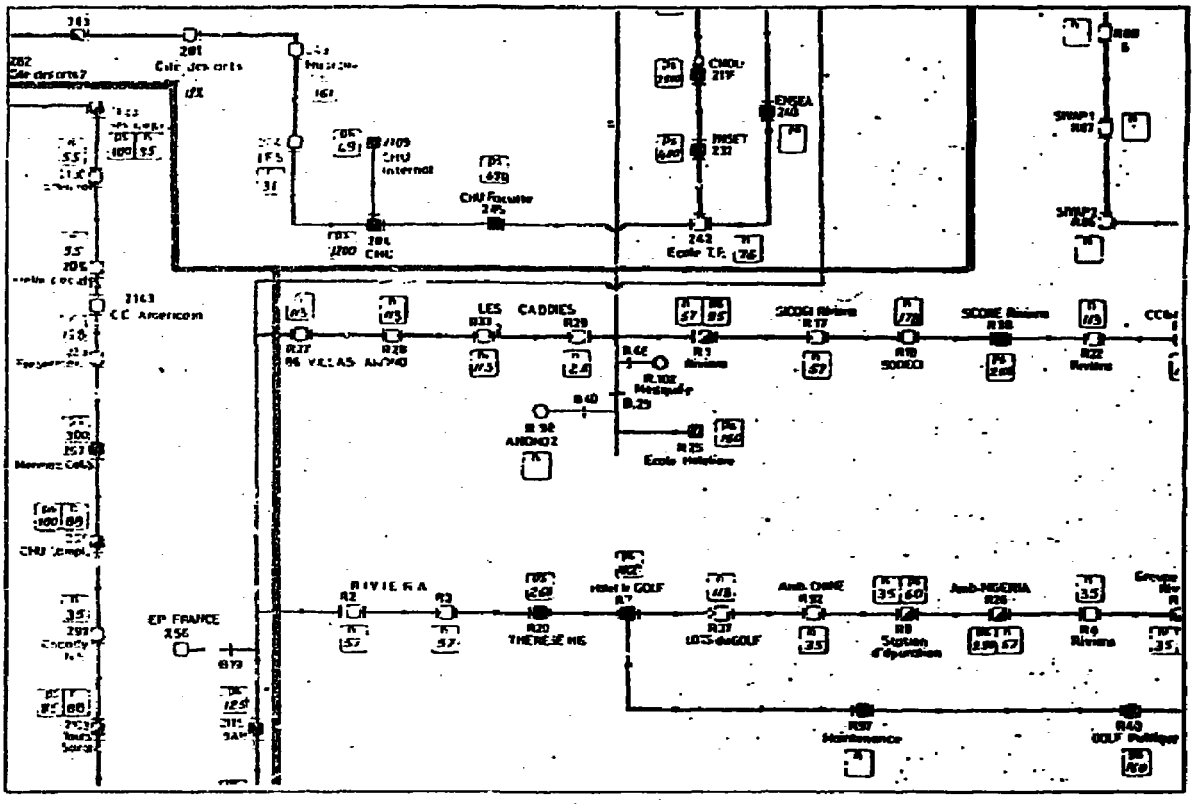
Map A–7. Water distribution—1:10,000



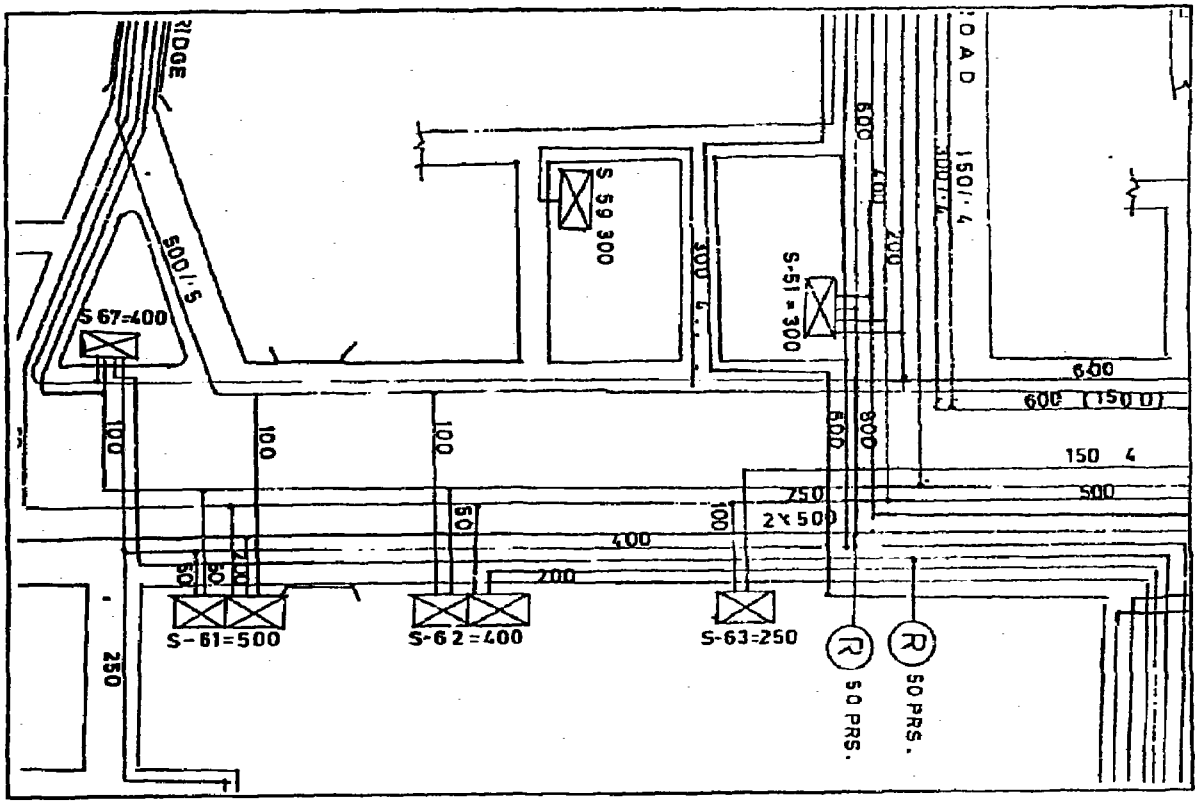
Map A–8. Local government—1:20,000



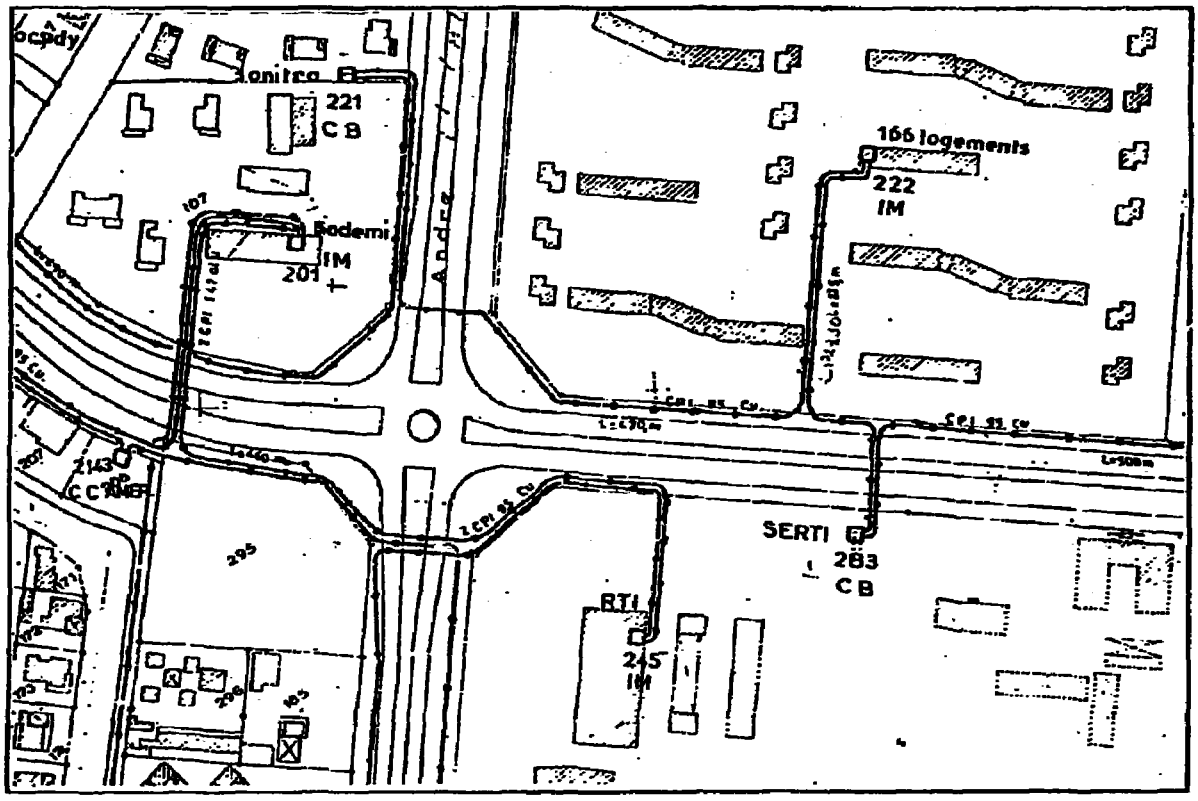
Map A–9. Electricity—schematic



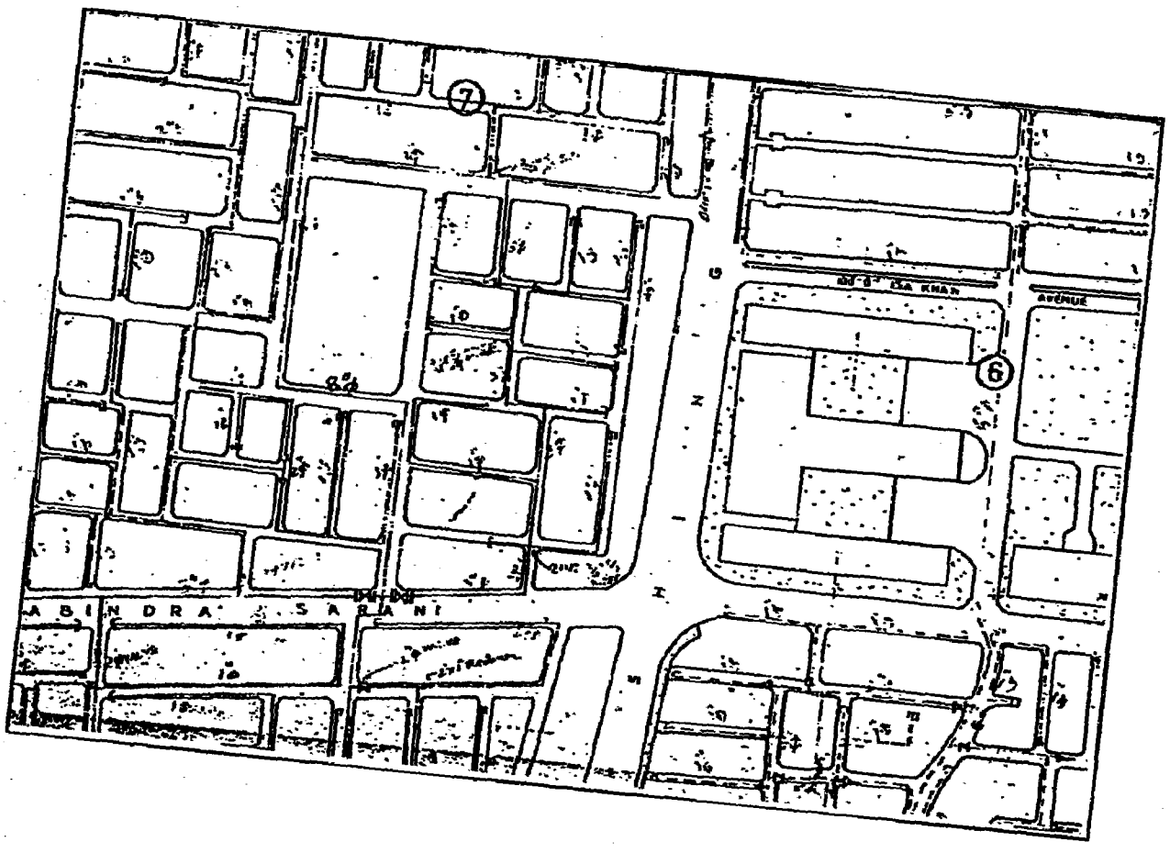
Map A–10. Telephones—schematic



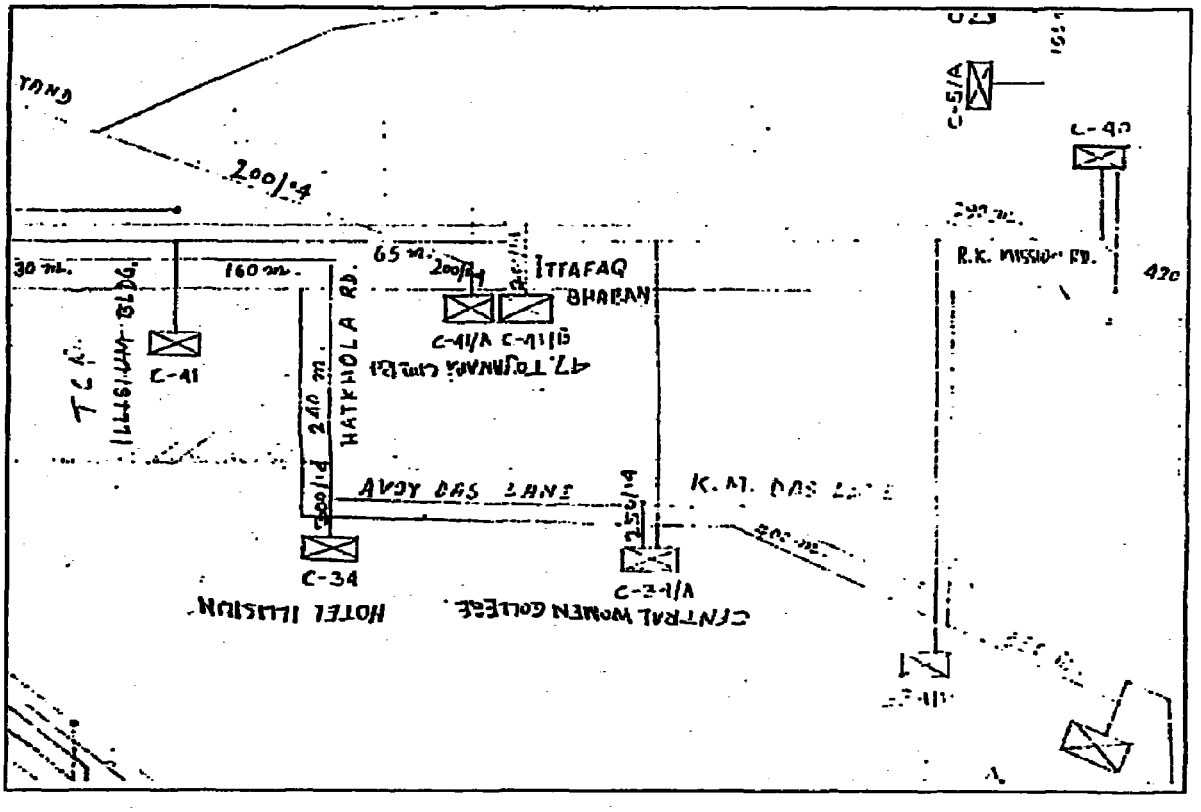
Map A–11. Electricity supply—1:20,000



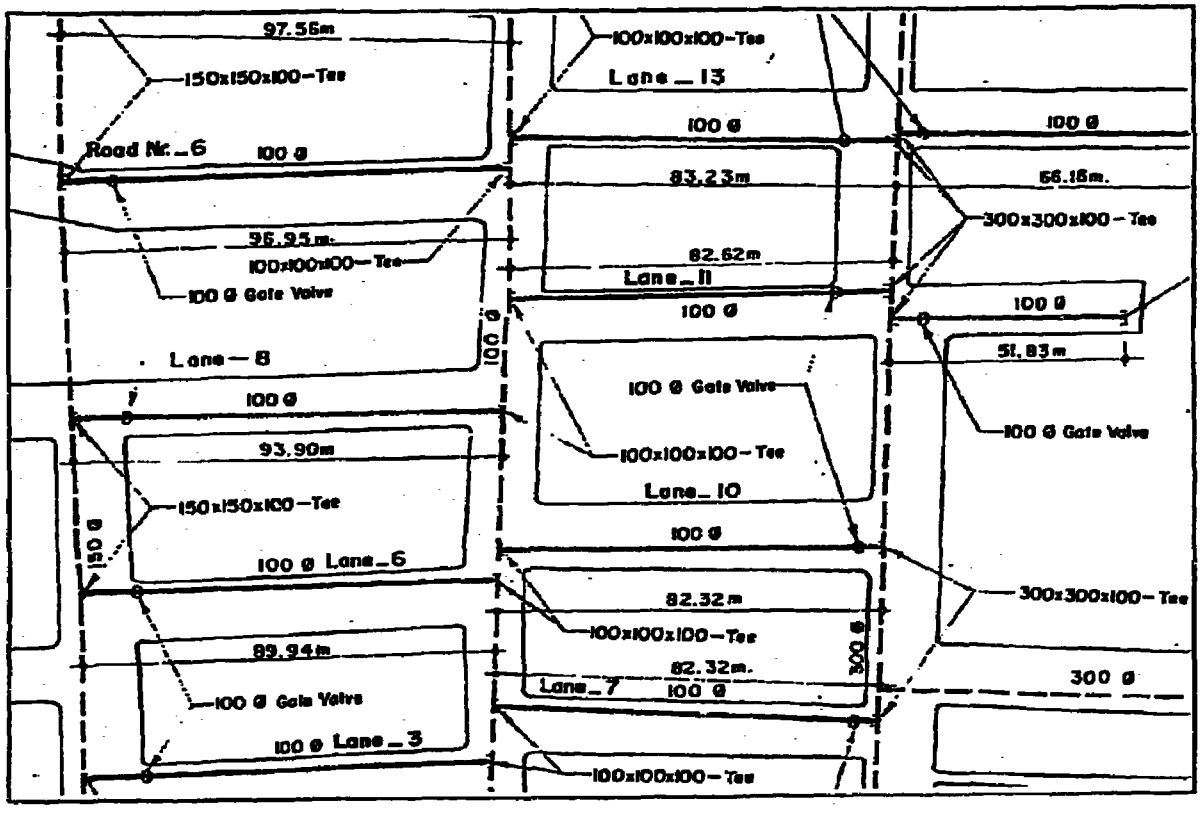
Map A–12. Gas distribution—1:3,960



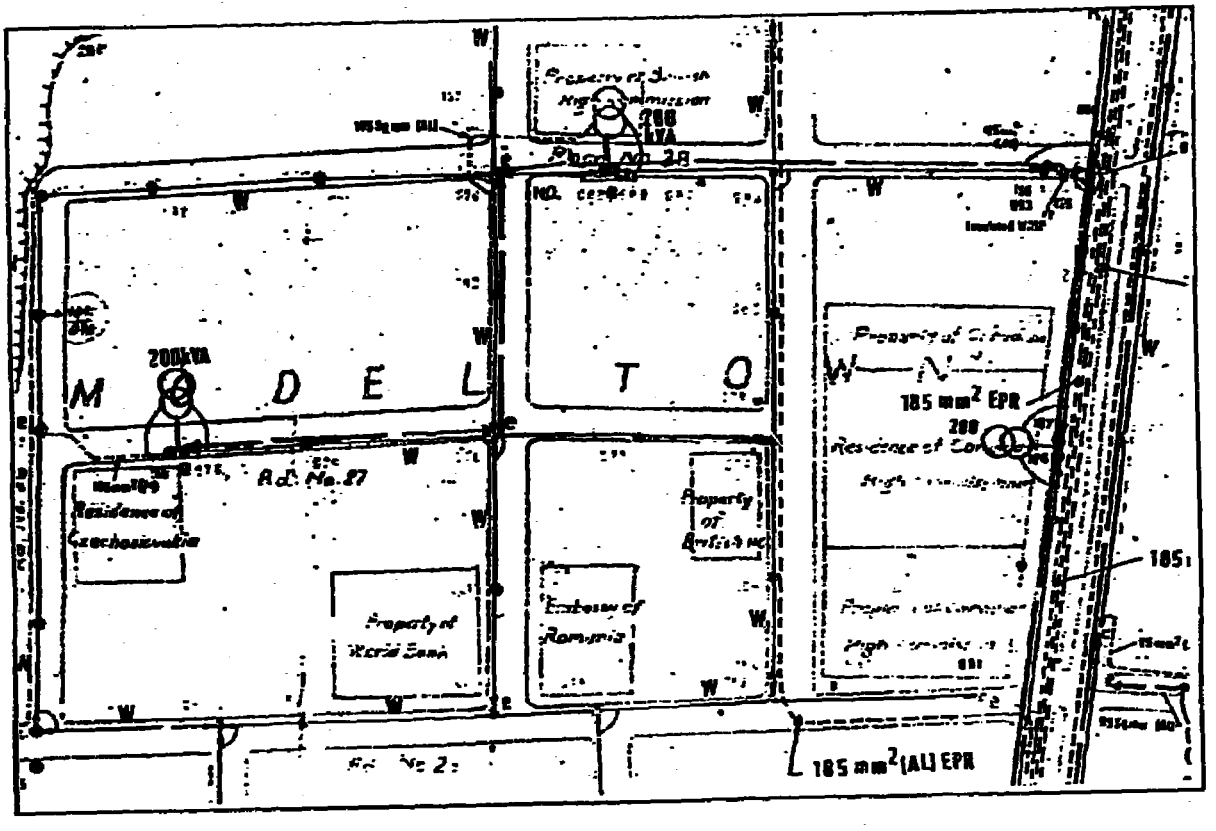
Map A–13. Telephones—schematic



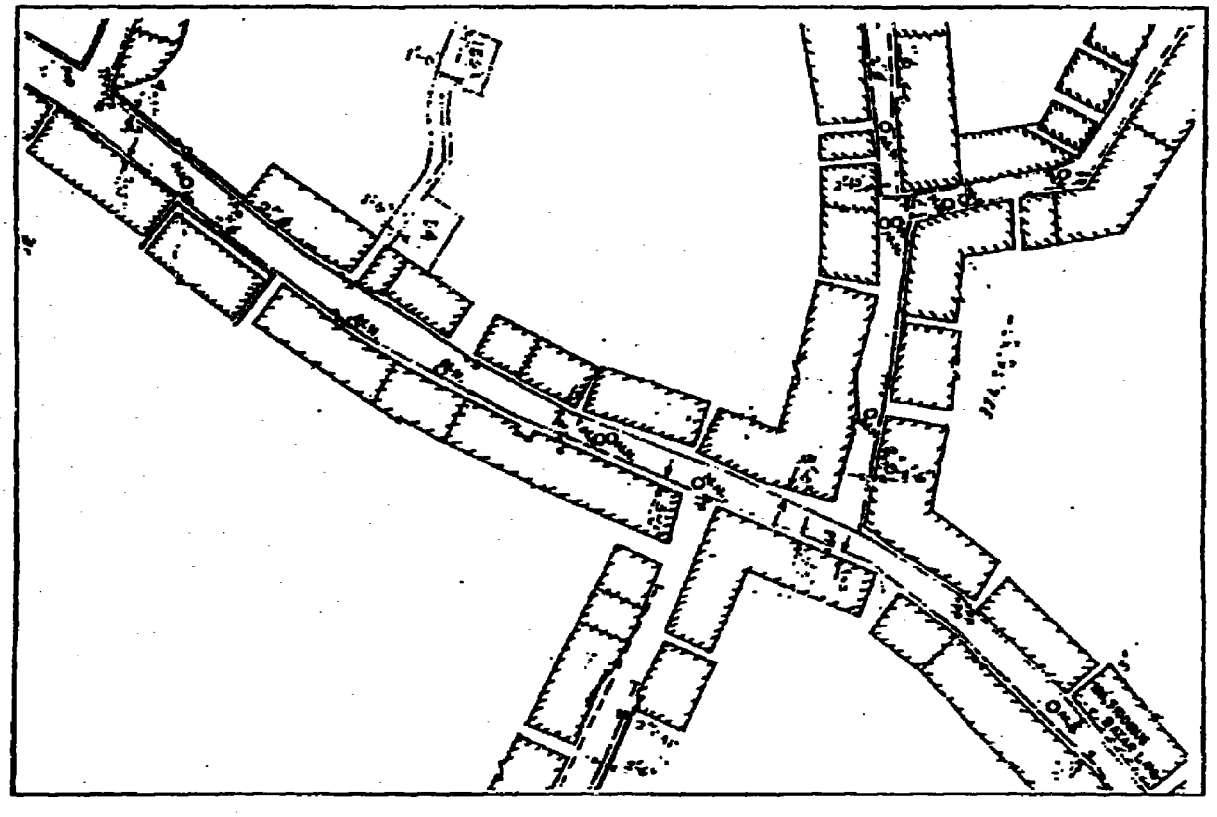
Map A–14. Water—1:1,000



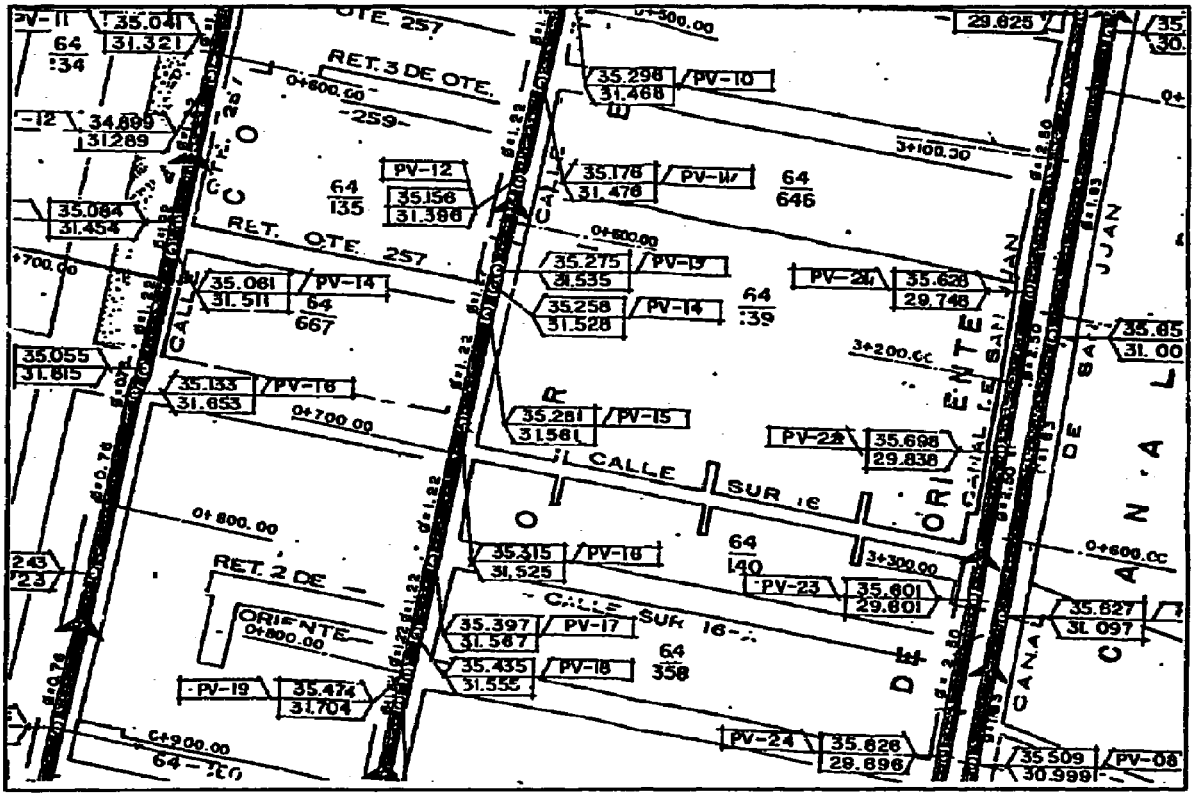
Map A–15. Electricity—1:1,200



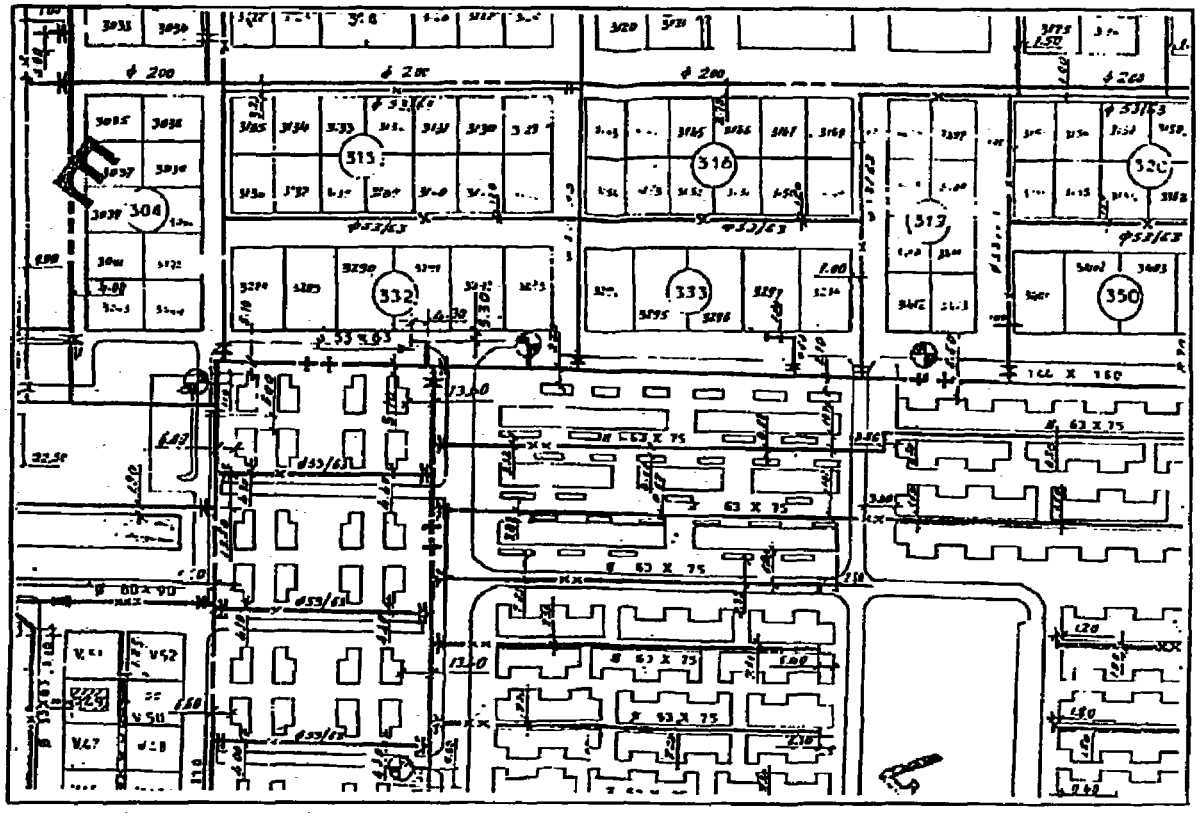
Map A–16. Gas—1:500



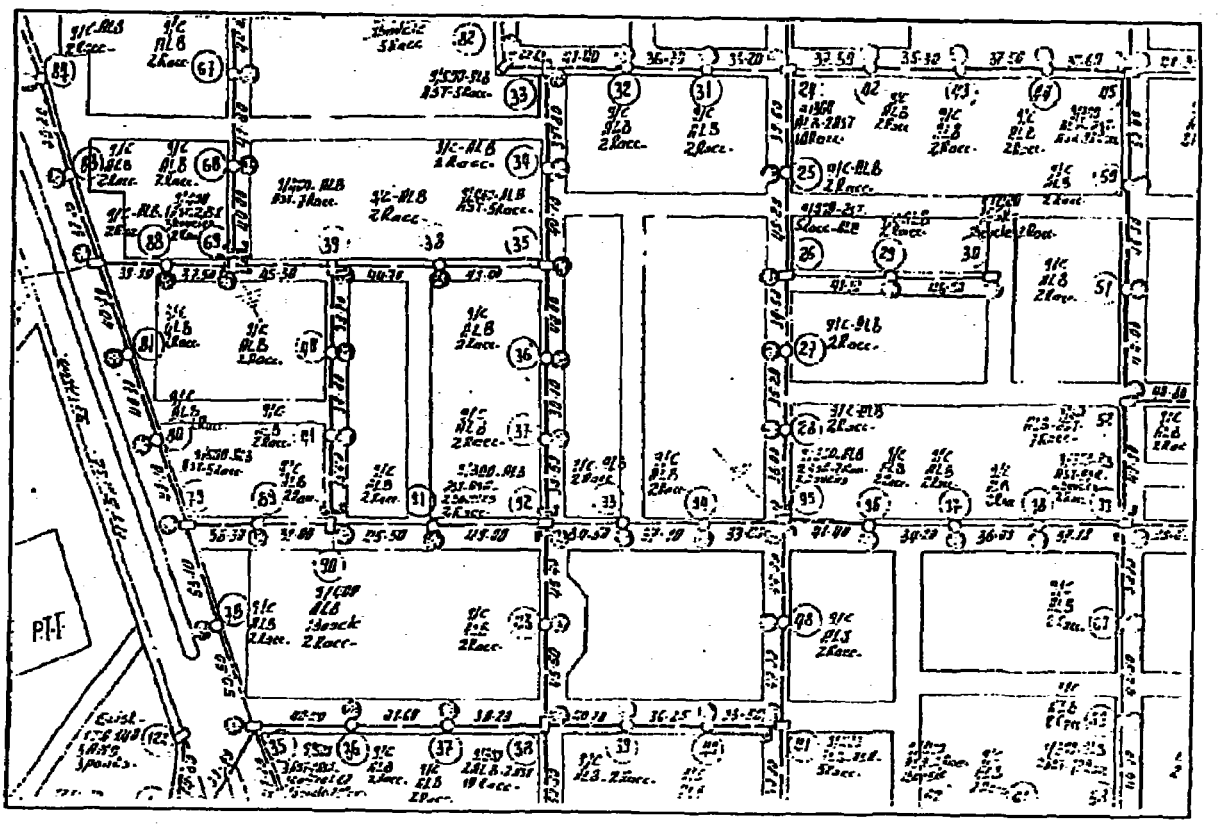
Map A–17. Sewerage—1:2,000



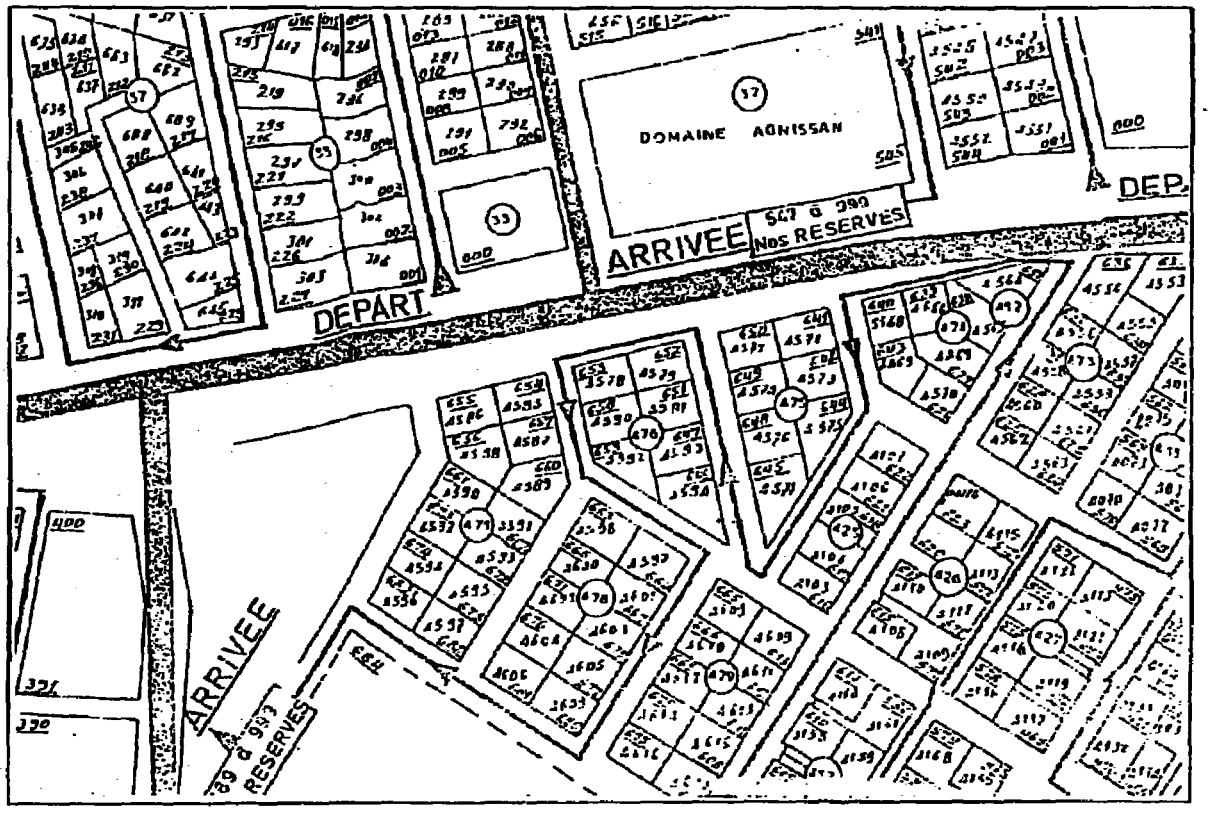
Map A–18. Water—1:2,000



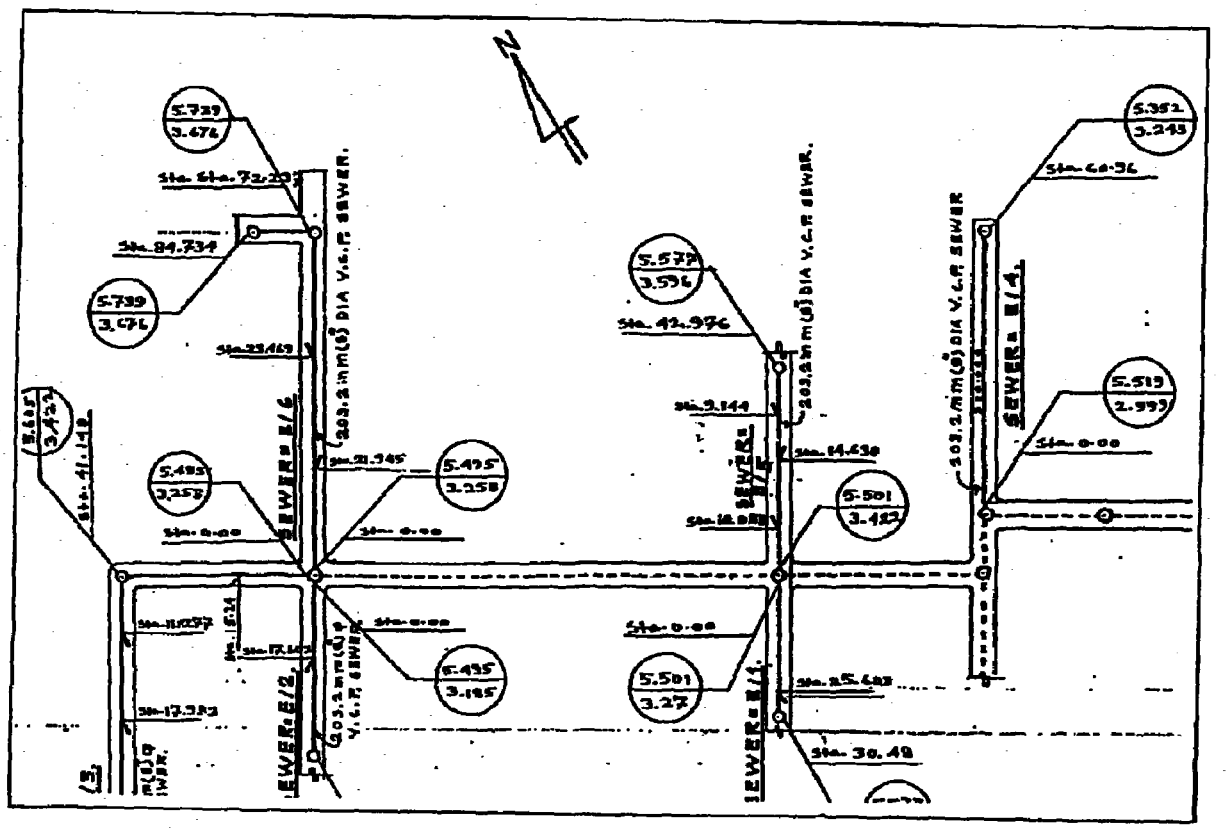
Map A–19. Street lighting—1:2,000



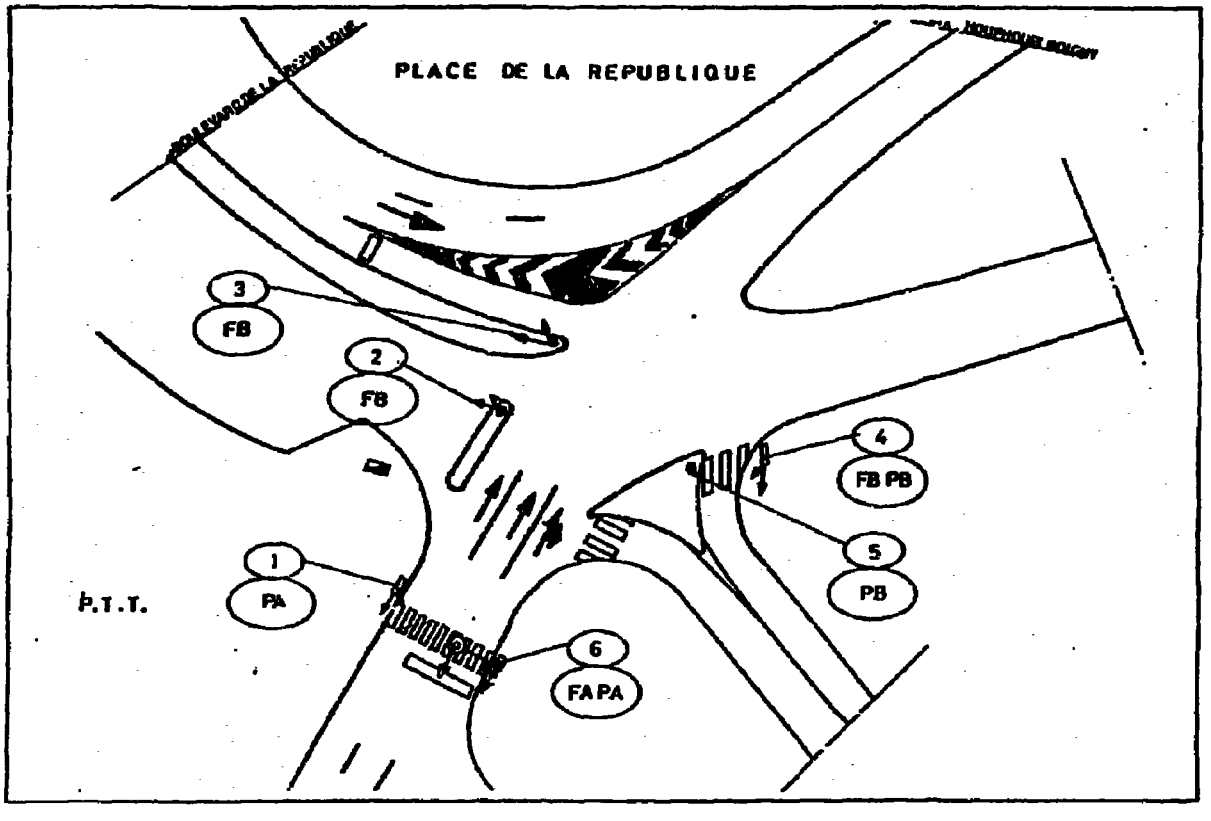
Map A–20. Customers and meter reading—1:2,000



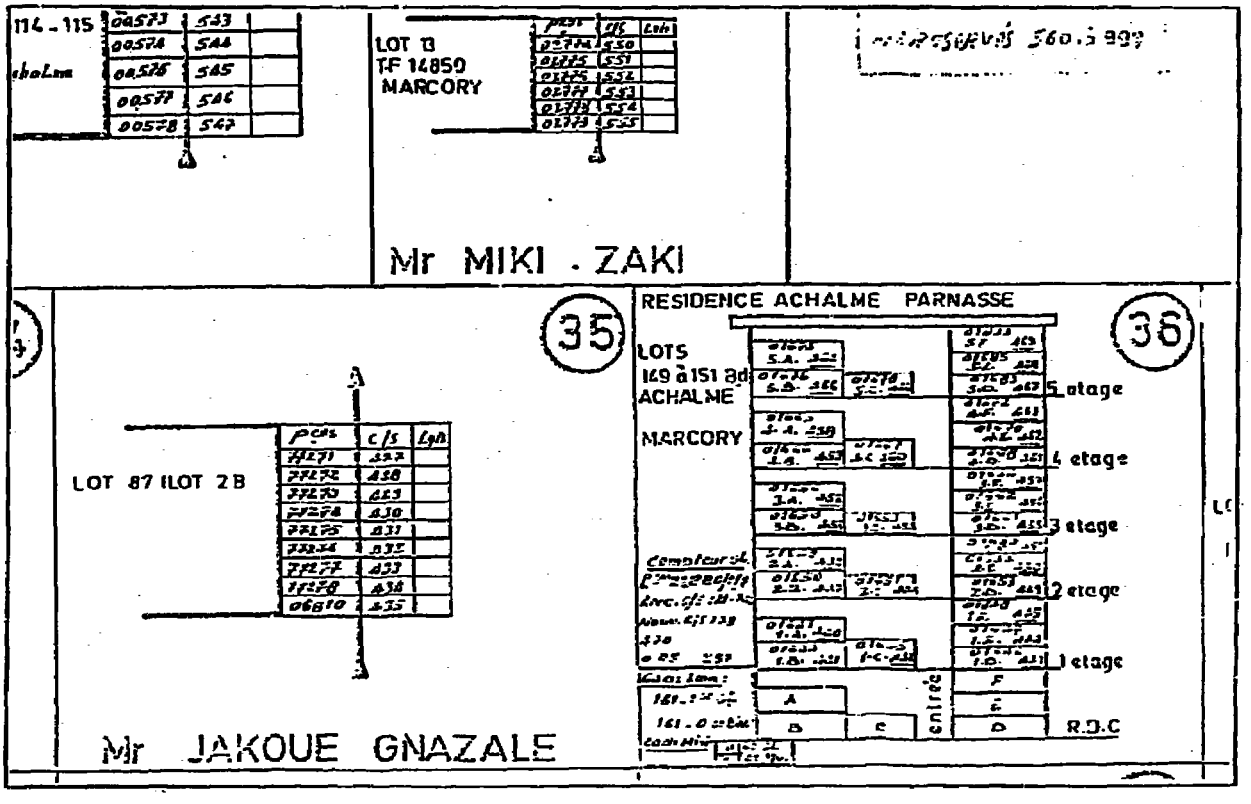
Map A–21. Sewers—1:1,000



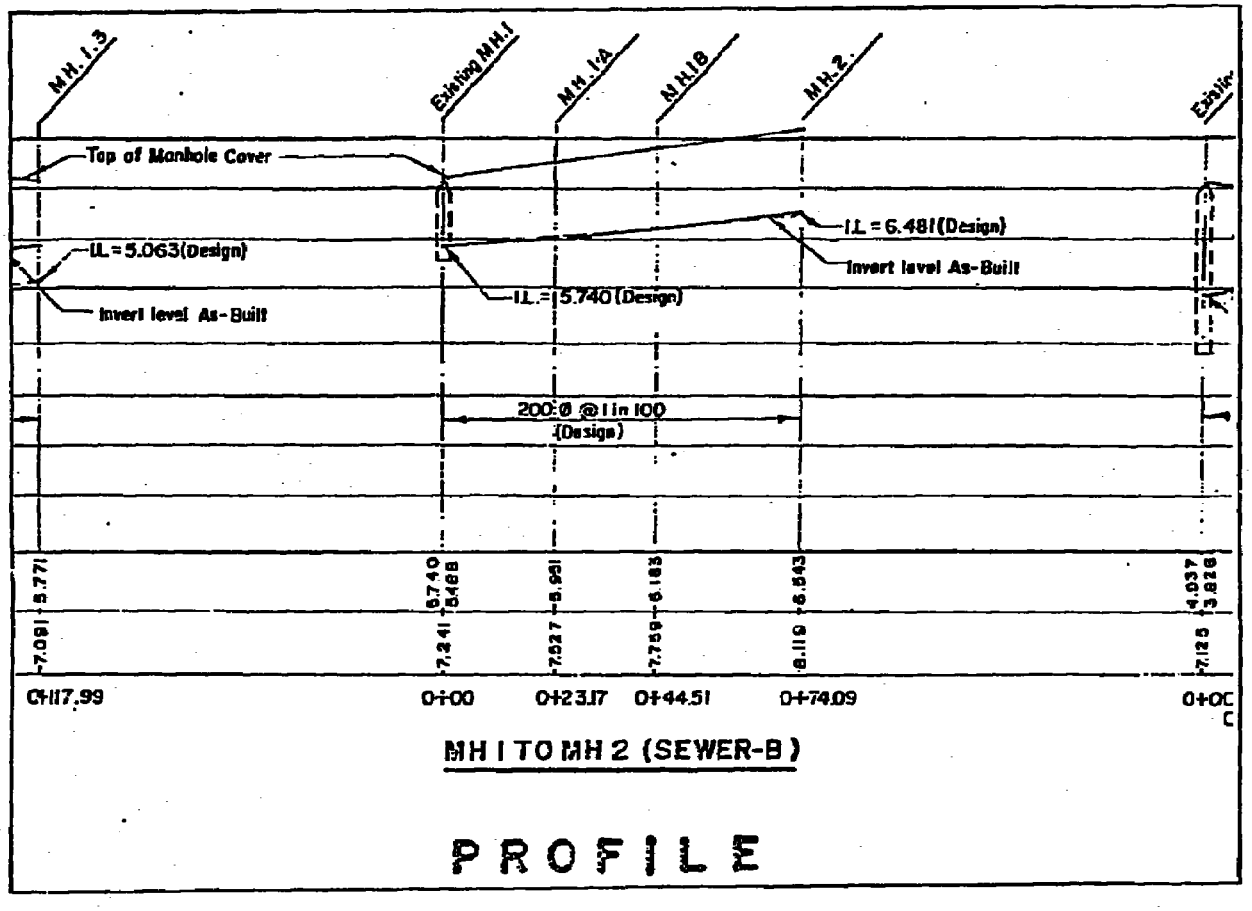
Map A–22. Highways—1:500



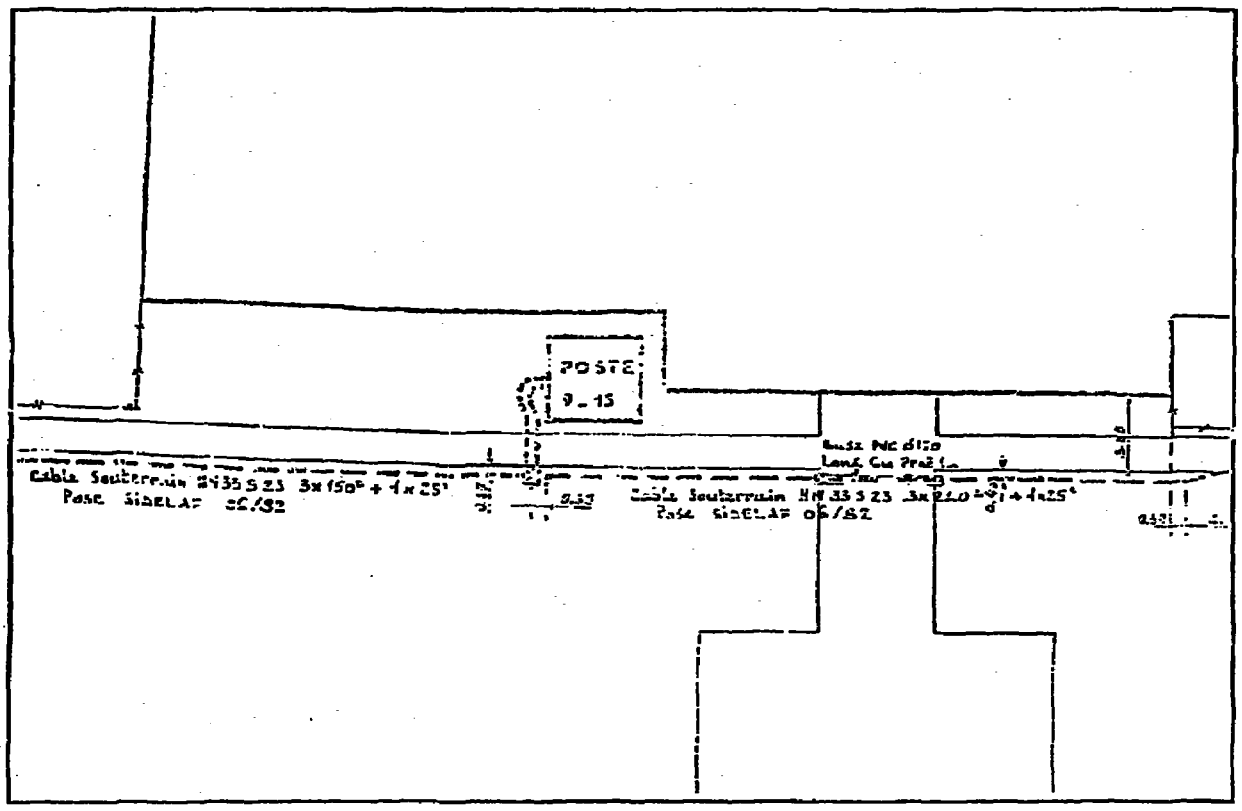
Map A–23. Customers and meter reading schematic



Map A–24. Sewerage—1:1,000



Map A–25. Electricity—1:200



ANNEX B: SUMMARY OF CASE STUDY VISITS

B1.1 This is a brief summary of study visits to three large cities in developing countries in 1990. The visits were made with two main objectives in mind: to obtain firsthand information on the quality of map-based records, and how they were managed; and to ascertain what steps were taken, or approaches considered, to improve the record systems.

B1.2 The cities visited were a) Dhaka, Bangladesh, from March 19 to April 2, 1990; b) Abidjan, Côte d'Ivoire, from April 22 to May 3, 1990; and c) Mexico City, Mexico, from August 26 to September 9, 1990.

B1.3 In the time available, it was not possible to arrange meetings with all the relevant organizations in each city. Neither was it feasible to look at all aspects of mapping and record management in the agencies visited. Nonetheless, it was possible to obtain a useful overview of salient features, thanks to the management and staff of the organizations visited.

B1.4 The information that follows was valid at the time of the case study visits, but subsequent changes may have occurred.

Dhaka, Bangladesh

B1.5 **General.** Dhaka is the capital city of Bangladesh and covers an area of some 55 square miles. The population is about 4.2 million and is expected to rise to 5.5 million by the year 2000. The old part of the city lies mainly on the north bank of the Buriganga river. Development has spread northward from there for some 10 miles.

B1.6 Within the Dhaka Metropolitan region, management of the various aspects of infrastructure falls within the remit of several ministries. These include the Ministry of Energy and Mineral Resources, Ministry of Communication, Ministry of Local Government and Rural Development and Co-operatives and Ministry of Public Works.

B1.7 **Base Maps.** The official agency for mapping is the Survey of Bangladesh (SOB). For Greater Dhaka city, they produce two sets of maps. A colored one at 1:20,000 and a 1:10,000 series updated in 1989. Several utilities have produced their own copies, most of which are derived from the 1978 aerial photographs at 1:5,000 or a later 1:10,000 set taken in 1987. The surveyor general has put forward proposals for digital mapping, but in-house knowledge is limited.

B1.8 **Electricity Distribution.** The Bangladesh Power Development Board (BPDB) was formed in 1972 when it was split from the Water Distribution Organization. It started mapping work in 1973, when it also began numbering all its poles. In 1977, the BPDB arranged with the Survey of Bangladesh (SOB) to create a set of 1:1,200 base maps. Since then, these maps have been updated in-house. The expenditure budget for the distribution system also provides for the upkeep of records. When planning power provision for new developments, BPDB creates any new maps that are necessary. In addition to the physical layout maps, there are schematics for each set

of transformers and a diagram of the city's high-tension system. In 1986 a computer network management system was introduced, which works well, and has now been enhanced by tying it to the computer software AUTOCAD.

B1.9 **Water Distribution.** Water distribution is managed by the Dhaka Water and Sewage Authority (DWASA), which was set up in 1963. Their base maps were copied from those of BPDB. One set has been marked up to show the line and diameter of the water mains, but only some valves. Pumping stations and water towers are shown, however. New works have been added to the water records and construction job numbers noted to facilitate reference to as-built drawings. In addition to the 1:1,200 records, a master sheet at 1:20,000 shows pipes down to 6 inches, the deep tubewells, and the zone boundaries. A pilot study to confirm the network found many unknown connections, duplicated pipes, capped off mains, and closed valves. Initial investigations in the old city suggest that even worse problems exist, including new houses built over mains. Also the larger pipes are often some 2 to 2.5 meters deep. Consultants are engaged in an overall record improvement project and, although much information for the older installations is not available, a system is being set up by which all new work details will be included.

B1.10 **Sewerage.** The sewerage for Dhaka is managed by DWASA with an organization that parallels the one for water distribution. The two main sets of records in use are 1:1,200 map sheets marked with the sewer lines and the as-built drawings. The map records tend to be used for planning and design, while the zone engineers rely on the as-built drawings for more detailed information. There are no records of pipe condition and no system of manhole record cards. Off-sets from permanent surface features, such as buildings, to the manholes are not recorded on the as-built. Because the method of road resurfacing is simply to put on another layer of asphalt, manholes are soon lost. However, the city appears to be capable of maintaining records if a definite system was to be put into place.

B1.11 **Telephones.** The Dhaka telephone service is provided by the Bangladesh Telephone and Telegraphs Board (BTTB), which was set up in 1979. In the BTTB, the responsibility for records appears scattered. The primary network is held in schematic form, and the diagram of "existing primary cable network" is thought to be fairly accurate. However, the exact location of cables is not recorded. Central records of the secondary network are poor, although the division engineer has collected maps of some 80 percent of the network. Recently a Korean company completed a mapping exercise for Dhaka telephones and, although at the time of the visit it had not reported, BTTB was relying on receiving definitive map records of the whole of its system. At the operational level, record keeping is more complete. Each local camp has a map at between 29 1:500 to 1:1,000 showing the location of all items. Plus, all connections are registered, as are all faults and repairs. A detailed statistical report is submitted monthly to the division engineer.

B1.12 **Gas Supply.** The gas supply to Dhaka is furnished by the Titas Gas Transmission and Distribution Co. Ltd. It has a 1:10,000 overview map showing high- pressure mains, substations, and low-pressure lines. For each area there are plans at approximately 1:4,000 and sets of 1:500 standardized drawings fully detailing the network. The latter are based on 1:500 maps produced by the company's survey teams backed up by drawing office staff. These base maps and records account for some 10 percent of the planning department's budget. Besides the maps, the company

keeps extensive records, and it issues a monthly management report containing a large amount of readily retrievable information. A computer system is being implemented, which will start with the billing function.

B1.13 **Solid Waste Collection.** Refuse collection is organized by the Municipal Corporation. There is an inventory of plant and vehicles together with one listing solid waste collection points. However, no maps are marked to show collection point locations or the garbage collection routes.

B1.14 **Street Lighting.** Street lighting is provided by the Municipal Corporation. A record is kept of the number of lights in each ward, but there is no map of the lamp locations. Individual forms are used for failure reports and repairs. With the change to sodium lights, a numbering system is being introduced and a road plan indicating locations is being drawn up.

B1.15 **Roads, Surface Drainage, and Public Areas.** The responsibility for roads rests with the municipality. There are no maps of the roads, surface drainage, or of the infrastructure the department manages. The only available map of the city (in 1:20,000) shows ward boundaries.

Abidjan, Côte d'Ivoire

B1.16 **General.** Abidjan is the economic and administrative capital of Côte d'Ivoire. The city is modern in style, well laid out with industrial and residential zones located around lagoons. It has one of the best harbors on the West African coast. Following the French system of public works administration, it has a controlling organization, the DCGTX, which manages infrastructure planning. This body closely supervises the service-providing agencies, either through the relevant ministry or directly. Ministries involved include the Ministry of Industry, the Ministry of Public Works, and the Ministry of Transport.

B1.17 **Base Maps.** Abidjan is well provided with base maps produced by IGN, the French national mapping agency. The maps are essentially cadastral ones at 1:2,000, with 1:500 enlargements as necessary. Abidjan also has a new series of aerial photographs taken by IGN in 1985, and maps at 1:5,000. These maps have been available in digital form since 1989, and DCGTX is using them to set up a GIS.

B1.18 **Electricity Distribution.** The electricity service for Abidjan is provided by Energie Electrique de la Côte d'Ivoire (EECI). For the distribution department (33kV and low tension), there are two sets of plans, one at 1:2,000 or 1:5,000 for overhead systems and one at 1:200 and 1:500 for the underground network. The 1:500 series shows the street layout with details of cable ducts and IACMs (Interrupteurs a Coupeur Manual), and the 1:200 series shows individual cables with offset measurements and detail lengths between duct access points or switches. Information on transformers and distribution boxes is shown in more detail on schematic diagrams. Other plans include a set prepared for meter readers showing all the consumer meter positions. The EECI is considering introducing digital mapping.

B1.19 **Water Distribution.** Water supply to Abidjan is managed by the Direction des Eaux with planning decisions by DCGT (Grand Travaux) and SODECI (Société de la Distribution d'Eau de

la Côte d'Ivoire) running the system. Departments in both Direction des Eaux and the SODECI look after records, the coverage of which is quite extensive. General plans of the network at 1:2,000 are used for forward planning. SODECI has the following five main categories of map records: land parcels with lot numbers, pipe networks at 1:2,000, house connections, meter reading routes, and master or index plan sets at 1:10,000 and 1:5,000. The 1:2,000 network plans incorporate enlarged features that are supported by record books of detail sheets. Checks and updating are carried out at six-month intervals. There is an overall schematic of the city network for the management and analysis of the distribution system.

B1.20 **Roads and Traffic Control.** Traffic flow and road maintenance is looked after by the Service d'Exploitation de la Circulation (SEC), while planning and highway construction rests with DCGTX, and road drainage with the sewerage department of SODECI. The traffic situation was studied in 1980 and a control system set up in 1981 with one-way streets and phased traffic lights. There is a general 1:10,000 plan for the Plateau, with the sets of lights numbered. In addition, there are detailed plans of each cross-road at scales of 1:500 to 1:20. There is an overall 1:20,000 plan of Abidjan showing all traffic light locations with date of installation. Since 1981 the traffic lights have been controlled centrally by computer and records include full details for each location. Any utility wishing to dig up a road must inform SEC, which can dictate how it is to be carried out and working hours.

B1.21 **Public Transport.** Public bus, taxi, and water bus services in and around the metropolitan area, including the lagoons, are provided by Société des Transports Abidjanais (SOTRA), which has two 1:20,000 plans showing the full extent of the city. One is in outline showing bus routes as a single line plus bus stops and terminals. The other plan shows the street layout plus bus routes with the numbers alongside and particulars of the terminals for each route. Because the city route is growing rapidly, plans are soon out of date.

B1.22 **Solid Waste Collection.** Solid waste collection is the responsibility of SITAF, whose duties are laid down by the Town Hall and DCGTX. There are skips positioned in the market areas and probably definitive refuse collection routes, but there are no plans showing garbage truck routes or the location of communal collection points.

Mexico City

B1.23 **General.** Mexico City, the capital of Mexico, has a population of 18 million, which is expected to reach 28 million by the year 2000. It is a modern city that has rapidly expanded to become the most densely populated metropolitan area in the world. The urban area covers the whole of the enclosed valley that forms the Federal District. Because of the considerable urban growth that has taken place, the institutional arrangements for Mexico City are somewhat complex. There are sixteen delegaciones of the Distrito Federal plus twenty-seven municipalities belonging to the adjacent State of Mexico. Although both federal and national departments play a role in managing each of the utilities, most of the operational aspects are run by individual local governments. The approach to infrastructure is mainly sector-based.

B1.24 **Base Maps.** There are three main sources of base maps in Mexico: the Instito Nacional

de Estadistica e Informatica (INEGI), the Secretaria de Desarrollo Urbano y Ecologia (SEDUE), and a variety of private concerns such as Guia Roji. INEGI was formed by amalgamation in 1983, and it puts out 1:50,000 maps derived from aerial photography, as well as 1:5,000 maps for large cities such as Mexico City. The 1:50,000 maps are updated every five years, and INEGI is about to use digital mapping. SEDUE produces many urban land-use maps at between 1:40,000 and 1:8,000, but these do not cover Mexico City.

B1.25 **Electricity Distribution.** Electricity production and the high-tension national grid fall under CFE. The distribution system, from 23kV downward, is contracted out to separate companies. In the case of Mexico City, the electricity is distributed by Compania de Luz y Fuerza del Centro (CLFC). There is a fairly comprehensive system of map-based records in CLFC. These include 1:10,000 maps of the 23kV and low-tension (LT) aerial lines, maps at 1:6,000 showing the 6kV network, and a 1:3,000 series showing the 23kV and LT networks in more detail. There are records at 1:3,000 for the 23kV underground system and the LT network in the residential area with cable information detailed. In addition, there is a 1:3,000 map of the automatic 23kV middle-town network showing major consumers. For the crowded Zona Rosa, there is a similar map plus one at 1:1,000 showing much more detail. Consistent symbols are used on all maps and there is a clear mechanism for transferring as-built information onto the record plans. There is a team continually keeping records up to date, plus the operations department carries out checks to confirm details in the field. In the outlying suburbs, up-to-date base maps are not always available, in which case plans are created as an interim measure.

B1.26 **Water Distribution.** The national authority for water is CNA. However, for the Federal District and Mexico State, the Direccion General de Construccion Operacion Hidraulica (DGCOH) is responsible for hydraulic construction and operation. This includes potable water distribution as well as raw water drainage and the sewerage system. The main set of water distribution record plans at 1:2,000 was created in 1979 by an outside contractor. Since then there have been many changes and additions to the network—not least because of rehabilitation work required after the 1985 earthquake. In 1986 a major project was begun to update records in an organized way, and a manual was prepared for the use of all contractors engaged in the work. Information on construction drawings has not been transferred to the records, often because as-built drawings have not been prepared. In 1990 the production of as-built drawings was made a requirement in all specifications for construction work. In 1986 DGCOH purchased some digital mapping equipment, which is being used to digitize background topographic maps at 1:2,000 for water distribution and 1:500 for sewerage records, but progress has been slow. The old water records consisted of 263 maps, whereas the new series will cover 549 sheets, of which only 66 had been digitized at the time of the visit. A manual for the production of records has been developed over the years and is now quite comprehensive. A start was made in 1989 to keep leakage repair details. There are detailed records of wells, both technical and operational, and considerable information on flooding. Much of the record information is held and manipulated on computers and each year a considerable amount of the information is published in summary form.

B1.27 **Sewerage.** The organization of sewerage is similar to that for water, with DGCOH being responsible for the construction and operation of the main network. Being organized by the same department, record systems parallel those for water distribution.

B1.28 **Telephones.** The telephone system in Mexico is managed by Telefonos de Mexico (TELMEX). There are separate sets of maps showing the trunk system and the primary and secondary networks. Each set comprises both topographic layouts and schematics, and for the primary networks there are details of the gas protection system. The external network plans show the lines and number of pairs. The existing plans vary between 1:1,000 and 1:5,000, depending on the size of the district. There are separate two-sheet sets for each switch box district, of which there are some 29,000. There is an index map of the districts. Information from as-built drawings is transferred onto the network record plans founded on base maps obtained, for the past ten years, from INEGI. Several sets of records are maintained covering such topics as commercial information, complaints, and details of new services. Failures are recorded together with details of necessary repairs. Much of the information is held on computer, which can also report failures on the trunk and primary systems immediately. TELMEX is starting to digitize plans using a CADMAN system developed in-house, but background maps take rather long to digitize.

B1.29 **Solid Waste Management.** Solid waste management is supervised by the Direccion General de Servicios Urbanos (DGSU), which is a section of Department del Distrito Federal (DDF). There appear to be adequate records of the operational system with collection sites well documented, as are the routes for road sweeping.

ANNEX C: GREATER CAIRO UTILITY DATA CENTER, EGYPT

C1.1 This annex is based on a description by Syed Badr and Timo Puhakka. It is one example of a pragmatic and successful approach to underground utility mapping. The description provides some organizational details.

The Urgent Need for Utility Mapping

C1.2 Greater Cairo is an urban agglomeration with more than 12 million inhabitants, extremely high population density, and a rapidly growing population. Between 1970 and 1990 the number of inhabitants more than doubled.

C1.3 At present, the network of underground utilities in Cairo consists of almost 70,000 kilometers of different kinds of pipes and cables (water, sewerage, electricity, gas, and telephone) and the network is growing at the rate of about 1,000 kilometers annually. The mapping of underground utilities has been inadequate, and there are almost no maps for older pipelines. Traditionally, mapping and data collection and retrieval on underground utilities has been carried out separately by each utility organization without coordination at the central city administration level.

C1.4 The need for accurate maps and data bases on underground utilities has been clearly recognized for a long time. During the 1980s, this need was particularly strong in the planning and implementation of major infrastructural and construction projects, especially the Metro project.

C1.5 In the 1980s, the economic losses resulting from unnecessary damage to underground utilities during excavation and construction operations amounted to hundreds of millions of Egyptian Pounds (LE). Estimates of unnecessary costs from damage to underground utilities in connection with the Metro project have been estimated to be close to 30 percent of the total project expenditure.

Establishment of the Underground Utilities Data Center

C1.6 The Underground Utilities Data Center of Greater Cairo (UDC) was officially established in October 1988 as an independent service organization within the framework of the Governorate of Cairo. The role of UDC is to collect, process, and store data for the urban management of Cairo. For this purpose, UDC is to create and maintain a geographic information system containing accurate, relevant, and basic information on underground utilities. The data bases can also be extended to cover land use, cadastral, soil, and other environmental data.

C1.7 The director general of UDC reports directly to the governor and the operational costs are covered through different utility agencies, that is, the water authority, the sewerage authority, the electricity company, the gas company, and the telephone company. The establishment of UDC was endorsed by the Egyptian Parliament in August 1989. A technical committee chaired by the director general of UDC has been established to strengthen the liaison with the utility agencies.

C1.8 An important step in the consolidation of UDC's status within Cairo Governorate has been a decree issued by the governor declaring that all contractors have to consult and obtain a license from UDC before they will be allowed to undertake excavations.

C1.9 The resolutions specify the procedures for obtaining excavation operations and thus contribute to preventing any damage to underground utilities caused by accidents during excavation works. They also improve UDC's possibilities to generate income from services provided to contractors and other excavators.

C1.10 Until April 1992 *no* damage to underground utilities had occurred at construction sites where UDC has carried out utility detection and mapping.

C1.11 The role and status of UDC in the surveying and mapping of Greater Cairo deserve some attention. According to Egyptian law, surveying and mapping are the sole responsibility of the Egyptian Survey Authority. No separate mapping and surveying institution exists within the Cairo Governorate. The availability of large-scale base maps of Cairo is inadequate; existing base maps on scale 1:500 date back to the 1940s and have not been updated. A more recent base map (1985) exists on a scale of 1:5,000, but it is not exact enough to serve the needs of site planning and construction works. It is used mainly for overall land-use planning, traffic planning, and so on.

C1.12 During the process of utility mapping, the UDC is updating and digitizing the 1:500 base maps. This could provide UDC with an opportunity to develop into a general surveying and mapping institution for Cairo in the future. Proposals on this issue have been presented for discussion within Cairo Governorate.

Current Status

C1.13 During the past three and a half years, the UDC has established a main office of some 800 square meters in Heliopolis. The detection and survey of all underground utility lines of the Roda Island pilot area have been completed and the data collected in the UDC's GIS system. The UDC has already issued some 6,100 excavation licenses and registered the clients concerned in the data file. This activity alone has generated an income of more than 40,000 LE since the debiting of license fees was approved. UDC is by decree the only institution to issue excavation licenses.

C1.14 Up to now, commitment contracts have been concluded with various consultants and contractors to a value of about 850,000 LE. Contracting is definitely the path UDC will continue on. This will be the main source of income in the future.

C1.15 UDC has started to market its services directly to various authorities, consultants, and contractors, as well as through public media such as newspapers. The interest in UDC is growing,but because of its limited resources, it has been forced to refrain from taking up assignments in some cases. Extensive cooperation has been established with a number of consultants and contractors. This has brought savings in both time and costs.

C1.16 Cooperation agreements have been signed with the water and sewerage authorities, and the Cairo electricity distribution company. UDC has also been negotiating with other organizations such as the gas and telecommunication companies and the Metro authority. So far, only contracts on a case-by-case basis have been concluded. There are, however, strong indications that other organizations are willing to join the system if UDC could provide a comprehensive service covering larger areas than at the present time.

C1.17 The training program has been very extensive. A total of 60 training courses have been arranged with a total of 550 persons attending. The main emphasis has naturally been on improving technical skills in detection, surveying, and data handling. In addition, training of a more general nature such as administration, finance, English, and word processing has been arranged. Lecture material is collected and compiled on a continuing basis as the planned expansion of UDC personnel and activities will probably increase training needs enormously.

Prospects for the Near Future

C1.18 Currently, UDC operations cover only 6-10 percent of the total area of Cairo. According to Egyptian regulations, an institution can be granted the status of organization when its activities cover about 60 percent of the area designated. UDC must gain organizational status if it is to strengthen its position among other organizations and be able to keep the trained personnel. It could do so by establishing branch offices and increasing its activities. The main target is to cover all new constructions up to nearly 100 percent, provided that all the necessary information is received from the authorities and parties concerned.

Organization and Personnel

C1.19 UDC operates directly under the Cairo Governorate and is headed by a director-general. It consists of four departments: Administration, Data, Client Service (with two field teams), and a Field Department (with seven field teams). The total work force is currently made up of eighty-five persons. The personnel are young and well-educated: sixty have high school or a higher level of education and sixty-three are below thirty years of age. Eighty percent of the staff are in the productive sector of the institution, and only 20 percent in more administrative tasks, including PR and training. The male/female ratio is roughly 80/20. The organization communicates and works efficiently.

Equipment and Data Management

C1.20 Since Cairo is one of the biggest capitals in the world, the magnitude of executed projects is also considerably larger than in many other cities. Cairo is a very old city and its utility capacities and traffic flow are overloaded. Therefore the maintenance and renovation projects are generally large-scale. The average UDC project generally involves about 6 kilometers of utility lines.

C1.21 In order to cope with this situation and to provide fast services, UDC has adopted a policy to obtain high-tech field and data equipment in the initial stage. According to UDC plans, the branch offices should be at least partly equipped with high-tech equipment such as total stations, PCs, and plotters in order to facilitate ground control tasks, base mapping, map production, and area detection.

C1.22 In the long-term development plan, future branch offices can partly be established with more modest equipment than the headquarters. Depending on the construction activity, some of the teams could be furnished with detection equipment only. In this case, the investments in surveying equipment will be considerably lower (prisms, measuring tapes, and the like). This applies also to the planned computer configuration in the branch offices. UDC will determine the appropriate technical level on the basis of the size of the area, population, estimated construction activity, and maintenance activity in old areas.

C1.23 The approach adapted in data collection and the establishment of the graphical data base has been pragmatic. Unnecessary digitizing has been avoided and all data input is based on accurate ground observations instead of unreliable maps. This has brought excellent results.

Organization of Fieldwork

C1.24 The main tasks of the UDC field staff are to detect and measure any type of underground utility networks; collect existing old utility maps; provide any kind of utility or survey services to UDC customers; connect all measured data in the UDC coordinate system; train new and old personnel continuously; and perform maintenance on the field equipment.

C1.25 The work is divided into five sectors: area mapping and detection, client services, ground control, training, and maintenance.

Area Mapping and Detection

C1.26 The area mapping and detection sector is manned by four fully equipped field teams that perform systematic detection and mapping tasks in the designated areas. Usually the work starts with collection of existing utility maps from the relevant authorities. In every project, UDC contacts each authority to obtain assistance from their representatives for open manhole covers, distribution boxes, transformers, and so on.

C1.27 The next step is visual checking in the field, whether the information received from the organizations matches the actual street situation or not. A plan for necessary ground control observations and traversing work is also made. After the observations, the collected data are transferred to the geodetic section for the calculation of coordinates. Detection work starts by locating and exposing hidden manholes and valves.

C1.28 Thereafter, detection is started by selecting the least complicated utility network. After completing one network, the field team continues to the next until every utility network is detected. Field data are edited daily on the PC working level and are transferred directly to the UDC data base. After all networks are detected and the information transferred to the cartographic section, a semifinal plot for checking is created. The final check is made by the sweeping method. The area mapping can be interrupted at any time if a team is needed for client service activities. Field teams return to their basic work site after completing their mission for the client services sector.

Client Services

C1.29 UDC has furnished four fully equipped field teams for client service activities. One team is nominated as an emergency crew that is on alert twenty-four hours a day. In addition to carrying out emergency fieldwork and detection and mapping for area projects, this sector provides services such as detection and mapping for house connections, follows up on new utility lines, and conducts base-map surveying, contour mapping, quantity calculations, and setting out.

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