Irrigation Management in China
A Review of the Literature

James E. Nickum

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ABSTRACT

This report analyzes irrigation management in the People's Republic of China. It is based on Chinese-language materials published in China and now available in the United States. Major topic areas covered are the institutional environment, the organizational structure (including staffing), water fees and funding, and water allocation (including the conjunctive use of multiple sources). It is found that despite a markedly different institutional framework, including collectivized agriculture and a Leninist Party, China's irrigation management is by and large quite similar to that of other Asian LDCs.
IRRIGATION MANAGEMENT IN THE PEOPLE'S REPUBLIC OF CHINA

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Note

15 mou = 1 ha  
2 jin = 1 kg
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SUMMARY

Introduction

i. The purpose of this report is to provide an outside view of water management in the PRC, based on China materials, which may serve as a base for comparison with other systems and for further investigations into China's water management.

ii. The PRC relies heavily on irrigated agriculture, with approximately 47 million hectares (700 million mou) of farmland under irrigation, nearly the same as India and a much larger percentage of China's total cultivated area of less than 110 million hectares. China has invested heavily in hydraulic constructions in recent decades, resulting in a total of 2,500 reservoirs, 82,000 smaller reservoirs, about 150 major irrigation districts, 2.2 million pump-wells, and 75 million horsepower of irrigation and drainage machinery. Despite all these advances, China's rates of utilization appear to be considerably below design capacity.

iii. This paper is based on a set of Chinese-language materials now available outside the PRC. Given the nature of the sources, we are constrained to look in the main at the concerns of their compilers. The paper sorts and investigates the data from the Chinese sources in the following major categories: the institutional environment; the organizational structure including staffing, water fees and funding; and water allocation including the conjunctive use of multiple sources.

iv. The most important data sources for this research have been five major case studies, although the material reviewed here makes reference to at least 46 reservoir and irrigation districts. The case studies are: The Qianjin Reservoir, the Meichuan Reservoir Irrigation District, the Yeyuan Reservoir Irrigation District, the Shaoshan Irrigation District and the Yinjing Canal Irrigation District. These cases are not modal; this is not their purpose.

Institutional Environment

v. China has a long history of hydraulic construction, much of it sponsored by the state. With the exception of major flood control and navigation, water management before 1949 was most commonly in the hands of families or of village or clan organizations. Concomitant with the socialization of land-ownership (between 1947 and 1952), accompanied collectivization was a concern with putting "plan water use" into practice.

vi. During the 1960s and 1970s there were few apparent changes in the basic structure or operation of water management. Planned water use was extended and the end-user organizations were involved in various aspects of management. The need for professional management was claimed, but it was not expanded in many areas. Since 1978, rural collectors and households have
exercised significantly increased decision-making powers over the use of their own resources. The market mechanism plays a greater role, and farm production is less oriented to meet output targets.

vii. The management organs of an irrigation district are formally in the governmental system, although they usually contain a Party committee or branch as well. Within the governmental system, agriculture and water conservancy have always been separated functionally. This may lead to poor synchronization of water release and crop needs. These problems are mitigated in China, since both departments follow civil administrative boundaries, and the Party can function as a coordinating agency. However, several problems have arisen, and the management of water projects now appears to be firmly in the hands of the water bureaucracy, as evidenced by the presence at the central level of the bureau of farmland water conservancy and of water project management in the Ministry of Water Conservancy.

viii. Water rights are not very well spelled out, leading to some anarchy in the use of water resources. *De jure* and *de facto* rights to water use are somewhat better specified at the project level. The centralization of rights over water allocation takes on particular importance in projects with multiple water sources, such as the "melon on a vine" schemes.

Organizational Structure and Staffing

ix. In practice, the management of state-operated irrigation districts appears to be kept at the lowest reasonably comprehensive level in the administrative structure. On the other hand, there are some pressures to centralize, especially at the local level. According to guidelines which appeared in 1965, a reservoir with a storage capacity in excess of 10 million $m^3$ may have a management body separate from its irrigation district.

x. A successful PRC irrigation district management has three organizational components: (a) the "professional management structure," (b) the "democratic management organizations," and (c) the "mass management organizations."

xi. The professional management structure is the institution that directly manages the project. It is the executive unit which concretely carries out management operation and implements the policies of the Party and the directives of higher levels. A more recent description indicates that intracommune professional management is organized along administrative lines rather than on a project basis. In 1965, guidelines were issued to establish staffing norms in terms of personnel per 10,000 hectares; however, these guidelines are applied with a lot of flexibility. It seems that a high percentage of a project's management staff is drawn from its locality. There is virtually no market for skilled or professional labor in the state sector. A common characteristic of professional management personnel in smaller projects has been their lack of prior training in water conservancy and a low level of education in general.
xii. Formal authority in an irrigation district resides in the "democratic management organizations" such as irrigation district congresses and irrigation management committees at various levels.

xiii. Basic-level watering operations and project maintenance are commonly placed in the hands of "mass management organizations" whose members are paid in work points from the collective sector. In most cases, project maintenance is allocated to the beneficiary units in proportion to some means of benefit.

Funding

xiv. The basic principle to be pursued in funding irrigation management is that an irrigation district or pumping station should be self-sustaining and not rely on state or collective subsidy to sustain operations. According to the nature of the project, fees may be levied for agricultural, industrial, electric power and navigational uses. Sometimes, water charges are collected in kind.

xv. The evidence investigated for China indicates that, while variable price schemes have desirable properties in reducing both waste and conflicts over water use, they are far from being a cure-all and are more likely to be a useful implement to otherwise good management of water distribution. However, fixed charges are still more commonly paid. In the absence of an enforceable nonpricing method of water allocation, the interests of upstream and downstream users tend to conflict.

Water Allocation

xvi. The case studies show that, especially in the early days of a project's operation, professional managers may focus on water release without consideration of crop requirements, even in monocultures. The basic-level water managers are in charge of inspecting and determining the water needs of the crops on an ongoing basis, drawing up basic-level water use plans and releasing water to the technical units. In some cases, terminal production units are issued water allocation permits, or they buy coupons.

xvii. In the main systems, various sequencing rules have been adopted in order to ensure the even distribution of benefits. It is common in multiple-sources ("melons on the vine") systems to use various sets of "first/labor" sequencing principles to guide water allocation decisions. A melons-on-a-vine system integrates the use of small facilities owned by terminal users with that of the large core project. Such integration entails a number of difficult problems: the extra time and effort, finding economic inducements for end-users, etc. As one would suspect, especially where the smaller projects have preceded the construction of the core reservoir and canal facilities, there are likely to be some difficulties in establishing a melons-on-a-vine system from the standpoint of at least a portion of the end-users.
Conclusion and Recommendations

xviii. Generalizing about any aspect of the Chinese subcontinent is hazardous under the best of circumstances. In the area of water management, the available data base is narrow, selective and often conflicting. It covers projects which vary widely in size, ownership, history, location, energy source, degree of water scarcity and so on. A large majority of the irrigation projects on which this report is based are owned and operated by the state, whereas most of the irrigated land is watered by local collective-owned schemes. The North China Plain is virtually unrepresented by the case studies, yet it is the focus of great concern in water management, especially in the context of the potential effects of large-scale water diversion from the Chang Jian (Yangtze). Impressive accomplishments have been achieved by the Chinese in their development and management of water. The case studies are only part of the testimony thereto. Yet there are continual and widespread complaints in China of unsound (or even nonexistent) management and of low water utilization rates.

xix. The best irrigation districts appear to operate very much like the oft-praised irrigation associations of Taiwan, albeit with a lower component of technical expertise. Water is recognized as a scarce factor which should be paid for and carefully husbanded; there are good two-way information (and possibly control) systems between managers and users of water; and irrigation is linked to crop requirements.
1. INTRODUCTION

1.01 The lack of effective on-farm water application and removal is one of the most significant bottlenecks to improving agricultural output in much of the world. Yet the vital nontechnical organizational and operational aspects of water management have only recently been studied in a systematic way. The few comparative or general studies which are available (e.g., APO, 1577; Bottrall, 1978b; Chambers, 1977, pp. 340-363; and Coward, 1980) have not taken full account of the experiences of the People's Republic of China (referred to herein as the PRC, or China). The purpose of this report is to provide an outside view of water management in the PRC, based on Chinese materials, which may serve as a base for comparison with other systems and for further investigations into China's water management.

1.02 The PRC relies heavily on irrigated agriculture, with approximately 47 million hectares (700 million mou) of farmland under irrigation, nearly the same as in India and a much larger percentage of China's total cultivated area of less than 110 million hectares. With its more temperate climate and multiple cropping, China's annual yields are much higher than in India. Over 200 million metric tons of grain, two thirds of the national total, are produced on irrigated fields.

1.03 China has invested heavily in hydraulic construction in recent decades, resulting in a total of 2,500 reservoirs with a storage capacity of at least 1 million cubic meters each and 82,000 smaller reservoirs (total PRC reservoir capacity is 400 billion m$^3$); about 150 major irrigation districts each serving 20,000 hectares or more and many thousand smaller districts; 2.2 million pump wells; and 75 million horsepower of irrigation and drainage machinery, both diesel and electrical, operating on about 30 million hectares. In addition, there are 165,000 km of embankments along rivers, seas and lakes, protecting 32 million hectares of farmland.

1.04 As in many other parts of Asia with large-scale water investment, China's rates of utilization appear to be considerably below design capacity. Certainly it is the consensus of scholars and policymakers within the PRC that water management levels are too low. For example, Vice Minister of Water Conservancy Li Boning recently claimed that most of the electro-mechanical irrigation and drainage facilities in China are "low in efficiency and high in consumption; the management system is not perfect and rules and regulations are urgently needed" (FBIS, 6 August 1979, p. L 15). Vice Minister Li later announced that the Ministry of Water Conservancy is in the process of mapping out rules of project management in order to reduce waste (FBIS, 20 February 1981, p. L 2). The degree of perceived slack is indicated in a 1979 claim by agronomists in Henan that that province's irrigated acreage was 2.7 million hectares (40 million mou) below its potential because of a lack of ancillary works for 10 large reservoirs built in the 1950s and for the more recently dug 110,000 pump wells (FBIS, 12 March 1979, p. H 1).

1.05 Especially since the mid-1950s, China's water management has operated within a markedly different political and institutional framework than in most of the rest of Asia. Aside from a Leninist party overseeing and coordinating the administrative organs, the PRC has collective user groups at...
the watercourse (village and subvillage) level (these are discussed in chapter III). One reason for investigating China's water management is therefore to shed light on the relative merits of producer cooperatives as basic organizational units. At least as important is to determine the degree to which problems encountered in irrigation management are universal and determined by factors other than the organizational form of the end-user--factors such as the nature of the water problem, the technology available and the level of economic and cultural development. For example, the Chinese have wrestled with problems of state and village, of upstream and downstream, of professional manager and generalist farmer, which are similar to those which have plagued others. In addition, considerable latitude of project level decision making has led to some experimentation in several important areas such as water allocation sequencing and water charge bases. Thus China's approaches and solutions should yield important lessons, some of which may be transferable to different socioeconomic systems and some of which may help in drafting universal guidelines to improved water management.

1.06 This report is based on a set of Chinese-language materials now available outside the PRC. These materials are described in the next chapter and in Appendix 1. Of particular interest have been the descriptions of how specific projects have operated. A full listing of these "case studies" is in Appendix 2 and their characteristics are summarized in Appendix 3. The five irrigation districts which the materials reveal to us in the greatest detail are described in chapter II.

1.07 Given the nature of the sources, we are constrained to look in the main at the concerns of their compilers. Fortunately, these are often areas of universal interest to analysts of irrigation management organization outside China. This report sorts and investigates the data from the Chinese sources in the following major categories: the institutional environment (chapter III), the organizational structure, including staffing (chapter IV), water fees and funding (chapter V) and water allocation including the conjunctive use of multiple sources (chapter VI). The final chapter presents conclusions and recommendations.

1.08 After presenting a quick survey of organizational developments since 1949, chapter III explores some of the basic background institutions and rules which have an impact on water management in the PRC. As in many other countries, agriculture and water conservancy are functionally separate within the governmental administrative system, with the latter dominant over water management. This would appear, as elsewhere, to have led to an excessive concern with the engineering aspects of water development to the relative neglect of management and agronomy. A mitigating factor is the Chinese Communist Party which can provide the necessary horizontal coordination—if water management is on its agenda. Major multipurpose projects commonly have multiple leadership organs from different levels of the administrative hierarchy. Sometimes this leads to poor results in irrigation management.

1.09 Almost all land in China is farmed by three-tiered collectives, the "rural people's communes." The middle tier of the commune system, the production brigade, is the most common end user for water. The lowest level, the production team, provides work points to rural labor. A work point scheme is
more effective than a wage system in mobilizing low-productivity labor and in absorbing labor costs locally. The water supply on the vast majority of China's irrigated land is managed directly by the collective sector. Our main concern here is with larger schemes, however.

1.10 Water rights are not very well specified in China, especially at the macro level. At a project level, however, fairly clear use priorities have been established. Of particular note is that the rights of prior developers are recognized. Water scheduling may be centralized in the hands of the management body of an irrigation district, but this is not done automatically, especially where multiple water sources are involved.

1.11 Chapter IV turns to the specific features of PRC irrigation management organization. An irrigation district is placed under the lowest reasonably comprehensive level in the administrative hierarchy. Decentralization below this level may heighten local flexibility and responsiveness but also appears to lead to inequities and inefficiencies in the overall allocation of water.

1.12 A successful irrigation district has three management components: "professional," "democratic" and "mass." The professional management structure is the executive organ of the district. Trim staffing norms appear in the literature. Most of the case studies reporting figures fall within these standards, but the exclusion of "mass" (collective-funded) personnel as well as mechanics and electricians diminishes the usefulness of the criteria.

1.13 Information is sketchy on professional staff origin and attitudes. Fragmentary evidence indicates that the vast bulk of personnel have low levels of formal training and that water management is considered a dead end for those who are better educated. Staff remuneration levels appear to be low and in some cases uncertain due to problems in fee collection. Difficulties in revenue generation may also lead to inadequate maintenance, especially for pumping stations which have high recurrent monetary costs. A vicious cycle may ensue between poor maintenance and low remission rates.

1.14 The case studies present arguments for subdividing professional project management along either canal system or administrative lines. In virtually all of the cases considered, however, the basic water-using unit is delineated along existing administrative boundaries.

1.15 Formal authority in an irrigation district lies in "democratic management organizations" such as congresses which periodically bring together representatives of political-administrative, professional management and user groups. These democratic organizations appear to play an important role in information exchange and possibly in decision making as well. They are probably prerequisite to good management.

1.16 Basic-level watering operations and project maintenance are commonly done by "mass" groups whose members are enrolled in the collective economy and are paid in work points. Such mass personnel, temporary or full-time, handle
maintenance and water release functions within each watercourse (below a branch or subbranch canal). Many districts have turned over maintenance on the main canals as well to the mass organizations. An essential ingredient of successful user-based maintenance at higher system levels appears to be the involvement of the democratic management organizations and the Party.

1.17 Unlike other state-owned enterprises which are funded out of a state budget, irrigation management is supposed to be supported primarily by user fees and sideline operations. In practice, it is often heavily subsidized by the state. Chapter V focuses on the internal funding sources, especially water fees.

1.18 In general, fee levels appear to be significant but low, especially for the water component of pump irrigation. On the other hand, the crops watered are also underpriced and are subject to state procurement, and many production teams are cash poor. Thus there is often a conflict between cost recovery and the ability to pay, and there is indirect evidence that this creates a downward spiral similar to that noted for pumping stations. The problem may be mitigated by the collection of fees in kind, especially grain and labor.

1.19 Even where end-users can pay the water fees, they are often reluctant to do so, and there is some evidence that they use the threat or practice of nonpayment as a source of leverage over management. This leverage may be reduced in larger projects which are allowed to turn over collection of agricultural water fees to the normal governmental procurement apparatus.

1.20 Volumetric pricing bases are generally recognized as superior in principle in promoting efficient and equitable utilization of water. In practice, however, fixed charges appear to predominate, especially in water-short north China. It would appear that usage-based pricing is a good supplement to proper management but not a substitute for it.

1.21 Sideline "multiple operations" are significant supplementary sources of income in most of the major case studies. They provide a means of attaining self-sufficiency financially when water fee revenue is inadequate. They may also serve to increase the bargaining power of professional management bodies vis-à-vis beneficiary units and the state administration, but this is not indicated in the literature.

1.22 Chapter VI treats the nonfinancial mechanisms of water allocation. "Planned water use" is the ideal which is not always put into practice. Besides well-informed and flexible planning, the following are pointed to as essential ingredients of good management: a high degree of communication and mutual involvement in water allocation; water sequencing guided by simple key slogans; the predetermining of the principal elements of distribution, including personnel responsibilities and rewards; and a system of rules and prohibitions which is enforced.

1.23 The allocation system of professional management structures has from one to three tiers, depending on the size of the irrigation district. The basic tier varies in scope but is the key to harmonizing water distribution with crop needs.
1.24 Many of the case studies involve the conjunctive use of multiple water sources. When these are major and minor surface storage facilities, a "melons on a vine" system may be set up. This often requires a resolution of the conflicts between the interests of upstream users and those of the system as a whole. The specific methods by which user ponds are incorporated into the greater plan appear to differ widely, depending in large part on the size of the system. In all cases, it appears that the local units are given priority in the use of water from their own ponds.

1.25 Many projects provide strictures governing water allocation. Violations appear to be punished most commonly by depriving the offending unit of its water allotment, but fines may be levied as well. It is unclear how well or how often the strictures are enforced. The extent of bribery is also not certain from the literature consulted. Pulling of rank may be a more important source of distortion in water distribution.

1.26 The final chapter presents a number of "first approximation" conclusions and, where appropriate, recommendations for areas requiring further study. The discussion in this chapter is structured by 16 hypotheses which were drawn up before the materials used in the report were consulted in detail. At present there is widespread internal dissatisfaction with the past performance of virtually all rural institutions in the PRC, including those in irrigation management, and some significant organizational reforms are taking place. This is therefore a suitable time to sum up the experiences of the past in light of existing perceived deficiencies. Much more work appears to be necessary, however, especially involving a more intensive, multidisciplinary investigation of actual conditions, before clear guidelines can be established for future development assistance.

II. MATERIALS CONSULTED

2.01 China's authorities have expressed a recurrent concern that the level of water management is inadequate, especially in the area of irrigation. This concern was articulated most notably in 1957-1958, 1963-1965 and 1972-1974--periods of an upsurge in construction which preceded and were overwhelmed by major political movements (the Great Leap Forward of 1958-1960, the Cultural Revolution of 1965-1969 and the struggle for succession of 1974-1976)—and in the years since 1977. During these four periods, a number of materials were published on water management, including laws and regulations, technical manuals and reports, and descriptions of specific instances of relatively successful project management. A large portion of these Chinese-language items have been collected by the library of the Center for Chinese Studies at the University of California, Berkeley.

2.02 These works are usually targeted at rural administrators ("cadres"), water technicians and the educated populace at large. They are the primary source material for this report. Appendix 1 provides a description of the main works used. Additional information has been gleaned from the official press, monitored radio broadcasts, and the first-hand materials and perspectives acquired by the author in 1974 and 1980 in the course of visits to the PRC as a member of water-related delegations.
The Case Studies

2.03 The most important data sources for this research have been the descriptions of model units. Forty-six reservoir and irrigation districts and 12 instances of pumping station management (usually with several stations each) have been identified in the literature. Appendix 2 lists them, including data when available on location, irrigated area, project components and crops. Appendix 3 provides a brief but detailed analysis of these characteristics. Figures 1 and 2 in the Appendix show the locations of these "case studies," Figure 3 arranges them according to area and precipitation levels, Figure 4 displays the range of annual grain yields reported and Table 1 classifies the irrigation districts according to their main components and the dates of their construction.

2.04 Five of the case studies are the most publicized and provide the primary although far from exclusive data base for this report. In increasing order of size, they are the Qianjin Reservoir, the Meichuan Reservoir Irrigation District, the Yeyuan Reservoir Irrigation District, the Shaoshan Irrigation District and the Yinjing (or Jinghui) Canal Irrigation District. The principal characteristics and model traits of each of these may be summed up as follows:

2.05 (a) Qianjin. The Qianjin Reservoir Irrigation District is located in a hilly area in the middle of the southern province of Hunan. Its core reservoir, built in 1954 before agricultural cooperatives were formed in the area, has a capacity of but 720,000 m$^3$, somewhat less than half the total storage within the entire district. The originally designed control area of 4,400 mou (293 ha) was enlarged to 7,684 mou (512 ha) by 1972, virtually all of it devoted to rice with double cropping predominant.

2.06 Qianjin became a province-wide model in the early 1960s, noted for the work style of its management cadres, especially its head, the largely self-educated Nie Bingfa; for its centralization of water rights and direction of operation by the management office while using a multitiered management system; for being a pioneer of the "melons on a vine" irrigation and drainage scheme, whereby the reservoirs, ponds and canals are linked together in an integrated system; and for being self-sufficient in management expenditures. The irrigation district subsequently became known as well for its full and economical utilization of available water sources, for its water allocation criteria and for its good combination of professional and farmer ("mass") management organs.

2.07 (b) Meichuan. The Meichuan Reservoir Irrigation District in the mountains just north of the Chang Jiang (Yangtze River) in eastern Hubei Province received a great deal of publicity in the mid-1970s. A descriptive booklet on Meichuan has been translated into English (in CES, Summer 1977, pp. 9-91; and Nickum, 1981, pp. 77-159). Although considerably larger than Qianjin with 16 times its irrigated area, Meichuan shares many characteristics with the smaller, earlier founded district. Most notably, it is in a hilly, largely monocultural marginal double-rice growing area where the variable topography and the tightness of fit between water supply and crop requirements
have provided the impetus for setting up and operating a "melons on a vine" conjunctive use system. At Meichuan, this involves the linking of state-owned reservoirs and canals with the ponds owned by the villages (or "production brigades"). As at Qianjin, the core reservoir has a beneficial capacity (27 million m$^3$) less than half that of the entire district. Like Qianjin, Meichuan is known for financial self-sufficiency, an effective system of water allocation criteria, good linkages of professional and mass organizations, and the use of experimentation to determine local crop water requirements. Descriptions of Meichuan have also focused quite informatively on the process of development of its management systems.

2.08 (c) Yeyuan. The Yeyuan Reservoir Irrigation District governs an area, part hill and part plain, about twice that of Meichuan (221,000 mou = 44,200 ha) in Shandong Province near the North China Plain. The large core reservoir has a total capacity of 165 to 185 million m$^3$, of which roughly 70 million m$^3$ are beneficial capacity. Used for both flood control and irrigation, the Yeyuan Reservoir is far more predominant a single source of water supply (over 90%) than in the previous two cases. Conjunctive use of major and minor components is therefore much less important. There are some "melons on vines" in the hilly areas, and user-owned wells in the plains provide "double insurance" of water supply to one quarter of the irrigation area. The cropping system has been simplified since the introduction of irrigation to the area and now consists of winter wheat, maize and tobacco in two growing seasons, with a monoculture in wheat.

2.09 According to a booklet describing Yeyuan which is even more extensive and detailed than that on Meichuan, there are four bases for the irrigation district's success. These are: (1) sound professional and mass management organizations; (2) the construction of a relatively complete field canal and ditch system, together with land consolidation and soil improvement; (3) the urgent need of the water-using units (production brigades) for irrigation water and their relatively high consciousness with regard to its use according to plan; and (4) a fairly complete system of irrigation management rules and regulations tested in practice (Yeyuan, 1977, p. 59).

2.10 The sources on Yeyuan contain a wealth of detail on its organizational arrangements, both in the mid-1960s and in the 1970s. These arrangements include rules and regulations; the composition, duties and funding of professional, mass and "democratic" organs; and the relationship of these bodies to each other and to the regular political-administrative structure of the xian (county).

2.11 (d) Shaoshan. There is also an abundance of organizational information on the Shaoshan Irrigation District in Hunan, the newest of the five projects and the most significant in terms of political symbolism. This project delivers water along one of its side branches to the village of Shaoshan, birthplace of former Chairman Mao Zedong, and it was built in 1965 and 1966 under direction of the man who succeeded him in office, Hua Guofeng, at the time a secretary of the provincial Communist Party Committee. It is reported that Hua directed that the Shaoshan Irrigation District be made a "model of democratic management, scientific management and high, stable agricultural output."

2.12 The project itself is a large-scale, multiple-source "melons on a vine" system centered on the diversion of water from the Lian River down-steam from the 560 million m³ capacity multipurpose Shuifumiao (or Shaoshan) Reservoir, which is managed separately from the irrigation district. The irrigation district, which reached its designed benefited area of 1 million mou (67,000 ha) in 1976, affects several xian and is under the leadership of Xiangtan Prefecture (diqu). It has a well-articulated water management and distribution system based in large part on existing administrative boundaries, which is amply described in a recent book on the project (Shaoshan Guanqu, vol. 3, 1979). Double-crop rice predominates in Shaoshan, with some triple cropping using wheat as the third crop.

2.13 (e) Yinjing. The largest and oldest of the projects on which there is a relative abundance of specific project data is the Yinjing Canal Irrigation District on the Guanzhong Plain north of the Wei River in Shaanxi Province. Now serving over 2 million mou (144,000 ha), 60% from surface sources and 40% from groundwater, Yinjing is based on a diversion canal built in the 1930s to cover the area once serviced by a famous ancient canal constructed 2200 years ago.

2.14 Yinjing is run by a management bureau which is under the leadership of the province, and so is administratively the most centralized of the five projects listed here. Internally it is organized in layers along project rather than administrative lines. It also has the most complex cropping system of the five projects, with cotton and wheat the principal items grown, supplemented by maize, legumes and coarse grains.

2.15 The materials used on Yinjing in this report cover the longest time span, from 1958 to 1973, not counting contemporaneous materials from the period of construction. The 1958 document, a copy of Yinjing's winter irrigation plan, is the most informative on any project from that period. Since the late 1960s and early 1970s, when the total irrigated area was increased significantly by the addition of a large number of pump wells, Yinjing has been distinguished in its conjunctive use of subsurface and surface water sources. It is also one of a set of three Guanzhong irrigation districts which have been praised for their successful handling of the heavy load of loessial soil in their surface waters in a province where about 40% of the reservoirs have silted up (silt control and environmental effects are not a principal focus of this report, however).

A Note on Models

2.16 Model units are not modal, of course. That is not their purpose. But the cases used in this report are far from being mere Potemkin Villages. Few of them have been visited by foreigners, and information on them is for domestic consumption. Their main purpose is to be used as a part on an educational process wherein "advanced experiences are popularized" and "a point is grasped to lead a surface" (zhua dian dai mian). These "points" may be developed explicitly, as was Shaoshan, or they may be discovered like Qianjin or Meichuan. In either case, for the "surface" to be led, it must be
possible to learn from the experiences of the organization presented and real
problems must be addressed. It is with the premise that the sources identify
genuine problems and indicate the ingredients of successful approaches to
their solution in the Chinese context that, tempered with additional revela-
tions and observations on the nature of modal management, have led to the use
of these materials in the preparation of this report.

III. INSTITUTIONAL ENVIRONMENT

Brief History

3.01 China has a long history of hydraulic construction, much of it
sponsored by the state. With the exception of major flood control and naviga-
tion works and a small number of large irrigation districts relying on river
diversion, however, water management before 1949 was most commonly in the
hands of families or of village or clan organizations. These management
bodies were one of the few instances of a professional structure independent
of direct village administration in traditional Chinese society. This func-
tional separation from the mainline politico-economic system has persisted
into the period of the PRC.

3.02 The land reform of 1947-1952 broke up the former village landholding
elite and made landownership more equal between families. It is unclear what
transfers were made in the ownership of village-level water rights during
this period. For a short time after the Qianjin Reservoir Irrigation District
was established in 1954, the ownership and use rights of ponds remained in
private (probably household) hands. Water use was collectivized at Qianjin
slightly before land was (Renmin ribao, 16 April 1964, p. 5). The nationwide
collectivization of agriculture in 1955-1957 brought with it a deprivatization
of all major means of production. Water has remained under collective or
state ownership ever since.

3.03 Concomitant with the socialization of ownership and the upsurge in
new project construction which accompanied collectivization was a concern
with putting "planned water use" into practice. Only 800,000 ha were con-
sidered to have planned water use by 1958, however. The Great Leap Forward
(1958 to 1961) witnessed a further step-up in the pace of water conservancy
construction, especially of reservoirs. The haste made for a good deal of
waste, and a period of "readjustment" followed in which renewed stress was
placed on the need for proper management of existing facilities.

3.04 By 1962, the basic institutional structure of the Chinese country-
side had been established, centered around the three-tiered rural people's
 commune system. The management of village-wide or intervillage water facili-
ties was at least supposed to be placed in the hands of specialized manage-
ment personnel or bodies under the collective or state. The commune system
and water management structures are dealt with later in this chapter.
3.05 During the 1960s and 1970s there were few apparent changes in the basic structure or operation of water management. At least in the model instances, planned water use was extended and the end-user organizations were involved in various aspects of management. This latter "reliance on the masses," much touted in the literature of the time, has rarely involved total decentralization of decision making in any but the smallest projects, except through default (see below). In its initial phase (1967-1968), the Great Proletarian Cultural Revolution challenged the existing structure of authority and brought into question the need for professional management; but any effects of this on project management were ephemeral and probably quite local.

3.06 A greater challenge to the planning of water use appears to have arisen in the past decade or so through the extension of more capital-intensive and small-scale water projects. New pumping stations have made it necessary (and possible) to coordinate the use of gravity and lift irrigation and drainage. Two million new pump wells, concentrated on the North China Plain, have raised problems of avoiding the depletion of various aquifers and of coordinating the use of surface and subterranean water.

3.07 Since 1978, rural collectives and households have exercised significantly increased decision-making powers over the use of their own resources. The market mechanism plays a greater role in determining economic activity than before, and farm production is oriented increasingly towards net economic results rather than output targets. Chinese decision makers and scholars have also expressed a growing concern with the environment and with intersectoral competition for water resources at the macro level. The effect of these new policies and concerns on rural water management is not yet clear and is not evidenced in the materials consulted for this report.

Party and Government

3.08 The PRC is governed by the dual parallel structures of the Chinese Communist Party (or "the Party") and the government, with the Party in a position of primacy. Formal power in each structure resides in congresses of representatives at various levels, but real working power lies in standing executive organs. 1/

3.09 The government and the Party are each layered vertically into several levels: the center, the province, the prefecture, the xian or county and in some provinces, the qu or district. The "state" sector of government formally merges with the collective sector at the next lower level, the commune, but the Party extends further down to the production brigade and sometimes to the basic collective work and income distribution unit, the production team. 2/

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1/ This executive-"legislative" type arrangement is replicated in water management for larger projects (see chapter IV).

2/ At the end of 1978, there were 29 provincial-level administrative units, including 3 municipalities (Shanghai, Beijing and Tianjin); 210 prefectures and 190 prefecture-level municipalities; 2,138 xian; approximately 53,000 communes, 690,000 production brigades and 5,000,000 production teams.
2.10 In practice, personnel and duties tend to overlap at all levels of Party and government administration. "Party and government" are often referred to as if they were nearly the same. As a first approximation to differentiating the two, however, the Party tends to be organized with greater stress on overall policy, horizontal supervision and coordination at each level, and mobilization and political education, while the government is set up on a more detailed functional line basis and focuses on day-to-day administration.

3.11 The management organs of an irrigation district are formally in the governmental system, although they usually contain a Party committee or branch as well. The exact position of an irrigation district management body in the governmental structure is often unclear to an outsider, in part because most of the time organizational detail is obscured in the Chinese writings through vague references such as to "higher levels" or to the "Party committee" or the "revolutionary committee" (or "government") 1/ or, slightly more specifically, to "those in charge of water conservancy."

3.12 Within the governmental system, agriculture and water conservancy have always been separated functionally. Bottrall (e.g., in 1978a) has suggested that such a partition may lead to poor synchronization of water release and crop needs in large continuously irrigated areas because engineering (irrigation) tends to be more prestigious than agronomy and because the areas of jurisdiction of agriculture (following civil administrative boundaries) and irrigation (following the command area of a project) are not coterminous. One alternative is to set up a single command area agency, as India has done in recent years.

3.13 Some of these problems raised by Bottrall are mitigated in China since both departments follow civil administrative boundaries and the Party can function as a coordinating agency. Indeed, one theme stressed again and again in the case studies is the necessity of placing the problem of irrigation management onto the daily agendas of Party committees at all relevant levels, including especially that at the immediately superior position in the administrative hierarchy. The clearest statement of this is from a description of the Meichuan Irrigation District:

In the beginning, individual leading cadres of the reservoir paid insufficient attention to respecting the leadership of the local Party committee. They paid attention to line leadership and neglected area leadership, so at times contradictions over water use arose between them and the qu Party committee. Afterward ... the qu Party committee's leadership (was strengthened) over the work of the reservoir Irrigation district ....

1/ From 1967 to 1979, the organizational units responsible for state and collective administration at provincial level and below were called "revolutionary committees."
Several times a year, the reservoir management office submits a report to the qu Party committee on water stored, meteorological conditions and plans for fighting drought and using water .... The reservoir irrigation district work is entered in the daily agenda of the qu Party committee, which makes arrangements and inspections and personally handles key problems. (Meichuan, 1974, p. 44.)

3.14 Nonetheless, problems clearly do arise from the administrative separation of irrigation and agriculture. Within the governmental structure, the departments of water conservancy appear to have dominated irrigation management, although there have been attempts to bring in agricultural departments. When the Ministry of Water Conservancy merged with the Ministry of Electric Power in 1958, irrigation management and the management of irrigation canals were transferred to the Ministry of Agriculture in order to allow the new engineering-oriented Ministry to concentrate on electric power and major river basins. In 1965, the Ministry of Agriculture did issue "Provisional Measures for the Planned Use of Water," but by and large, irrigation management was clearly back under the water conservancy departments by the early 1960s. This was made explicit in a 1964 organizational scheme from Shaanxi Province which placed irrigation management oversight organs directly under the water conservancy departments at provincial, prefectural and xian levels. The same article noted that "joint research on agriculture and water is still very inadequate" (NTSL, 5/1964, pp. 2, 6).

3.15 An early case in the 1950s of local conflict between professional irrigation management departments and agricultural departments was brought out in a description of the Luohui Canal Irrigation District in Shaanxi, where the two departments, it was noted, "shared the same goals, but there were many conflicts in their working arrangements." The solution adopted was to set up irrigation management committees with local Party and state leaders and representatives of agricultural departments among their members (NTSL, 5/1964, p. 32). On the other hand, the management committees of the Shaoshan Irrigation District, built later, explicitly include representatives from the departments of water conservancy and finance and grain (which collect water fees on behalf of the district) but make no provision for agricultural representatives (Shaoshan, 1979, p. 3) (see chapter 4). Similarly, Beijing's Pinggu xian set up an "electrical irrigation project planning group" comprised only of the water conservancy, electric power and agricultural machinery departments to oversee pump well development (Nickum, 1981, p. 239).

3.16 The ministries of water conservancy and electric power were reseparated in February 1979. The management of water projects now appears to be firmly in the hands of the water bureaucracy, as evidenced by the presence at the central level of the bureaus of farmland water conservancy and of water project management in the Ministry of Water Conservancy.
3.17 Since the Ministry is engineering-oriented, this arrangement may lead to some of the difficulties of coordination pointed to by Bottrall, although the successful case studies do work to develop an orientation towards investigating and matching the water requirements of local crops, both in quantity and in timing. Common specific mechanisms adopted to forge this linkage are for the Party to "educate" politically the leaders and staff of the professional management bodies and to set up a "scientific experimentation" network which involves end-users.

3.18 One noteworthy problem is that the construction orientation of water conservancy departments has led to management being given short organizational shrift. One of many examples in the literature pointing in this direction is the following call by a Shandong provincial water conservancy work conference:

> Water conservancy departments at all levels should give attention to management as well as construction, assign a sufficient number of personnel to the management work and improve the organizational structure [emphasis added] and grasp the management of water conservancy projects conscientiously as a matter of major importance. (FBIS, 12 December 1978, p. G 7.)

3.19 Major multipurpose projects commonly have multiple leadership organs, including some from different levels of the administrative hierarchy. Shaoshan Irrigation District is under the leadership of a prefectural government, but province-level electric power people have a hand in the management and operate the reservoir which, although outside the irrigation district, regulates much of the water which it receives.

3.20 This dual leadership appears to work at Shaoshan. Indeed, many masters may be necessary to the operation of a multipurpose project in the PRC. On the other hand, project performance may be hampered if they do not communicate well or if there is no clear method for handling conflict among them. An example of this is the convoluted management system of the giant Bishihang Irrigation District, which provides guaranteed irrigation to only half its designed area of 727,000 hectares. The leadership structure has "changed many times," and at present is as follows:

> [One] reservoir is managed by the provincial Water Conservancy department, four (other) major reservoirs ... are managed by the provincial Office of Electric Power, the right to release water from the reservoirs is in the hands of the provincial Flood and Drought Prevention Headquarters, and the irrigation district is managed by the Bishihang Irrigation District General Management Office, but management is actually carried out by Luan Prefecture on behalf of the general management office. Clearly, there is no unified, authoritative, sound management organ for the irrigation district as a whole. (Li and Zhang, 1980.)
3.21 The lack of sound, authoritative management led the affected peasants to take water distribution into their own hands. Indigenous bank cuts and local additions to the ancillary projects, presumably upstream, have led to the usual problems of waste and underutilization.

The Commune Sector

3.22 The countryside is divided vertically into "state" and collective or "mass" organizations. The two join at the "commune" level which is the apex of the three-tiered rural people's commune system. (In Chinese, the "commune" can refer either to the system as a whole or to the one level.)

3.23 The commune level corresponds to the former xiang, or township, which was the lowest unit of state administration in the 1950s. It is part collective and part state in nature. For example, many of its administrative personnel ("cadres") are paid out of the unified state budget, but it is allowed to retain the profits of its economic enterprises, although there are restrictions on the use of these funds. This "integration of government administration with economic management" (zheng-she heyi) was a much-vaunted characteristic of the people's communes but has come under attack recently for being excessively bureaucratic, stifling local entrepreneurship.

3.24 The middle level is the production brigade, usually a natural village. Economically, the brigade is less important than the tiers it is sandwiched between. It is the most common basic unit of water use, however.

3.25 The smallest collective unit is the production team, where most peasants receive their work assignments and their remuneration. This payment is denominated in work points. The work-points system creates an entirely different regime of reward from that of the wage-based state sector. This system was described in a previous article (Nickum, 1979, pp. 172-173):

Production team members earn work points that entitle them to participate in the distribution of collective produce and income. The value of work points and their mode of assessment differ from team to team but the basic principles are the same. [A portion of] the net product of the production team ... is distributed to each team member in proportion to the number of work points earned during the year. Work points are earned according to the amount and difficulty of work done and the skill level required.

In China, the work point system allows a production team to mobilize and reward additional labor ... without increasing the total wage bill. The net product each year is the same no matter how many work points have been earned; what varies is the value of each work point ....

Peasants working on projects initiated at the production brigade and commune levels also receive work points, which are recorded in their home production teams. Labor quotas are allocated to production teams on the basis of expected benefit.
3.26 Peasants may also be required to contribute a small amount of corvee labor (yiwu gong). This tax in labor is rarely a significant proportion of the total, however.

3.27 The militia is a very important organization within the commune sector as it is involved in "farmland capital construction" (land consolidation, tertiary watercourse construction, etc.), patrolling the canals, emergency repairs and the like. Sometimes the militia forms the backbone of full-time construction or patrol crews. The army is not a significant actor in farm water management.

3.28 In 1957, the state managed only 7.7% (ca. 40 million mou or 2.7 million ha) of the irrigated area, with the collective sector responsible for the remaining 92.3% (Laws, p. 384, 24 December 1957). No figures have been released since then on the proportions of state and collective management, although the nature of developments in water conservancy construction and policy point to a continuing predominance of collective management. One concern expressed in the 1957-58 legal documents and echoed ever since, especially regarding pump well development, is that the collectives quite often have not set up any management structure at all for their projects.

Water Rights

3.29 At the macro level, rights to water use are not very well spelled out, leading recent Chinese commentators to criticize the current state of "anarchy" in the use of water resources. One writer claimed that, in contrast to many other countries, "China has no unified management department for water resources, nor have we any laws [governing their use]" (He Zhi, 1979).

3.30 De jure and de facto rights to water use are somewhat better specified at the project level. The "Provisional Measures for the Planned Use of Water" issued by the Ministry of Agriculture in January 1965 include among their "principles of water allocation" the following:

(3) When water sources are insufficient and rotational irrigation is carried out, priorities must be established: drinking water for people and animals; areas of severe drought; areas in which the economic benefits of irrigation are comparatively high, and areas that have been benefited for a long time.

(4) For projects whose main purpose is irrigation, other uses of water should not affect the use of water for farm irrigation. During nonirrigation periods and when water sources are not abundant, water should not be released solely for the generation of electricity, [industrial] processing or fishing. (Nickum, 1981, p. 254.)
3.31 The 1972 Zhejiang Province draft regulations on water management elaborate on the functional priorities of flood control and irrigation:

Irrigation, electric power, fisheries and so on should be secondary to flood prevention in water projects which are mainly for flood prevention. Electric power, fisheries, navigation, processing with hydraulic power and so on should be secondary to irrigation in water projects built mainly for irrigation. (Nickum, 1981, p. 268.)

3.32 Shaoshan is a concrete example of this latter principle. It is a multipurpose project whose main function is irrigation. Water release at the dam governing most of the flow into the irrigation district is expected to respect this priority when there is a conflict between irrigation and electricity generation. This is despite the separate management of the dam by the provincial electric power department and the fact that the reservoir was installed and was generating power before the irrigation diversions were constructed.

3.33 As indicated above in Article 3 of the 1965 regulations, special consideration is given to the interests of prior developers. There are numerous examples of this respect for intertemporal rights, among them:

(1) In Chaoyang xian, Guangdong, the "original" irrigation districts which were providing water before the construction of five reservoirs were to be given additional subsidies of water during irrigation (NTSL, 7/1965, p. 11).

(2) Taohuadian Reservoir in Henan supplemented its water sources by tapping a prior extant canal during the periods when the water in that canal was not being used for irrigation (Yikao, 1973, p. 39).

(3) In Yujiang xian, Jiangxi, a new canal was proposed to divert water from a river which was already used by two canals. A "new and old irrigation canal representatives' meeting" was called at which the representatives of the extant canals acknowledged the needs of their "mountain class brothers, who helped us build our canals" while the representatives of the new canal "resolutely guaranteed that in a year of great drought, the old irrigation canals would certainly have priority in using water" (Renmin ribao, 8 November 1974, p. 4).

3.34 Within a given project, rights of use and allocation may be centralized in the hands of the management structure. At Yeyuan, management rights, by resolution of the irrigation district congress, are "under the unified leadership of the xian Party committee and handled in a unified manner by the Yeyuan Reservoir Management Bureau. No [other] unit or individual has a
right to willfully direct or force a transfer (of water)" (Yeyuan, 1977, p. 71). Similarly, water rights are unified [tongyi shuquan] in the hands of the Qianjin Reservoir Management Office which is thereby empowered to transfer surplus water to deficit areas and to direct the water scheduling of the entire system, including minor as well as major facilities. Yinjing has a four-tiered distribution structure where "water rights" are "centralized" by each of the top three levels over those who actually allocate the water. In this case, the rights appear to mean the authority to make ad hoc changes in the distribution of water among subordinate units as long as the total planned allocation is unchanged (see Nickum, 1981, pp. 27-28, 208-209).

3.35 What is interesting in these descriptions is that a project management body does not have an automatic entitlement to the disposition of all waters within its domain. These rights appear to evolve and are specified on a project-by-project basis. The centralization of rights over water allocation takes on particular importance in projects with multiple water sources, such as the "melons on a vine" schemes. These are discussed in greater detail in chapter VI.

IV. ORGANIZATIONAL STRUCTURE AND STAFFING

Any water project which benefits or affects a single prefecture, xian, commune, brigade or team is the separate management responsibility of that prefecture, xian, commune, brigade or team. In principle, the higher level is responsible for the management of any water project which benefits or affects more than one prefecture, xian, commune, brigade or team, or the next higher level can assign the management responsibility to one beneficiary unit (GYG, p. 102).

4.01 In practice, the management of state-operated irrigation districts appears to be kept at the lowest reasonably comprehensive level in the administrative hierarchy. For example, both Shaoshan and Bishihang benefit portions of more than one prefecture, yet both are managed under the prefectures in which the predominance of their benefits lie.

4.02 On the other hand, there are some pressures to centralize, especially at the local level. Thus, Chaoyang xian in Guangdong Province, when considering whether to centralize management of its cross-commune reservoirs in the hands of the xian or entrust it to the communes, opted for the former. The description of their decision-making process draws out clearly the trade-offs between the greater responsiveness of decentralized management to both natural and human factors on the one hand and the more desirable overall location of water (both in equity and in efficiency terms) under a more centralized operation:
Some people advocated having the xian do the managing, for the reason that several communes share benefits at the same time and if there is no centralized management structure, it will not be easy to unify water distribution during periods of irrigation. But others advocated entrusting management to the communes, feeling that this could increase the responsibility of the communes; that it would be better if the reservoirs were only managed up to the commune level so that when problems arose at lower levels the commune would be responsible for solving them; that a great deal of trouble could be spared by solving the problem of personnel expenditures at different levels and that it would facilitate using water for irrigation. We acted according to the latter opinion, but a number of specific difficulties arose in the implementation. For example, there were problems in unifying the distribution of water during an irrigation because some communes used much water and some used little, plus there was the problem of fields in upper and lower reaches. With no unified distribution of water, irrigation was perforce irrational and water fee collection was not uniform. (NTSL, 7/1965, p. 11.)

4.03 According to guidelines appearing in 1965, a reservoir with a storage capacity in excess of 10 million m³ may have a management body separate from its irrigation district, although "under the right conditions, a unified management structure may also be set up" (CCGL, in Nickum, 1981, p. 65). In most of the cases investigated here, except for the very largest such as Shaoshan and Bishihang, the right conditions have obtained.

4.04 A successful PRC irrigation district management has three organizational components. These are the "professional management structure," the "democratic management organizations" and "mass management organizations." Each will be discussed in turn.

Professional Management

4.05 The professional management structure "is the institution which directly manages the project" (NTSL, 5/1964, p. 2). It is the "executive unit which concretely carries out management operations and implements the policies of the Party and the directives of higher levels" (Shaoshan, 1979, p. 4). In general, a large irrigation district, defined since 1973 as one covering more than 300,000 mou (20,000 ha), has a two-tiered professional management body consisting of a "management ju" and below it several "management zhan" or "management suo." A medium-sized irrigation district (10,000 to 300,000 mou (667 to 20,000 ha)), and a small irrigation district usually have a "management chu" or a management suo. 1/

1/ The Chinese names have been retained for the specific organizational units because they have no exact counterparts in English. An earlier (1965) classification is the following: irrigation districts with effectively irrigation areas over 1,000,000 mou have a management ju; between 100,000 and 1,000,000 mou, a management ju or chu; between 10,000 and 100,000 mou, a management chu or suo (GGGL, 1965, p. 8).
4.06 The division of professional management organs into only one or two levels may make the management structure look more streamlined than it actually is. Not included are full-time personnel paid by the collective sector who operate the watercourses (or subbranch canals systems (dou)), sections (duan) and the like. These people belong to the "mass" component of management (see below). Nonetheless, the "flatness" of the organizational pyramid is remarkable, indicating that a premium is placed on maintaining short vertical lines of communication even at the cost of widely varying spans of control from project to project.

4.07 Projects operating in the collective sector may also have a professional management unit. For example, Qianjin is within a commune. The following situation described the situation in Shaanxi Province in 1964, but it appears to apply elsewhere and at subsequent times:

In general, the production team appoints a special person (or persons) to be responsible for regular upkeep and maintenance and to take care of the utilization of small canals, reservoirs, wells, ponds, flooded land and pumping equipment. Larger projects or projects which cross team (or brigade) or commune boundaries generally set up a management zhan (or suo) or a management committee to carry out normal management operations, upkeep and maintenance. (NTSL, 5/1964, p. 2.)

4.08 A more recent description indicates that intracommune professional management is organized along administrative lines rather than (or as well as) on a project basis:

The commune sets up a water conservancy zhan (or irrigation and drainage zhan) to handle all items of water control work within the scope of the commune.... The brigade sets up full-time water management personnel who are responsible for year-round water project construction and management. The production team sets up one full-time water management person for each 100 to 200 mou in keeping with the distance of the plots, whether or not they are scattered, and the difficulty of irrigation. This person is responsible for irrigation management in the summer and autumn and for the maintenance and management of drainage from the wheat fields in the winter and spring. (SLGL, 1975, p. 34.) [This text is based on the conditions in southern China, including the Chang Jiang.] This "professional" management structure is organized in roughly the same way as the "mass" component of a larger system, discussed later in this chapter.

4.09 The management structure of a larger project may also be more complex horizontally than simply ju or zhan or suo or chu. In Shaanxi in the mid-1960s, especially in the large- and medium-sized irrigation districts, there were specialized "water distribution zhan" equal in rank to the management zhan which did not distribute water but had as their task "water use activities" (NTSL, 1/1964, p. 22). This is the only locality in the sources consulted which had this particular division of labor, however.
4.10 Internally, a management organ may be divided into several sections. The Shaoshan Project Management Ju has seven of these: office, political work, security, project (or "engineering") and irrigation management, production and construction, finance and equipment, and reception. The Yeyuan Reservoir Management Ju is divided into an office and five sections: project, financial, production, electromechanical and reservoir district. Relatively large irrigation districts are likely to have project (engineering) teams, repair shops, experimental stations, transport teams and the like.

4.11 The following is a typical list of the functions of the professional management structure:

To carry out Party and state policies under the leadership of higher-level Party committees and to strive to manage and make effective use of water facilities; to unify the distribution of water and control the operations of project facilities; to formulate in a unified manner long-term plans for the repair, improvement and expansion of the projects and to carry out the resolutions of the irrigation district congress.

Its "specific tasks" are

... to inspect and survey to ascertain project conditions; to carry out upkeep and maintenance ...; to irrigate rationally and in combination with other farming measures in order to improve the soil and raise production; and to carry out experimental research. (GGGL, 1965, p. 9; see also Shaoshan, 1979, p. 4.)

4.12 Staffing norms. In 1965 the following staffing norms were given for the professional management structure of an irrigation district:

<table>
<thead>
<tr>
<th>Effectively irrigated area</th>
<th>Personnel per 10,000 mou</th>
<th>per 10,000 ha.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 1,000,000 mou (67,000 ha)</td>
<td>1 - 3</td>
<td>15 - 45</td>
</tr>
<tr>
<td>100,000 to 1,000,000 mou</td>
<td>2 - 4</td>
<td>30 - 60</td>
</tr>
<tr>
<td>10,000 to 100,000 mou</td>
<td>3 - 8</td>
<td>45 - 120</td>
</tr>
</tbody>
</table>


Of these, technical personnel should constitute 30 to 40% of the cadres, and presumably a smaller percentage of the total staff. Engineers are to be provided when the area irrigated exceeds 200,000 mou.

4.13 Table 1 lists the size of professional staff for those case studies reporting such a figure. With the exception of Dandong, which had too many, and Gunlubei, which reported too few, all these 15 projects had staff sizes within the 1965 norms. Qianli started out with a well-padded management
<table>
<thead>
<tr>
<th>Project Name (Province)</th>
<th>Irrigated Area (in mou)</th>
<th>Professional Management Organ(s)</th>
<th>Staff</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shaoshan (HUN)</td>
<td>1,000,000</td>
<td>management ju; 10 management suo</td>
<td>184</td>
<td>1977</td>
</tr>
<tr>
<td>Fen He (SAX)</td>
<td>1,000,000</td>
<td>&quot;management departments&quot;</td>
<td>100+</td>
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</tr>
<tr>
<td>Yeyuan (SD)</td>
<td>205,000</td>
<td>management ju; 6 management suo</td>
<td>48 a/</td>
<td>1973</td>
</tr>
<tr>
<td>Guniubei</td>
<td>185,000</td>
<td>&quot;reservoir&quot;</td>
<td>13</td>
<td>1972</td>
</tr>
<tr>
<td>Dandong (HEN)</td>
<td>169,000</td>
<td>management ju; 5 management suo</td>
<td>83</td>
<td>1965</td>
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<tr>
<td>Qianli (SC)</td>
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<td>&quot;management structure&quot;</td>
<td>44 b/</td>
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<tr>
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<td>33</td>
<td>1973</td>
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<tr>
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<td>mgmt. cte.; 4 branch mgmt. ctes.; 4 management zhan</td>
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<tr>
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<td>37</td>
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<td>9</td>
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<tr>
<td>Yangjiachong (HUN)</td>
<td>5,366</td>
<td>res. irrn. management committee</td>
<td>4</td>
<td>1957</td>
</tr>
<tr>
<td>Longhui (SEX) c/</td>
<td>3,000+</td>
<td>&quot;management personnel&quot;</td>
<td>5</td>
<td>1965</td>
</tr>
</tbody>
</table>

Notes: The above case studies are those which specify the number of staff members.

a/ Was over 60 before the Cultural Revolution.
b/ Was 180 before it began to rely on the masses.
c/ Commune-operated.
staff nearly as large as that of Shaoshan which covers seven times the area. It then trimmed down to a within-norm level by decentralizing maintenance and water release functions to user-based mass organizations and personnel.

4.14 According to the 1965 guidelines, the number of professional personnel was to be reduced over time. One reason for this is presumably to alleviate the costs of professional management and to allow more widespread use of China's very limited supply of skilled labor. The insufficiency of adequately trained middle-level managerial and technical labor has pervaded the entire PRC economy from the beginning and has even been exacerbated in politicized periods such as the Cultural Revolution, when technical schools and universities were closed for a number of years.

4.15 Another reason for reducing the density of professional personnel is to cause, or reflect, an increasing assumption of management burdens by the beneficiary rural collectives. This has certainly been the development process of projects such as Qianli and Shaoshan (see "mass management" below).

4.16 Perhaps indicating a continuing concern with trimming the professional staff, the manual Guan'gai yongshui guanli (1974, p. 102) provided a much lower set of personnel guidelines "in keeping with the situation in Hunan." These limits appear to be far too low, however, even for the model units surveyed (for example, 1 to 1.5 persons per 10,000 mou for an irrigation district over 200,000 mou).

4.17 Most economic enterprises in the PRC state sector are overstaffed with unskilled labor. It is quite possible that the modal or even the other model irrigation districts which do not report personnel figures have more personnel than given in the 1965 guidelines. On the other hand, water management bodies are unlike most other state enterprises in that their personnel expenditures are funded from local sources, not a unified state budget (see chapter V). To the extent that revenue comes from water fees, there would be a built-in incentive to keep the number of personnel down. This may be mitigated if sideline economic operations or easy state subsidy are a significant revenue source.

4.18 The 1965 staffing norms are far from rigid. There are number of very important exemptions. The standards do not include personnel for irrigation experimentation stations or full-time maintenance crews. Perhaps even more significantly, given that two thirds of China's irrigated area is subject to pumping, is the exclusion of mechanics and electricians. Thus one commune in Guangdong Province reported a staff of 57 in its electrical pump station which governed only 27,600 mou (1,840 ha), with no indication that this was considered excessive (NTSL, 4/1965, p. 6). It should be noted, however, that collective sector management personnel are paid in work points recorded in their production teams. This removes the wage-bill constraint on overstaffing that state management bodies are subject to.

4.19 It may be interesting to note that the 1965 norms provide fewer personnel per unit area served than Taiwan's 26 irrigation associations actually employ. In 1966, the associations employed 5.6 people per 10,000 mou, a density recommended in the PRC guidelines for only the smallest irrigation
districts. Reflecting the relative abundance of middle-level skilled technicians in Taiwan, about 60% of employees were technicians, a much higher density than in the PRC (Chin, 1972). The many exceptions to the PRC norm listed above make an already hazardous comparison with Taiwan's reality even more tenuous. What can be said is that Taiwan's experience indicates that the PRC norms are quite lean. If a district management actually has a staff size which falls within those norms, it is probably either overworked or has successfully decentralized some operations to the end-users.

4.20 Staff origin and attitudes. The materials consulted present little systematic information on the origin of professional staff and workers, especially on the larger projects. For example, we are told at Shaoshan that Hua Guofeng "personally chose a group of cadres with experience in mass work and who had been tempered in the building of the irrigation district to assume responsibility for management" (Shaoshan, 1979, p. 1), but we are given no particulars of their origin or training. References elsewhere indicate that it may be common for some of the cadres who direct the building of a project to be assigned to its subsequent management. It would be surprising if this did not inject a "builders' bias" into management.

4.21 Certainly a high percentage of a project's management staff is drawn from its locality. This local attachment is said to have worked out quite well for the North Huimin Canal Irrigation District in Hebei, which also had the advantage of being in existence for a long time and which continued to employ personnel who were managing portions of the project before 1949.

These professional management personnel come from the benefited masses.... In general they all love water conservation activity and do their work conscientiously, and therefore have won the confidence of the masses. Most of them have worked on the canals for a decade or more, and some for 20 or 30 years, and have accumulated rich experience in management. Over half of them can design, build or survey canals and structures. Because they are locally born and bred, have personally participated in canal upkeep and repair and have gone out into the fields, many of them are thoroughly familiar with the topography and the soil and can distribute water rationally and promptly according to the crop area and water needs. (Renmin ribao, 13 December 1963, p. 2.)

4.22 As there is virtually no market for skilled or professional labor in the state sector of the PRC, management personnel are assigned or selected for their positions. That they do not always welcome their assignment, especially when they are trained outsiders, is evident in the story of a university graduate who requested upon completing his studies to be given a job in scientific research, teaching, survey design or project design. Instead, he was consigned to practical rural drudgery as a subbranch canal manager. In the beginning, he is reported to have felt that "It's all over for me" (at Luohui [SEX], in NTSL, 5/1964, p. 18).
4.23 Similar frustration of the astral ambitions of recent school graduates is common everywhere, of course, and may be expected to be tempered over time with the resolution of their cognitive dissonance. More serious than the lowliness of water management, however, is the apparent consideration by many who are career-oriented that it is a dead end.

4.24 A more recent indication that problems persist in the use of skilled, formally trained labor is an April 1981 report on the status of agricultural scientists and technicians:

According to statistics, 730,000 students have graduated from our colleges and agricultural secondary schools in the past 30-plus years, but at present only about 250,000 of them are actually taking part in scientific-technical or teaching work on the agricultural front....

How has such a situation emerged? ... There are three principal causes:

1. Prejudice against agricultural science and technology and agricultural scientific and technical personnel still is serious among a number of cadres.

2. The working conditions for agricultural scientific and technical personnel are poor, their income is low and the difficulties in their work and lives have not been properly solved.

3. Their chances for promotion are scarce. (FBIS, 20 April 1981, p. K 7.)

Although this description applies to agricultural personnel, it may be assumed that conditions are similar for technical personnel in water management as well.

4.25 The attitude of personnel that "there is no future" in their work was reported (after it was changed) at Yeyuan and in the pumping facilities of Nan Xian, Hunan. In the latter case, the solution (in 1963) was found in the convening of a conference to educate people in the "internationalist, patriotic and socialist future," to let them know the importance of their work in the overall and immediate schemes of things, to "establish the thinking of treating the [pumping] station as one's family and irrigation and drainage as one's occupation," to hold work competitions with prizes for the best workers, and to "make proper arrangements for the livelihood and welfare of the staff and workers" (NTSL, 2/1964, p. 13).

4.26 The last measure indicates that an insecure or underpaid present may be as much a source of dissatisfaction as frustration with future prospects. This in turn may be due to the nature of irrigation management funding (see chapter V). In addition, local management personnel often have useful alternative skills. Their opportunity cost becomes particularly apparent in relatively poor areas where irrigation is new and when some local freedom of employment is allowed, as in the very early 1960s and at present.
4.27 All of these factors came together in the early years of the Longhui Canal in Shaanxi, built in 1958. There the management personnel were all peasant handicraftsmen, mostly carpenters, who had worked on the construction crew. In the beginning, they did not even know how to water the land. During the difficult years immediately following the Great Leap Forward, the families of some of these neophyte managers encouraged them to return home to work in their original professions or to go elsewhere to engage in trade. Although this instance has a number of specific features, including the famine conditions of two decades ago, the opportunity cost problem in local projects may have taken on renewed and more general importance with recent relaxations in collective labor allocation conditions.

4.28 A common characteristic of professional management personnel in smaller projects has been their lack of prior training in water conservancy, and a low level of education in general. Nie Bingfa, the model leader of Cianjin, had had a year and a half of formal schooling before he was transferred to head the project in 1954, and he knew absolutely nothing about water projects; indeed, some of the locals felt that he had been demoted to do reservoir work because of his incompetence elsewhere (Renmin ribao, April 16, 1964, p. 5). The four staff members of the xian-level Zhujia Station Lock in Zhejiang could not read blueprints when they began to work, nor had they ever seen a gate installed, much less refitted; in addition, they were given an inadequate number of tools (e.g., no drills, no lathes) (SGG, 1973, p. 109). At Heshui Reservoir (Guangdong), most of the office employees were "poor and lower-middle peasants" from the villages who had to learn through the hard knocks of practice about the tradeoffs between the flood control and irrigation functions of the reservoir (SGG, 1973, pp. 46-54). Of the eight professional personnel, all of them from the beneficiary units at the commune-run Jiulong Reservoir in Jiangxi, one was a "youth with some education who is called a 'technician'." Because he participated in the building of the irrigation district, he studied in a technical training class within the commune and could do some general surveying of canals and building of structures and was working on runoff calculations. The clear implication of the text was that none of the other seven personnel were even that well trained (NTSL, 3/1964, pp. 27-28).

4.29 It is difficult to determine whether or how much a lack of prior education or training has proven to be serious handicap to project performance for larger projects, over time, or in other areas. In one case, the commune-run Shidu Electric Irrigation Station in Jiangsu, located in a highly developed part of the PRC, the station acted as a repository of tools, technical know-how and spare parts for the farm machinery of the local production teams (Yikao, 1973, pp. 90-91).

4.30 An interesting insight into the attitude problems of both senior and junior staff in a similar station in the same area as Shidu but at an earlier date is provided in the revelations of the director of the Yihe Commune Electromechanical Irrigation and Drainage Station:
... Before 1961 I was the head of the commune water conservancy section. When the station was built, the leadership requested me to be its head. In the beginning my thinking was not straight. I felt that this work was technically demanding and had a strong seasonality, that I was not versed in the profession, and it would be hard to make the work develop. I was afraid that the staff and workers would be hard to lead, with so many personnel, 45 of them, with complex mental attitudes. I was afraid of not doing things at the right farming time and affecting production. I was afraid that there were too many apprentices, that the technical level was not high, that the types of machinery were complex, and that if the machinery didn’t work, my responsibility would be made heavier. I was afraid that we would not be able to collect water fees, that we would [therefore] not be able to issue wages to the workers, and that we would have no money to maintain the machinery. I was afraid that matters such as the policy on [distribution of] burdens and water use conflicts would not be handled well and this would affect our relationship with the masses.

To sum up, when I began to assume the duties of station head, I felt that this work had too many difficulties, the responsibilities were too great, the status was too low, and that I was too much a layman. I was unwilling to assume the responsibility.

4.31 In addition, he did not know how to keep accounts. His fears were justified:

In the beginning, after I came to the station, I ran into a number of concrete problems in my work. The machinery broke down and there was no money to fix it. We had no fuel when we needed to pump water. The masses wrangled with me when they wanted water. The livelihood of the mechanics was not stable. And the leadership said I wasn’t doing good work.

As for the people who worked under him:

The ideological conditions of the staff and workers at my station were of various hues and forms, but they may be summed up in the following general types: (1) The new apprentices had a low technical level, could not operate even a small machine, and were mentally vexed; (2) Some individual workers were disgruntled and complained that the wages were too low. Some had conservative thinking, and some did not pass on their skills; (3) When the apprentices had studied a bit of technology, they thought of "flying high and far away"; and (4) Some mechanics who had been small proprietors operating irrigation and drainage stations before Liberation, who in the past had operated shops and made money and had authority, felt that now they were "not free," and they had a poor work attitude. (NSTL, 2/1964, pp. 15-16.)
4.32 Nothing this revealing about staff attitudes has appeared in the subsequent literature. Certainly there have been some changes in the intervening years as the apprentice workers (and managers) have finished their training and gathered experience and the older workers have departed from the scene. It is quite probable, however, that much remains the same: in particular, the low technical level of both management and staff, the low status of the work, the reliance by smaller pumping projects on water fees and the vicious cycle of low fee collection $\rightarrow$ inadequate repair and fuel $\rightarrow$ low fee collection.

4.33 Principles of subdivision. Arguments are presented in the case studies for both channel-based and administratively based subdivision of project management. Basically, making use of existing administrative boundaries helps the decentralization of maintenance and distribution functions to lower levels and thereby both reduces the burden of detail work of the professional management bodies and involves beneficiary units and the extant Party and state structures more directly than with channel-based subdivision. On the other hand, relying on existing boundaries helps to reinforce them, and water disputes are more prone to break out between upstream and downstream units. In addition, the assumption of maintenance burdens is likely to be unevenly matched with benefits received if they are decentralized along administrative lines (see Nickum, 1981, pp. 22-24). The arguments are thus similar to those presented above for centralization versus decentralization. Both Shaoshan and Yeyuan have opted for a subdivision of their secondary and tertiary professional management offices along administrative lines. In virtually all cases considered, however, the existing village structure (production brigade or team) is the water-using unit.

Democratic Management Organization

4.34 Similar to the Party and government, formal authority in an irrigation district resides in the "democratic management organizations" such as irrigation district congresses and irrigation management committees at various levels. These organizations are comprised of representatives of "relevant departments" and beneficiary units and meet at regular intervals (once or twice a year) to study and discuss pertinent matters of importance such as project repairs, water utilization plans, canal system rebuilding, the levy of water fees and the formulation of relevant contractual systems. The matters discussed and decided upon by the congresses and management committees are reported to higher-level leadership departments for approval and then implemented. (Guan'gal'guanli, 1965, p. 10, in Nickum, 1981, p. 70.)
As a concrete example, at Shaoshan

... The irrigation district congress is composed of representatives of the benefited xian, qu, communes and production brigades. All these representatives are brought forth democratically from below. Besides these, participants include principal members of the Party committees of the benefited prefectures, xian (or municipality), qu and communes as well as responsible comrades of the provincial Bureau of Water Conservancy and Electric Power, the Shaoshan Irrigation District Hydroelectric Power Station and the Shaoshan Irrigation District Project Management Ju.... In the past, about 110 people have attended the congress [which meets once a year] and the sessions have generally lasted from 5 to 7 days.

Under the irrigation district congress, an irrigation district management committee is established. Each beneficiary xian (or municipality) has set up a management committee. The main canals have set up section management committee according to their sections, and canal system [watercourse] management committees have been set up for each canal system at the branch canal and below. The irrigation district management committee is headed by a responsible comrade of the Xiangtan Prefectural Revolutionary Committee [Government] while responsible comrades of the provincial Bureau of Water Conservancy and Electric Power, the revolutionary committees of the main beneficiary xian (and municipality) and the irrigation district project management ju are assistant heads. The xian (or municipal) management committees are headed by a responsible comrade of the xian (or municipal) revolutionary committee, with a responsible comrade of the water conservancy departments as assistant head and responsible comrades of the xian (or municipal) finance and grain departments, section management committees and the management suo as members. The section management committees are headed by a responsible comrade of the main beneficiary qu, with responsible comrades of other beneficiary qu and the irrigation suo as assistant heads. The canal system committees are headed by responsible comrades of the main beneficiary qu and communes of the canal system, responsible comrades of the management zhan or cadres of the canal system as assistant heads and responsible comrades of the beneficiary commune sectors as members.

The functions and powers of the various levels of management committees are to carry out the resolutions of the irrigation district congress, to mobilize and organize the masses to cherish the canals and protect the trees, to do a good job of project and water use management, to direct annual repairs, flood prevention, vernification, erosion control, planned water use, scientific water use, economical water use and farmland capital construction in the irrigation district, and to organize agriculture for high yields. (Shaoshan, 1970, pp. 3-4.)
4.35 More generally, the role of democratic management organizations at various levels is to bring together the line operations of the canal system and a real authority of the administrative districts, and to provide a means of communication and decision making for leaders, technicians and masses (NTSL, 5/1964, p. 2). It would seem that a well-functioning democratic management organization is necessary, although probably not sufficient, for good irrigation district management.

Mass Management Organization

4.36 The experience of the PRC corroborates Coward's observation that...

...there is increasing recognition that the style of articulation needs to be modified from a highly agency-directed pattern of interaction to one in which water users play active information-providing and decision-making roles. Clearly, the operation and maintenance of irrigation systems has been improved when irrigation agencies have succeeded in eliciting and using local information, local workers, and local management skills. (Coward, 1980, p. 26.)

4.37 Basic-level watering operations and project maintenance are commonly placed in the hands of "mass management organizations" whose members are paid in work points from the collective sector. At Shaoshan, only 184 of the irrigation district's 6,192 management personnel were on the state rolls. Of the remainder, 349 were engaged in project maintenance (some of them organized into full-time maintenance squads or teams), 44 "cherished the canal and protected the trees" (presumably, patrolled), 14 observed the water level in the main canal and 19 managed the flood gates.

4.38 The vast bulk of personnel, a total of 5,659, were assigned to water use management. Of these, 114 were canal system cadres (including collective cadres attached to the management su), 327 were brigade-level water operators (xingshui yuan) and 5,217 were production team water watchers (kanshui yuan) (Shaoshan, 1979, pp. 6-10).

4.39 In most cases, project maintenance is allocated to the beneficiary units in proportion to some measure of benefit. Under this arrangement, administrative units appear to be responsible for the maintenance of all portions of the project within their individual domains.

4.40 One exception to this is in some of the larger irrigation districts where the principal project components are kept up by professional maintenance teams within the professional management structure. When these are described in the literature, they are usually presented in an unfavorable light. For instance, Shaoshan originally had a 250-member maintenance team under the direct control of its management ju, but the following problems arose:
First, during the period when maintenance tasks were urgent, the personnel were either too concentrated and could not meet the needs or were too scattered and could not solve the problems. Second, there was relatively little work during other periods, so this not only occupied rural labor power but required the state to pay out tens of thousands of yuan in wages and tens of thousands of kilograms of grain each year. Third, some in the commune sector developed a dependent mentality and some basic-level cadres did not act on their own initiative to help solve the problems of canal maintenance, saying, "There is a professional team to manage the state canals, so we can rest easy." (Shaoshan, 1979, p. 6.)

4.41 The irrigation district then changed to a subcontracting system whereby the production teams along the main canals were given 80 to 120 yuan per kilometer to do the maintenance. The main flaw with this method was that it did not "thoroughly arouse the enthusiasm of the masses for cherishing and protecting the canal." It elicited a "hired hand point of view" where some production teams took the money but did not do a good job of maintenance (Ibid., p. 7).

4.42 The Qianli Canal project in Sichuan actually did turn to "hired hands" in the form of temporary labor to help the professional personnel maintain the principal project components and operate the turnouts from the three main canals. The description is not even as detailed as that for Shaoshan, but this method did not work either. The irrigated area actually fell, and "the masses also complained about this method of doing things" (Yikao, 1973, p. 66, in Nickum, 1981, p. 195).

4.43 The next approach, apparently successful, at both Shaoshan and Qianli was to turn over main canal maintenance to user-based organizations. At Shaoshan, the following system was adopted after 1968:

... The main canals and small structures are sectioned off by xian and are the responsibility of the uxian, which divides them among the communes in fixed sections and turns them over to the masses for maintenance and management. Large structures are the management and maintenance responsibility of the management ju and suo. Necessary fees for materials and equipment for maintenance of the feeder canal are supplied by the management ju. Canal systems at the branch level and below, as well as electrical pumping stations, ponds, small reservoirs, etc., are the management and maintenance responsibility of the xian, communes, brigades and teams.... In agreement with the principles of bearing burdens according to the degree of benefit, the labor used in maintenance by each commune sector unit is provided according to the mou in graded sections with equal assumption of burdens and as much self-reliance as possible. The necessary steel, cement and timber shall be allocated by the xian (or municipality) with materials expenditures supplied by each xian (or municipality) from the water fees [which it collects on behalf of the irrigation district--see chapter V]....
Each year a winter maintenance plan for the main canals is proposed by the communes and brigades [or teams]. Acting in accordance with that year's annual maintenance tasks, expenditures and materials and supplies, the xian (or municipal) management committees decide on a program for the year's winter maintenance tasks. Before July of each year, the Irrigation District Project Management ju and suo organize personnel to carry out surveys and report the situation to the irrigation district management committee for its approval. Then the winter maintenance tasks are issued in a unified manner to lower levels. Regular maintenance of canal systems at the branch canal and below is handled on its own by each commune or brigade [or team]....

To sum up, this method has the following three advantages: one, it has strengthened the leadership of the local Party committee over management work, raised the consciousness of the masses in cherishing and protecting the canals and brought into play the initiative of the masses for maintaining and managing the canals; two, with the communes responsible for maintenance and management, arrangements are made flexibly and with initiative, problems are handled promptly and maintenance is carried out during all four seasons with full-time teams during busy agricultural seasons and mass movements during slack periods [especially the winter]; three, the personnel of the professional management structure have more time and energy to devote to investigation, research and scientific experimentation, creating good conditions for raising the management level of the irrigation district and for organizing agriculture to produce high yields. (Shaoshan, 1979, pp. 8-9.)

4.44 This passage has been translated and cited here at length because it is the most complete description of the organizational arrangements and the specific advantages of a reform of the management system in favor of greater "reliance on the masses." The above reform was carried out in the early years of the Cultural Revolution, when particular stress was being placed on deprofessionalization. Nonetheless, the use of mass organizations for project maintenance, even in very large irrigation districts, appears to have been a desideratum throughout. It should be noted that an essential ingredient of the success of user-based maintenance is the strengthening of the role of the nonprofessional coordinating agencies, in particular the democratic management organizations and the Party committees. The additional burdens of maintenance labor can be easily incorporated by the commune sector units into their normal "farmland capital construction" activities.

4.45 Yeyuan has full-time mass maintenance squads with personnel drawn from production brigades in accordance with the area benefited. In general one person is drawn for each 300 to 500 mou. The squads are drawn up along canal system (watercourse) lines and are led by the branch management committees. The management ju provides subsidies for office supplies, drinking
water, illumination for night patrols and medicines, but individuals are paid in work points. There is also a separate dam maintenance team drawn from the local brigades to take care of daily upkeep on the main and auxiliary dams (Yeyuan, 1977, pp. 79-80).

4.46 The commune sector commonly assumes responsibility for the release of water within each watercourse. Guan'gai guanli notes that there are two kinds of irrigation crews in the commune sector:

1. The year-round professional irrigation crews. During the irrigation season, the year-round professional irrigation crews are responsible for the irrigation of the farmland, and during the irrigation season they take care of maintenance and, under certain conditions, can also develop sideline production. Most of these organizations are based on the production brigade and draw their personnel on a unified basis in accordance with the area benefited in each production team (generally one labor power for each 100 to 250 mou). The crews have a unified organization under the leadership of the brigade.

2. The seasonal professional irrigation crews. The seasonal professional irrigation crews are under the leadership of the production brigades in some places, but others are under the direct leadership of the production teams. In addition to providing fixed personnel responsible for watering the farmland during the irrigation season, they immediately participate in agricultural production once the watering is concluded.... This organizational form is now more common in irrigation districts.

The experience of the past few years proves that the year-round professional irrigation crews' tasks and responsibilities are clear and their professional thinking is stable. This helps raise the technical level of irrigation and facilitates effective maintenance work on the projects. Their watering efficiency is generally high. However, because the year-round professional irrigation crews are divorced from agricultural production for long periods, they gradually become estranged from the conditions of agriculture, thus adversely affecting the quality of their watering. In addition, the fact that a portion of the labor force participates for a long time in the professional irrigation crews adversely affects the labor force needed for agricultural production. Therefore, this form has not yet been widely adopted. (Guan'gai guanli, 1965, p. 11, in Nickum, 1981, pp. 70-71.)

4.47 The text goes on to claim that seasonal personnel are more likely to water in accordance with agricultural needs, but not efficiently. Since this description appears in a nationwide manual, it may be assumed to be of more general significance than if it were in an individual case study. If so, then the problem of organizational and attitudinal divorce of water management from agriculture may extend down to the most basic levels. Chapter IV elaborates on the organization and principles of water release.
V. FUNDING

5.01 The basic principle to be pursued in funding irrigation management in the PRC is to "use water to sustain water" (yi shui yang shui). In other words, an irrigation district or pumping station should be self-sustaining and not rely on state or collective subsidy to sustain operations. It should be "operated as a [socialist] enterprise [with] economic accounting" (Renmin ribao, 13 December 1963, p. 2), but unlike other enterprises its revenue is to be handled as earmarked funds (zhuan kuan zhuan yong), not treated as local financial income nor to be transferred for use on nonwater expenditures (Laws, 1958, p. 379, in Nickum, 1981, p. 261. This principle has been reiterated since, in Renmin ribao, 25 April 1964, p. 4; Shaoshan, 1979, pp. 14-15; et al.).

5.02 Management expenditures are primarily financed through the levy of water fees from beneficiaries. Additional revenue may come from income-earning sideline or "multiple" operations. These sources will be dealt with in turn.

Water Fees

5.03 "All water using (beneficiary) units should pay water fees to the water management organizations" (Shuili guanli, 1975, p. 36, in Nickum, 1981, p. 267). According to the nature of the project, fees may be levied for agricultural use, industrial use, electric power or navigation. Shaoshan, the most multipurpose of the projects studied, relies on all four sources, but least of all (since 1972) on agricultural fees (see Table 2). In most other cases, however, irrigation and drainage are the principal sources of fee income. The focus here will be on these agricultural fees.

5.04 Water fee levels are set by the democratic management organizations subject to the approval of the next higher political authority. The principles used in their determination appear to be cost recovery, ability to pay and, in some cases, the encouragement of pump irrigation, presumably to assist the less favorably sited. The most explicit list of principles in the literature surveyed is for the reservoir irrigation districts of Fujian Province:

1. Carry out the principle of "use water to sustain water, spend in accordance with receipts and accumulate a suitable amount [of surplus funds]."
2. Reservoirs with small amounts of water which cannot entirely guarantee irrigation adopt equal standards for those who use pumps or who use more water to change dry land into paddy, but priority must be guaranteed to gravity irrigation and to water on high-output, low-water-use land.
3. Reservoirs with more than sufficient water to guarantee all irrigation adopt the principle of lowering the water fees below the common rate for those who use pumps or who use more water to change dry land into paddy or to irrigate sandy fields, in order to encourage more sides to open up paths to water use and thoroughly bring the reservoir
Table 2. SOURCES OF WATER FEE REVENUE, SHAOSHAN

<table>
<thead>
<tr>
<th>Year</th>
<th>Index of Water Fee Revenue</th>
<th>Agricultural Water Fees</th>
<th>Industrial Water Fees</th>
<th>Electricity Generation</th>
<th>Canal Navigation and Lock Fees and Other Charges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1966</td>
<td>100</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1967</td>
<td>106</td>
<td>100</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>1968</td>
<td>205</td>
<td>37.2</td>
<td>20.2</td>
<td>--</td>
<td>42.6</td>
</tr>
<tr>
<td>1969</td>
<td>92</td>
<td>17.4</td>
<td>28.1</td>
<td>--</td>
<td>54.5</td>
</tr>
<tr>
<td>1970</td>
<td>1,080</td>
<td>30.6</td>
<td>47.8</td>
<td>--</td>
<td>21.6</td>
</tr>
<tr>
<td>1971</td>
<td>1,092</td>
<td>18.9</td>
<td>57.5</td>
<td>--</td>
<td>23.6</td>
</tr>
<tr>
<td>1972</td>
<td>1,140</td>
<td>0.2</td>
<td>48.0</td>
<td>31.4</td>
<td>20.4</td>
</tr>
<tr>
<td>1973</td>
<td>2,180</td>
<td>3.0</td>
<td>42.5</td>
<td>42.5</td>
<td>12.0</td>
</tr>
<tr>
<td>1974</td>
<td>1,320</td>
<td>1.9</td>
<td>49.0</td>
<td>34.2</td>
<td>14.9</td>
</tr>
<tr>
<td>1975</td>
<td>2,110</td>
<td>6.1</td>
<td>41.7</td>
<td>40.1</td>
<td>12.1</td>
</tr>
<tr>
<td>1976</td>
<td>1,870</td>
<td>4.9</td>
<td>38.6</td>
<td>50.5</td>
<td>6.0</td>
</tr>
<tr>
<td>1977</td>
<td>2,400</td>
<td>8.2</td>
<td>38.0</td>
<td>43.9</td>
<td>9.9</td>
</tr>
</tbody>
</table>

Source: Shaoshan, 1979, p. 16.
water into play. 4. When reservoirs need to release water
to sluice off floods or for other purposes, they should adopt
water fee standards lower than normal to encourage the masses
to use the water and reduce its waste. (NTSL, 4/1964, p. 7.)

5.05 The strategy of using lower pricing to encourage pump irrigation is
reflected in the rate structures of some of the individual cases studied,
notably Yeyuan, where gravity irrigation is charged 1.8 yuan/mou/ann. and pump
only 0.6 yuan/mou/ann.; and Shaoshan, where annual charges per mou are limited
"in principle" to no more than 1 yuan for gravity-fed and 0.5 yuan for pumped,
with no fees at all charged for three-stage and four-stage pumped water (at
Shaoshan, specific fee levels are set by the xian). 1/ These charges do not
include the power required in pumping. Charges for electricity, although
lower for agricultural than for industrial or domestic uses, are often quite
substantial, and diesel pumping costs even more. Average electrical pumping
charges are reported as having fallen from 2.8 yuan/mou per annum in 1962 to
1.8 yuan/mou in 1964 in Jiangsu Province, while diesel pumping charges fell
from 4.8 yuan to 3.1 yuan during the same period (NTSL, 8/1965, p. 11). Indi-
vidual figures from the same period for pumping charges range from 0.6 yuan to
6 yuan, with diesel costs ranging from 50 to 126% higher than electrical.

5.06 More recent figures reported tend to be of the same orders of magni-
tude: Gravity irrigation water fees, when levied, range up to 2 yuan per mou.
The highest amount cited for pumped irrigation and drainage in an October 1980
field visit was 4 to 6 yuan per mou for diesel pump irrigation from the Weishan
Lake in Shandong. The highest figure in the literature consulted was 40 yuan
per mou for electrical irrigation, appearing in a critical radio broadcast
from the early Cultural Revolution. Since this charge exceeded total agricul-
tural output value from the land, it was paid not by the users but by the
state (FBIS, 14 February 1968, p. ddd 30). Estimates of the cost of mass
water transfer from the Chang Jiang along the proposed eastern route are of
comparable magnitude to this maximum, although the cost to the farm user may
be reduced through the levying of charges for transportation and the like, as
at Shaoshan.

5.07 Recently, a writer in the Party newspaper Renmin ribao charged that
the "price of water has deviated from its value for a long time. It is not
exchanged for equivalent value [i.e., its opportunity cost]. The benefits of
water investment are nearly given away to the user without compensation" (Li
Yupu, Renmin ribao, 29 October 1980, p. 2). This is perhaps less the case for
agriculture than for industrial and municipal uses, but it is clear that despite
the policy emphasis on project self-sufficiency in operating funds, full
charge pricing is hardly universal. 2/ Some places, such as the Jiangdu

1/ At the official exchange rate, 1 yuan/mou is approximately equivalent to
$10/ha.

2/ Construction costs are not included in recurrent fees. They are absorbed
by the state and/or the prospective beneficiaries at the time of building.
Pumping Stations in Jiangsu, still do not charge water fees, although we were informed there that they will in the future. At present, the Central Government pays all annual operating costs at Jiangdu. Some end-users such as the Wantou Commune near Yangzhou, also visited in 1980, pay electrical fees but nothing for water. Wantou pays over 2 yuan per mou for electricity.

5.08 The extent of outside subsidy to users is indicated in a breakdown of expenditures used to fight a drought in Jiangsu in 1978, a year when irrigation expenses were 20% higher than normal:

Last year, the production teams in Jiangsu Province spent 400 million yuan on irrigation to conquer the drought that affected more than 2.66 million hectares. Of this, 100 million yuan was provided by the central departments, 70 million by the provincial authorities, 10 million by county governments, and another 30 million by enterprises run by the communes and production brigades. (FBIS, 28 February 1979, p. G 1.)

5.09 It is hard to estimate the degree to which the underpricing of irrigation water has led to overdevelopment, in part because the main crops receiving water are subject to mandatory sale to the state at set prices. As one would expect, these prices appear to be below their scarcity values, despite recent increases. One indicator of this is the wide difference between freely negotiated "surplus grain" prices and those set for peasant grain rations. These were 0.70 and 0.30 yuan per kilogram, respectively, in March 1981 for wheat in Beijing's rural areas (Beijing Review, 18 May 1981, p. 7).

5.10 The other side of the coin is that water-using units are often unable to pay cash water fees. As recently as December 1980 it was claimed that most production teams barely break even. In some cases they even run in the red and in effect lie largely outside the cash economy (Renmin ribao, 12 December 1980, p. 2).

5.11 This cash poverty shows up in some of the project descriptions. One of the tasks of the Dandong Management Bureau in Henan was to work together with the government's supply and marketing departments to find markets for local and specialty products produced by user production brigades to bring in cash income (NTSL, 4/1964, p. 15). In Chaoyang xian (Guangdong), a switch from per-crop levying of fees to collecting each watering was welcomed by the production teams who felt it would be easier to pay more frequently with petty cash than to come up with a larger sum all at once (NTSL, 7/1965, p. 12). In the beginning, the Manas River West Bank Irrigation District (Xinjiang) set its fees to cover only current management expenditures with no allowance for depreciation or major repairs because "the level of agricultural output [of end-users] was not high." When output levels increased, so did the fees (NTSL, 5/1964, p. 10).

5.12 The adjustment of fee standards to meet local capabilities to pay is expressed in a legal document from 1957-1958:

... Water fee standards, set by each locality, should be set in accordance with the increases in production in the agricultural cooperatives and the capability of the masses for bearing
the burden [and provide for] suitable accumulation in addition
to maintaining normal management expenses, [the additional
funds] to be used for project improvement [emphasis added].
(Laws, 1958, p. 384.)

5.13 Clearly, this sort of policy could lead to a vicious downward spiral
in poorer areas where high levels of maintenance are required if no external
subsidy is provided. Indirect evidence for this is the case of Shaanxi
Province where in 1964 it was noted that “at some projects, waer fee collec-
tion is low or nonexistent” (NTSL, 5/1964, p. 6) and by 1980, approximately
4C% of the reservoirs in the province had silted up (SWB, 10 December 1980,
p. A/12). 1/

5.14 Even in the wealthier areas, production team leaders appear to have
been reluctant to pay water fees. A good summary of their attitudes and a
counterargument is provided from Fujian Province:

... A second ideological obstacle we encountered [in introduc-
ing a volumetric fee basis] was the fear that the water fee
standards would be too high, or even a lack of desire to bear
the burden of water fees. [The masses] said things like:
"Why should we turn over any 'water fees' for water conservancy
[projects] built by the masses themselves?" or "Levying water
fees will increase farming costs and place a greater burden on
the peasants." Our method for solving this problem, aside
from educating the masses to recognize that water fees should
be included in farming costs in the same was as fertilizer and
seeds, was to work out five accounts. These are: (1) to count
up the investment by the state on a given project; (2) to draw
up a balance sheet for water fees. After this was done, the
masses noted that the state took nothing in water fees, even
though it invested in the construction of the reservoir. Since
the water fees are only used for project maintenance and
management, they felt that they should hand them over; (3) to
count up how much water control increases grain output. For
example, in southern Fujian, 1 m³ of water can increase grain
output by at least half a jìn [0.25 kg], but the water fee is
extremely light, only 0.005 or 0.006 yuan [ca. one tenth the
procurement price of the grain]; (4) to count up the amount of
labor power [formerly] used to lift water by wheel which is
spared by water control. If it takes 20 labor days to water
1 mou of land each year by wheel and each labor day costs 0.8
yuan, the cost [of traditional watering] is 16 yuan per annum,
7 to 8 times the 2-3 yuan per mou annual water fee; (5) to
count up the maintenance and repair expenses on water wheels
spared by water conservancy [via the reservoirs], about 2 yuan
per mou per annum. (NTSL, 4/1964, p. 7.)

1/ It should be noted, however, that Shaanxi contains most of the world's
largest loessial soil region and is subject to awesome problems of ero-
sion. Some smaller dams are built purposefully to retain the silt and
eventually form new, flat farmland. It is uncertain whether any of the
reservoirs in the report monitored by SWB fall into this category.
5.15 Of course, this particular line of counterargument, especially "accounts" (4) and (5), works best in areas of previously extant labor-intensive irrigation. A similar argument, comparing past labor expenditures with present, is given in the literature on Shaoshan where the subdivision of maintenance of the main canals along commune boundaries leads to an unequal distribution of present maintenance burdens.

5.16 One implication of the Fujian and other citations is that volumetric charges (discussed below) are associated with water charges in general. This may indicate a greater ease of avoidance with acreage or other fixed charge bases.

5.17 There is considerable evidence that end-users use the payment of water fees, especially of pump irrigation, as at least an implicit means of leverage over management. "Some masses" at Yihe Commune (Jiangsu) are quoted as saying, "When the water fees are high, we delay; when they are low, we pay." This attitude problem was diagnosed as being caused by incomplete canal structures (presumably referring in particular to inadequate water-measuring equipment), unsound mass water management organization and the professional management structure keeping the masses in the dark about the item-by-item specifics of the water fee plan (NTSL, 2/1964, p. 17). A negatively reinforcing process appears to have been generated of inadequate service and a lack of local involvement.

5.18 A more felicitous case was that of Nan xian in Hunan. There the end-user collectives were satisfied because the pumps worked when they were supposed to and because water was delivered promptly upon demand. They therefore prepaid their 1964 water fees so that the state-operated stations would have sufficient circulating funds to buy and store fuel to guarantee pump operation that year (NTSL, 2/1964, p. 12).

5.19 The leverage which water users exert in practice over water managers undoubtedly varies from project to project and over time, and depends on factors such as the actual and potential productivity of irrigation and drainage, the level of economic development and the prior experiences of manager and user with irrigated agriculture and accounting practices. Certainly payment is more assured if it is collected by the normal governmental extraction apparatus. The only available provincial regulations on irrigation management, for Zhejiang 1972, state that "the financial departments may be requested to collect water fees on behalf of the larger irrigation districts" (Shuili guanli, 1975, p. 38, in Nickum, 1981, p. 267).

5.20 This may lead to a loss of control by professional management over a significant portion of the collected revenue however. At Shaoshan, the xian water conservatism departments dispose of much of the revenue collected in agricultural water fees, albeit in an earmarked fund:

... Agricultural water fees and water grain [shui liang] are collected and managed by the xian (or xian-level municipal) finance and grain departments on behalf [of the management ju]. These are sent down with the procurement tasks and are collected
together [with other procurement items] but held in a special account. They are under the control of the xian (or municipal) water conservancy departments in an earmarked fund. A proportional share of each xian's agricultural water fees is turned over to the irrigation district project management ju for outlays on materials and equipment to maintain the feeder canal and for maintenance outlays on the major structures. The other types of water fees [industrial, electrical and navigation] are managed and used by the irrigation district project ju as funds which are collected and spent by the ju itself. These are earmarked for special purposes and are managed independently of the state budget. (Shaoshan, 1979, pp. 14-15.)

5.21 Yeyuan appears to have a similar working arrangement with the state functional departments, except that the commune level, not the irrigation district management body, requests the finance, grain and credit *iepartments (presumably, of the xian) to collect agricultural water fees of various types, pool them and forward them to the reservoir management ju on its behalf. As at Shaoshan, industrial and fishery water use fees are paid directly by the consumers to the management ju (Yeyuan, 1977, p. 84).

5.22 Yeyuan is relatively unique in reporting separate financial and grain levies for agricultural water use, with a uniform grain surcharge for both gravity and pump irrigation of 1 jin (0.5 kg) per mou per annum (Yeyuan, 1977, p. 84). In most cases, water fees are denominated in financial terms, but they may be paid at least in part in kind. A nationally publicized report on the North Huimin Canal project in Hebei in 1963 noted that water fees were paid mostly with labor and materials, not cash (Renmin ribao, 13 December 1963, p. 2). In this case, water fee collection bears a close resemblance to the suballocation of maintenance and repair duties to beneficiary units via the mass organizations. The latter way of doing things does not appear to be usually considered part of water fee collection. For example, Hougengchuan in Shanxi Province reported a savings in water fees accumulated by the management organ because many of the burdens of labor, funds and materials were assumed by the beneficiary teams (NTSL, 2/1964, p. 5).

5.23 The collection of fees in kind is not due entirely to the lack of cash in the collective sector. The materials consulted do not make this explicit, but the acquisition of grain through water levies is an important means of ensuring that the management staff is fed, especially in the usual case when some or all of them are not on the state labor rolls. Until the past two years, and then only slightly less so, the state has maintained a tight control over the grain supply. It has only been recently that "surplus" grain has been allowed to be sold on the private (including collective) markets, which themselves have been shut down from time to time during extremist periods. Even when the grain markets have been allowed to operate, they have handled only a very small proportion of the total supply. In addition, it is usually not considered proper for a state agency to "go outside" for its grain supply. Furthermore, the mandate to be self-sufficient together with the separation of its accounts from the unified state budget give a professional irrigation management body only a tenuous, supplicant claim on state grain
stores. It is quite reasonable therefore that at least some of the grain supply necessary to feed the professional staff and workers is generated through water fees and, where possible, by the management personnel growing their own foodstuffs.

5.24 The most detailed breakdown of management expenditures in the literature is for Shaoshan. It is summarized numerically in Table 3. A more detailed listing of the management expenditures at Shaoshan is the following:

(1) Expenditures on necessary tools and materials for annual repairs and maintenance on the project and for flood prevention and emergencies and expenditures on project improvement and reconstruction as well as canal vernalization;

(2) Wages and grain supplements for the collective personnel of each xian;

(3) The wages of the personnel of the irrigation district project management ju (and suo), staff and worker welfare, office expenses [or business outlays--gongwu fei], expenses for housing repair, as well as professional outlays such as for publicity, awards, training and experimental research, and the necessary circulating funds for sideline production and the like;

(4) Fund accumulation and expanded reproduction [investment].

(Shaoshan, 1979, p. 15.)

5.25 Yeyuan has a similar list with only minor differences, such as "subsidies to mass management organizations" instead of "wages and grain supplements for the collective personnel" (Yeyuan, 1977, p. 85). Cost items for pumping stations in Jiangsu in 1965 were nine altogether: fuel, machinery and materials, depreciation, major repairs, maintenance, workers' wages, supplemental wages, enterprise management outlays and other direct production outlays (NTSL, 9/1965, p. 11). Helong Reservoir in Liaoning also took funds from the water fees to help collectives build an electric pumping station and three gates (SGG, 1973, p. 95).

5.26 Water pricing bases. Robert Chambers has recently raised the intriguing question of whether rationing water by variable pricing is a red herring as an approach to the problems of management of large irrigation schemes (see ODI, 1980, pp. 14-17). In other words, is good management a consequence of, or a necessary prerequisite for, a variable pricing system? 1/

5.27 The evidence investigated from China indicates that, while variable price schemes have desirable properties in reducing both waste and conflict over water use, they are far from being a cure-all, and are more likely to be a useful supplement to otherwise good management of water distribution. One clear indicator of this is the fact that volumetric charge systems have been

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1/ It is interesting to note that Taiwan's irrigation associations charge flat fees.
Table 3. MANAGEMENT EXPENDITURES, SHAOSHAN, 1976

<table>
<thead>
<tr>
<th>Management Expenditures as a Percentage of Water Fee Revenue</th>
<th>Various Outlays as a Percentage of Management Expenditures</th>
<th>Project Maintenance Outlays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Outlays</td>
<td>Management Outlays</td>
<td>Project Maintenance Outlays</td>
</tr>
<tr>
<td>Wages of Staff and Professional Workers</td>
<td>Business and Professional Outlays</td>
<td>Maintenance of Major Structures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Equipment and Materials for Maintaining the Feeder Canal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vernalization</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Electricity fee supplement for draining flood-waters from the reservoir district</td>
</tr>
<tr>
<td>15.7</td>
<td>10.7</td>
<td>22.0</td>
</tr>
<tr>
<td>57.2</td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td></td>
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<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.5</td>
</tr>
<tr>
<td>26.4</td>
<td></td>
<td>30.8</td>
</tr>
</tbody>
</table>

Source: Shaoshan, 1979, p. 17.
practiced, publicized and acknowledged as superior to fixed charges in reducing waste in many specific instances for nearly two decades, but fixed charge schemes are still more commonly found, even in many of the major models, such as Yeyuan and Meichuan and to some degree in Shaoshan.

5.28 Both in the literature and in personal conversations, Chinese analysts and decision makers point to serious weaknesses in using a flat-rate charge based on the area benefited or expected to be benefited. It is said that although fixed charges are simple to calculate, they lead to waste of water and to "contradictions between benefits and burdens" (NTSL, 7/1965, p. 2).

5.29 In particular, in the absence of an enforceable nonpricing method of water allocation, the interests of upstream and downstream users tend to conflict. Upstream users apply water heavily, often excessively, to the fields but abandon their own ponds and alternative sources of water while those in the lower reaches receive insufficient and uncertain supplies. Sometimes, large numbers of mass "water releasers" turn out at irrigation time to contend with other units for water use (NTSL, 6/1965, p. 12). Often, the putative beneficiaries express little concern for project maintenance and allow, or cause, the channels to become clogged or silted up. This is particularly a problem in the lower reaches (Renmin ribao, 10 March 1963, p. 2; Yikao, 1973, p. 68).

5.30 The superiority of volumetric pricing (including time-based charges for pumping) has been widely accepted in principle but is far from universally adopted in practice. Volumetric charging was promoted particularly strongly in a Renmin Ribao report of 10 March 1963 and in several articles in Nongtian shuili yu shuitu baochi during 1964 and 1965. It was reported that 53 out of 104 large reservoirs in Fujian Province were charging by the cubic meter (NTSL, 4/1964, pp. 5-7) and that a fixed cost plus variable usage charge basis was used for pumping stations in most parts of Jiangsu Province (NTSL, 8/1965, pp. 11-13). Curiously, all of the sites publicized for volumetric pricing were in the water-rich, rice-growing southeastern and coastal parts of the PRC.

5.31 Since then, and in other parts of the country, the record on volume-based pricing is mixed in practice. In an extensive tour of the North China Plain along two proposed large-scale water transfer routes in October 1980, we found no instances of the use of volumetric pricing, even in Jiangsu, although one site in Henan was planning to convert from an acreage charge in order to reduce waste.

5.32 The major case studies discussed at the beginning of chapter II indicate a wide variety of approaches to charging bases. For the most part, the materials consulted do not indicate that this is a matter of great concern. For example, water fees are charged at Yinjing but no mention is made of their basis (SGG, 1973, p. 85, in Nickum, 1981, p. 212).
5.33 Some of the xian in Shaoshan Irrigation District collect fees according to the mou benefited, with distinctions being made between gravity and pump irrigation. Others add a volumetric surcharge to a basic fee. The text provides no discussion of the advantages or disadvantages of either basis (Shaoshan, 1979, p. 14).

5.34 Like Shaoshan, Yeyuan charges industry and fisheries volumetrically (0.001 yuan per m$^3$). Irrigation water was charged on a per-mou basis, however, until 1977, after which the system was to be changed. The reason given was that "management practice in some irrigation districts proves that volumetric collection of fees is even more helpful in promoting land leveling, economizing on water use and carrying out planned water use." No further specifics are provided (Yeyuan, 1977, p. 84).

5.35 Qianjin, which has a "melons on a vine" system, uses a modified volumetric scheme:

... Water fee levies are calculated on a per-mou basis, with additional charges for excessive use of the reservoir's water and reductions in fees for using less than the predetermined amount of reservoir water. [These surcharges and discounts are calculated volumetrically.] Fees for electricity and fuel consumed in pump irrigation are assumed in a unified manner by the irrigation district if they are arranged by the management su to reduce the amount supplied by the reservoir. Pumping done on one's own is paid for by the doer. (SGG, 1973, p. 35.)

This is all that the reports on Qianjin have to say on pricing.

5.36 Meichuan actually abandoned volumetric pricing in favor of nonprice organizational solutions, in particular the establishment of a sound "democratic management" system. The argument against the "economic" approach was as follows:

... Water fees were collected from a purely economic viewpoint, at the rate of .008 yuan per cubic meter, but little was done to popularize the idea of using water sparingly and uniting to resist drought. A few in the commune sector believed that as long as they paid for it, water should be released to them regardless of other circumstances. They demanded too much water. They did not consider that there was little water in the Meichuan Reservoir, that the irrigated area was large, and that they should heed the balanced use of water throughout the irrigation district. A small number of communes and brigades upstream along the canal would not request water at the appropriate time but waited to use the water which seeped through as it passed by. Others did not request reservoir water at all and only used pond water, causing their fish to die and affecting both agricultural and fishery production. Therefore, collecting water fees according to the cubic meter was only carried out for two years [probably ca. 1960-61] and then discontinued. (Meichuan, 1973, p. 47, in Nickum, 1981, pp. 148-149.)
5.37 The evidence from the PRC tends to bolster the "red herring" hypothesis in that it indicates that usage-based pricing is a good supplement to proper management, but not a substitute for it. One manual put it succinctly when it noted that the "rational policy" of unit charging

... can promote frugality in the use of water, raise the quality of irrigating and help increase production. But it requires sound water measuring equipment and it demands that management work be done meticulously [emphasis added]. (SLGL, 1975, p. 35.)

Multiple Operations

5.38 One way a management organization can fulfill its mandate to be self-sufficient in funds when water fee revenue is inadequate is to engage on the side in productive activities. This is quite allowable and is even encouraged, as long as normal management operations are not affected. The unified state budget can also benefit, for unlike water fees, revenue from these "multiple operations" is taxable.

5.39 Multiple operations are reported as being significant sources of income in all of the major case studies except Qianjin. The most elaborate description is for Shaoshan. There the Irrigation District Project Management Ju was provided with 270 mou (18 ha) of land as a "production base." This area, originally wasteland, was converted into 13 mou of terraced fields, 65 mou of pear orchards, 35 mou of tangerine orchards, 20 mou of peach orchards, 24 mou of vegetable gardens and 100 mou of scenic forests, with the remainder used for construction and roads. Crops grown include tea, sweet potatoes, peanuts, soybeans and rice. Pigs are also raised. In 1974, two hydropower stations with an installed capacity of 26 kilowatts were transferred to the production base. The base is provided with its own staff, consisting of young school graduates sent to the countryside from nearby Xiangtan Municipality and the educated children of Shaoshan staff and workers. 1/ The "total output value" of the production base averaged 26.1% of agricultural water fee income between 1966 and 1977 and exceeded the latter in three of those years (1969, 1972 and 1974) (Shaoshan, 1979, pp. 17-18).

5.40 Yeyuan reports a total water fee revenue of 1.997 million yuan over "the past dozen or so years" and a total income from multiple operations of 568,000 yuan (Yeyuan, 1977, p. 85). This is a similar proportion to that for Shaoshan. Yeyuan's principal sources of outside income appear to be fish raising and trees (Yikao, 1973, p. 26).

5.41 Yinjing also relies on the cultivation of trees along its canals to provide income for the various levels of its management structure and for the production brigades along the canals (SGC, 1973, pp. 84-85, in Nickum, 1981,

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1/ State-owned economic units in China usually give priority in hiring to the children of employees.
p. 211). It is quite common for state water management bodies and the rural collectives to share the proceeds from trees. The People’s Yinjing Canal Management Ju also operates a hydropower plant generating over 2 million kwh per annum, a machinery repair plant and a cement factory. These provide essential services, materials and income to the ju.

5.42 Meichuan has been quite successful with its multiple operations. Reservoir enterprises yielded a 1972 gross income of 130,000 yuan and net income of 40,000 yuan. In addition, they provided more than sufficient grain, cotton and oilseeds for Meichuan’s employees. The principal activity is fishery. Hogs are raised to provide manure which is used as fish food. The existing personnel and their dependents provide the labor for sideline activities (Meichuan, 1974, pp. 50-53, in Nickum, 1981, pp. 153-157).

5.43 Descriptions of other projects often include sideline sources of income, but they differ little from those just described. Some water management organizations governing major river dikes or large flood control gates do not collect fees for water or electricity but have nonetheless met some or all of their expenses through the development of multiple operations (examples may be found in Nickum, 1981, pp. 29, 215-233).

5.44 The development of supplementary, perhaps alternative, sources of income to project management might be expected to reduce the dependency of the professional managers on beneficiary units and perhaps on the state as well. This would deprive both the masses and the leaders with an important source of leverage. The literature consulted does not indicate any deleterious consequences of this kind of financial autonomy, however. This may be due to a bias in the choice of topics reported on, but it is also possible that the development of multiple operations is a sign of effective management which is also responsive in other regards.

VI. WATER ALLOCATION

5.01 The previous chapter showed that the Chinese recognize the important adjunct role that a well-designed water fee basis can play in promoting an efficient and equitable distribution of water. The primary factors noted in the materials consulted, however, are a sound, well-articulated management structure (as outlined in chapter IV) and the use of well-informed yet flexible plans and allocation procedures. In other words, there should be “planned water use” (jihua yongshui).

6.02 Planned water use in China is said to have six "links":

1. **Tong** [unify] -- The storage, diversion, allocation, irrigation and drainage of water should have a unified plan [or arrangement].

2. **Suan** [calculate] -- Calculations and rational arrangements should be made with respect to the amounts of water supplied and needed, the periods of water use, irrigation tasks, necessary labor and animal power and so on.
3. **Pei [allocate]** -- The rational assignment of water and water allocation in the irrigation district is handled in a unified and centralized way by professional management organs in accordance with the plans formulated by the irrigation district management committee or congress and approved by higher-level leadership organs. No other organization or individual is allowed to jumble things up by interfering or giving directions.

4. **Guan [irrigate]** -- A rational irrigation system, rational irrigating methods and rational irrigating techniques should be implemented.

5. **Ding [fix]** -- An individual responsibility system with fixed tasks, quality and personnel should be carried out.

6. **Liang [measure]** -- The main canals and water distribution points can control and adjust the amount of water and carry out water measurement. (NTSL, 5/1965, p. 16, in Nickum, 1981, p. 246, see also Guan gai guanli, 1965, p. 16, for a simplified version).

### 6.03

As noted in chapter III, planned water use is not always achieved in practice. Indeed, it may be atypical. As late as 1975, even Shaoshan was only just beginning a pilot project in planned water use (Shaoshan, 1979, pp. 160-174). The model descriptions indicate that, especially in the early days of a project's operation, professional managers may focus on water release without consideration of crop requirements, even in monocultures. This would be consistent with the previous discussions in this work of staff origin and orientation. Often district managements do not have a clear idea of the supply capacities of their water sources. One manual outlines different methods of drawing up annual water allocation plans for an irrigation district depending on the degree of abundance of data such as precipitation, runoff or irrigation requirements of crops (Guan gai yongshui guanli, 1974, pp. 63-75).

### 6.04

Professionals and masses also sometimes do not cooperate closely, and the masses are left guessing--and hedging:

... In the beginning, some people ... viewed professional management as something very mysterious and did not tell the masses things like the amount of water stored [in the reservoir] and the amount released when the gates were opened. The masses had minimal understanding of the conditions of the reservoir. Every time they used its water to resist drought, they became anxious. Some people even hurried to the reservoir from several dozen li [1 li = 0.5 km] away to see how much water was left. (Meichuan, 1974, p. 47, in Nickum, 1981, p. 148.)
Meichuan's first attempt to solve the resultant problems of waste was to bring in 75 "worker-peasant water managers" to assist the professional management sections,

... but in actuality this still emphasized the need to have [only] professional management. The broad masses still did not understand the importance of good management and use of water projects; nor could they become self-consciously motivated to use water sparingly or rationally. (Ibid., in Nickum, 1981, p. 149.)

The solution in the end was to establish an active management committee involving the Party, to set up a 692-member "mass water management contingent" and to institute a "unified management system" wherein

... the management office regularly submits reports to the qu Party committee and the "management committee" concerning the amount of water stored, the water requirements, and the progress of irrigation. Before the gates are opened to release water, they send the water allocation plan and the water use targets to the various levels, handing them down to the communes and popularizing them broadly among the masses, thereby lending a high degree of unity to the water use plan for the entire irrigation district. When water is allocated, they hold to the "three first, three later" principle. When they irrigate, they carry out a "four fixed" system, that is, fixing personnel, acreage, flow and time. Moreover, they have set up a "four anti, six forbidden" management system. (Ibid., pp. 48-49, in Nickum, 1981, pp. 149-150.)

This passage touches upon several elements which are considered keys to the success of irrigation management in the Chinese literature on the subject. In particular, there is a high level of communication and mutual involvement in water allocation, water sequencing is guided by "first/later" type slogans, important factors involved in distribution are predetermined ("fixed"), including quite notably that of personnel responsibilities and rewards; and a system of rules and prohibitions is enforced.

The organization of water allocation. Effective water allocation requires a blend of centralization and decentralization, so that it is "unified but not dead, alive [flexible] but not chaotic" (NTSL, 5/1964, p. 4). Larger irrigation districts, including Yinjing, Shaoshan and Yeyuan, seek to achieve this blend with a three-tiered allocation system, usually involving the centralization of water rights. For example, at Yinjing,

... water rights for the canal system are centralized in the management ju and water allocation in the zhan; water rights for the main and branch canals are centralized in the zhan and water allocation in the subbranch canals; and water rights for the subbranch canals are centralized in the [subbranch] management committee, with water allocation done by the production teams. (SGG, 1973, p. 83, in Nickum, 1981, p. 208.)
Meichuan has a two-tiered allocation system with water being released to the basic units by management sections under the reservoir irrigation district chu (Meichuan, 1974, p. 26, in Nickum, 1981, p. 117). Qianjin is sufficiently small that its management suo deals directly with the production brigades. Very small projects such as pump wells or ponds are usually managed directly by the end-user, although their water supply may be incorporated into the planning and allocation of a larger system (see below).

The basic tier of water allocation is identified as the key to ensuring that water is distributed in harmony with crop needs. This tier lies at different levels in different irrigation systems.

At Shaoshan the basic tier is the branch canal. There are 33 branch canals with control areas in excess of 5,000 mou (333 ha) which are usually operated by a management zhan under the leadership of the xian or qu. An unspecified number of smaller branch canals governing areas within individual communes are managed by commune canal system cadres (ju xi ganbu). Even the larger branch canals have the commune as their "corresponding administrative organization." Below the commune canal system cadres are brigade "water operators" (xing shui yuan) and production team "water watchers" (kan shui yuan) (Shaoshan, 1979, pp. 6, 144). 1/

The corresponding basic tier at Yinjing is the subbranch canal, of which there are over 70. The average control area (15,000 to 30,000 mou) is comparable to, or greater than, the branch canal systems at Shaoshan (SGG, 1973, pp. 83-84, in Nickum, 1981, pp. 209-210).

At Yeyuan, the lowest tier is also based on the subbranch canal (or pumping station). There are an unspecified number of subbranch canal management committees, but since Yeyuan's branch canals govern areas similar to those of Shaoshan and like the latter are subdivided along commune lines for management, it is clear that the subbranch level is much closer to the field than are the basic levels at Shaoshan or Yinjing (Yeyuan, 1977, passim).

The basic-level water managers are in charge of inspecting and determining the water needs of the crops on an ongoing basis, drawing up basic level water use plans and releasing water to the terminal units. Cadres from the user units are involved in the inspection and planning processes. Two examples of how this is done in practice are from Yinjing and Meichuan:

1/ The duties of Shaoshan's water operators and water watchers are listed in Shaoshan, 1979, pp. 159-160.
... Through practice, we have come to realize that the allocation of water within a subbranch canal should be in accordance with the needs of the crops. "We should observe the skies, the earth and the crops," link ourselves to reality and make allocations in a flexible way. Cadres of the commune sector accompany the water management personnel to the fields to inspect the soil moisture of every piece of land and to look at the seedlings, classifying, arranging and clearly distinguishing the more urgent from the less urgent. They then arrange the water use plan, carry out democratic distribution of the water and irrigate rationally. In order to preserve the sequencing of water use and to ensure even distribution of benefits, we have measured water at fixed intervals and allocated in a timely fashion. We have carried out "two no-reductions" (no reduction [in allotment] if water is spared and more land watered, and no reduction if water allocated according to need is used further) and "three no-supplements" (no supplement after voluntarily relinquishing water rights, no supplement after wasting water and watering less and no supplement after discrepancies arise from not measuring the water). We have sought to have "three exact fits" (branch canals, sub-branch canals and fields) with respect to the amount of water. (SGG, 1973, pp. 83-84, in Nickum, 1981, pp. 209-210.) [Yinjing]

... Each water-using unit must submit a request to the management section before water is released for irrigation. The professional managers of the section and the leaders of the commune go together to the water-using unit to investigate, determine the drought condition, confirm the irrigated acreage and carry out the "four fixes," that is, "fix the people who will manage the water, the area to be irrigated, the amount of water to be released and the time of release." Only then are the gates opened for rational irrigation. (Meichuan, 1974, p. 26, in Nickum, 1981, p. 117.)

6.13 At Shaoshan a "five fix" system is implemented at each branch canal distribution outlet. Not only are personnel and the amount supplied and release times of water predetermined, but so are the compensation of the "fixed" personnel and a system of rewards and penalties for them (Shaoshan, 1979, p. 157). The particular emphasis on linking the responsibilities of assigned personnel with their material interests at this level indicates the critical nature of this transfer point in the water allocation system.

6.14 In some cases, terminal production units are issued water allocation permits (zheng) or they buy coupons (piao). The former method was used at the North Huimin Canal Irrigation District (Hebei), where charges were levied according to area (Renmin ribao, 13 December 1963, p. 2). The latter was found in several cases where irrigation and drainage were by pumping or where the end-users were state farms rather than collectives (NTSL, 5/1964, pp. 10, 13, and 6/1965, p. 1). These permits and coupons provide an additional control over water use. They also help the water users stabilize their expectations with respect to their entitlements and costs.
6.15 **Sequencing rules.** In the main systems, various sequencing rules have been adopted in order to ensure the even distribution of benefits. Projects such as Yinjing (and to a lesser degree Shao Shan) which rely on diversions from variable flows establish contingency rules which switch from continuous to proportional or rotational irrigation when the water supply falls below preset thresholds. At Yinjing, when the available water supply falls below requirements, it is distributed proportionally among the sub-branches. If the flow is reduced further (in 1958 the standard was set at 40% of normal), water is rotated in the main and branch canals (GJYS, 1958, pp. 46-52; the same source presents schematics for determining the supply to each main and branch canal based on total canal head diversion). A similar two-stage, three-tiered system operates at the nearby Luohui (Jingluo) Canal (NTSL, 1/1964, p. 24).

6.16 It is common in multiple-source ("melons on a vine") systems to use various sets of "first/later" sequencing principles to guide water allocation decisions. Meichuan has a "three first, three later" water use principle (Meichuan, 1974, pp. 23-26, in Nickum, 1981, pp. 113-118; SGG, 1973, p. 28; and Kexue shiyan, March 1976, pp. 23-25). In rotation irrigation within each branch canal, Shao Shan generally carries out a "seven first, seven later" water release system (Shao Shan, 1979, p. 157). The most elaborate system was the "nine first, nine later" reported for Qianjin. Since this is the most fully specified, it is repeated here to indicate the nature of these rules:

1. When storing water, first store in distant ponds, then in near ponds; first in high ponds, then in low ponds; and first in ponds with small catchment areas, then in those whose catchment areas are large.

2. When using water, first use living [active] water [in mountain creeks and spring-fed wells], then use dead [idle] water [in ponds and reservoirs]; first use pond water, then reservoir water; first use low-lying water, then use water situated at higher elevations.

3. In irrigating, first water distant fields, then near fields; first water high fields, then low fields; first water paddy, then dry fields. (SGG, 1973, pp. 37-39.)

6.17 An interesting variation of these sequencing rules are the "six first, six later" water release principles of Jiangxi's Jiulong Reservoir, a commune-run project. These principles differentiate between crops, "first grain and cotton, then other crops," and, uniquely, between collective and private plots (NTSL, 3/1964, p. 28). Until very recently, no consideration was usually given to the private sector.

**Multiple Water Source Management**

6.18 A very high proportion of the case studies involve the conjunctive management of multiple water sources of various sizes. Of the major studies, Qianjin, Meichuan and Shao Shan have "melons on a vine" systems combining reservoirs, canals and ponds; and Yinjing and Yeyuan have incorporated pump wells into their water use planning.
"Melons on a vine." This expression has been used since at least the Great Leap Forward (e.g., Changteng jiegua, 1959) to describe surface flow systems which combine major and minor storage facilities. A melons-on-a-vine system is a hallmark of good management, for it integrates the use of small facilities owned by terminal users with that of the larger core project.

Such an integration entails a number of difficult problems. The description of Meichuan highlights the difficulties as perceived by the professional management: the extra burdens in time and effort; the need to help the masses build and rebuild their ponds by providing them with plans, surveys, designs, training and the like; and the problem of finding economic inducements for end-users (in the case of Meichuan, fishery was promoted in user ponds).

The economic conflict between the part and the whole is especially acute in the upper reaches where beneficiary production brigades and teams tend to feel they can rely on reservoir water and fail to maintain their own storage facilities. They may even fill in their ponds to create new farmland. A 1969 survey of 47 communes in Shaoshan found that over 400 ponds had been so "abandoned" (Shaoshan, 1979, p. 154). In Huoqiu xian (Anhui Province), 57% of the more than 34,700 ponds extant in 1964 have been turned into fields or otherwise abandoned (Renmin ribao, 19 December 1980, p. 2).

As one would suspect, especially where the smaller projects have preceded the construction of the core reservoir and canal facilities, there are likely to be some difficulties in establishing a melons-on-a-vine system from the standpoint of at least a portion of the end-users. Such conjunctive use involves some imposition of outside "unified management," but this brings with it the risk that the interests of the part will be subordinated to those of the whole at the cost of the former.

The literature indicates that end-users are able to articulate their concerns about the use of their minor projects. Since these materials are all written from a "top-down" perspective, this judgment might be a bit suspect, but it is reinforced by many descriptions of problems in compliance and participation in an overall plan. There certainly are acceptable methods of intervention from above, such as the "centralization of water rights," but these require some consideration to be made to the prior rights of the end-user to a secure water supply.

A very good description of the issues involved in setting up a melons-on-a-vine system in the middle and late 1960s is provided for Shaoshan. Because of its richness of detail, this material merits excerpting in some length:

... Before the irrigation district, the farmland in this area mainly relied on existing water control facilities such as ponds and small reservoirs for irrigation. But because of the limitations of historical and natural conditions, most of these works were unevenly distributed and the water rights were under
the separate ownership of the local production teams. After the irrigation district was set up, the imbalance in water was enormously improved through canal diversions and electrical pumping, but it was not possible to centralize the water rights over the existing water facilities and there was no way to unify allocation. The imbalanced phenomenon of upper teams having much water and lower teams having little still appeared in individual districts, and it was very hard to avoid disputes over water use. For a time, ponds were abandoned in individual gravity-flow irrigation districts in the upper and middle reaches of the main canals. Some or most of the farmland which some small reservoirs and relatively large ponds were once responsible for irrigating was now watered by the canals of the irrigation district, but those impoundments still formed their own system closed off from the [outside] world and were not brought into the purview of their own irrigation districts. During abundant water periods the ponds and reservoirs would be filled with water but not utilized, and during the drought season [the production teams] were not willing to have the water regulated to other places. Some pumping stations could only pump water to irrigate the fields during the urgency of drought. In normal times they did not lift water to store in the ponds and reservoirs. Each party swept the snow away from his own door. [In consequence,] the electrical fees were burdensome and the utilization rate of the equipment was low. All of the above conditions presented an acute problem to water use management in the irrigation district, so that it was necessary to do a conscientious job of managing multiple water sources, centralize water rights and unify allocation.

... Fengjia Brigade, Yingtian Commune, Shaoshan District, to solve [this problem] came up with the "four join, five unite" management method. "Four join" is to join together the water sources of the canal, the ponds and reservoirs, the river embankments and the electrical pumping stations and irrigate in a united fashion. "Five unite" is to unify the leadership, the water rights, the plans, the management and the burdens. ... With a relatively large mountain pond as a mainstay, they divided the entire brigade into eight water supply districts [not coincident with team boundaries]....

... When this method began to be implemented, not all the production teams or masses felt the same about it. [Most approved] but some production teams which originally had many ponds and whose water was relatively abundant were concerned that after water rights were centralized, their own water would be allocated away during the drought season and their production would drop because of drought. Some teams with gravity flow canal water whose water control conditions were good and who
had bumper harvests which increased from year to year were concerned that being "united" with teams with inadequate water control conditions would add to the [financial] burdens of their own team. Some of the masses said, "Our team deserves its good water sources. Why should we have to let them be transferred around to be used?" ... In order to achieve an even increase in production, it is necessary to solve the problem of imbalance in water conditions ... but this definitely does not imply "pulling all down to the same level" ... or still less can it allow the water source exporting districts to suffer losses in production due to drought. (Shaoshan, 1979, pp. 149-151.)

6.25 The argument then is that water use is not a zero-sum game, and that everyone benefits (or no one is hurt) from a redistribution of surplus water.

6.26 The materials consulted emphasize the mutually beneficial aspects of centralizing water rights, so it is not clear how the conflict between the objectives of even distribution of benefits and no harm to the original developer is resolved in times of excess demand. Rather, one of the selling points of incorporating a pond into an integrated system is that it allows the smaller impoundment to be recharged more frequently with supplements from the principal components. This may be expected to provide the terminal unit with greater security of water supply in times of extreme drought. A similar risk-oriented line of argument is made to those who abandon existing local sources of water supply that they thereby increase their chance of loss in the extreme cases when the main project cannot supply sufficient water (e.g., Shaoshan; see below).

6.27 The specific methods by which user ponds are incorporated into the plan appear to differ widely. At the relatively small spring-fed Shuangquanyan Irrigation District in Shaanxi in the early 1960s, water storage contracts were drawn up with beneficiary production teams. In these contracts, the production teams undertook the actual storage and management of their ponds, while the district's management committee inspected, checked and approved their operations. They adopted the following water use principle: "Delimit the scope of benefit; whoever stores, uses; do not transfer if extra is stored; do not supplement if less is stored." With the rights of the teams to locally impounded water thus ensured, it was possible for the irrigation district management to allocate canal water to those areas which had not been covered in the contracts (NTSL, 3/1964, p. 29).

6.28 Qianjin, also quite small, is reported to have had a somewhat more active system of water use planning of "three fixes and one supply." The amount of water, irrigated area and drought resistance capacity were fixed for each project according to its storage capacity and each team's long-term production plan, and then any deficit was supplied by the main reservoir (Yikao, 1973, p. 15). It should be noted that Qianjin's reservoir is a larger and more secure source of supply than Shuangquanyan's springs.
6.29 Shaoshan, far larger, also appears to be much more remote in its arrangements with beneficiary production brigades and teams. The main canal allocations are based on the assumption that 40% of the water requirements will be supplied by ponds. Those who do not store according to plan are less likely to be supplied from the canals in time of serious drought. It is noted that the districts irrigated by pumping in Shaoshan pay more serious attention to ponds than those which rely on gravity (Shaoshan, 1979, pp. 154-156).

6.30 Often a conjunctive-use water plan is set up where different sources are relied upon at different times of the growing season. At Meichuan, the core reservoirs release water only at the most critical times or slightly before, when it is necessary to refill relatively depleted ponds. The 1974 water release schematic for Shaoshan, which differentiates between gravity-fed areas and pump irrigation districts, is shown in Figure 1 (from Shaoshan, 1979, p. 132).

Figure 1. CONJUNCTIVE USE WATER RELEASE SCHEMATIC FOR SHAOSHAN

a. Pump Irrigation Districts  b. Gravity Irrigation Districts

<table>
<thead>
<tr>
<th>Month</th>
<th>Canal Water</th>
<th>Impoundment Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>MJ</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>JSO</td>
<td>30</td>
<td>40</td>
</tr>
</tbody>
</table>

6.31 Wells. A small number of cases, all in the northern part of China, involve the joint use of surface flows and groundwater. Of the major examples, Yeyuan has "double insurance" of pump and wide-mouth wells and canals on one quarter of its irrigated area (see map), and Yinjing relies on pump wells for
much of the irrigation and drainage in its upper reaches. Although separate figures are given at Yinjing for the areas irrigated by wells and canals which appear to imply that the two sources govern discrete systems, the description of their use indicates some overlap:

... Since 1964, the broad masses have criticized that idea of relying on nature and on the canals which is typified by the saying "Much water passes by our door, so why should we dig any wells?" Thus many in the commune sector situated in the upper reaches have upheld the slogan of using more well water in order to save canal water to support fraternal communes in the lower reaches. As a result, a mass movement for self-reliantly digging pump wells quickly developed in the irrigation district....

... The entire irrigation district has now taken preliminary steps to form an irrigation and drainage system which combines canals and wells, with canals feeding the wells; canals and reservoirs, with canals supplementing the reservoirs; and irrigation and drainage, with wells substituting for drainage. (SGG, 1973, pp. 80-81, in Nickum, 1981, pp. 204-205.)

6.32 Intertemporal sequencing rules such as "using wells to irrigate cotton and canals to water the fall crops" and "cover the wells when the canals irrigate" have been popularized. The choice of terminology indicates that there is minimal compulsion to comply with these rules, however (SGG, 1973, p. 84, in Nickum, 1981, p. 210).

Discipline

6.33 Included among the rules and regulations of many projects are various strictures governing water allocation. These are usually expressed as numbered slogans, such as the "two no-reductions and three no-supplements" of Yinjing mentioned earlier in this chapter. Yeyuan has a "three must, four not allowed" system:

Water must be used according to the water period, irrigation must be rotated between day and night, and there must be unity in water use; it is not allowed to steal or contend for water, to build embankments across the canals to intercept the water, to put in private underground pipes or break the embankment to divert water, or to open and close the gates at will. In addition, it is clearly stipulated that anyone who causes losses in the water period through delay by being responsible for an accident or by watering during the day but stopping at night shall have none of the loss made up; and that the management departments are empowered to stop the supply of water to those who engage in flood irrigation, waste water or flood the fields and breach the canals because their projects are not in good order, their organization is not sound, or their preparatory work is not done well. (Yeyuan, 1977, p. 84.)
6.34 The Dandong Irrigation District in Henan Province had a "seven no-water, six not-allowed" system. Under this, water was not to be released to units which had no designated people responsible; which had not done a good job of organizing watering teams; which had not completely dug their canals of various sizes; which had not done good preparatory work; which did not do a good job of managing water; where rotation was not possible; and which had not done a good job of repairing the projects. Further, it was forbidden to use flood irrigation; to allow water to escape or seep; to steal or forcibly seize water; to accumulate water at the head of the fields; to flood the land and cover the roads; or to apply water unevenly (NTSL, 4/1964, p. 14).

6.35 There are only two references in the literature to a penalty other than depriving a unit of its water allotment. One was in a description of the North Huimin Canal (Hebei), which provided for a fine of 40 labor days (at this project, water fees were levied mostly in labor and materials) for those who used water without permission, and the persons responsible for the units concerned were to be criticized at the irrigation district congress. It was claimed that this had "basically eliminated the unauthorized use of water" (Renmin ribao, 13 December 1963, p. 2). The other reference was to a penalty that occurred in one of the brigades of Shaoshan Irrigation District:

... during the drought of 1978, a factory worker returned home to visit relatives and on two successive evenings privately opened the canal distribution pipe so he could fish. This wasted several hundred cubic meters of water. After the incident was discovered, the worker was criticized and educated, but he was not open to mending his ways, so the brigade Party branch ordered him to write 100 self-criticisms and to pay 10 yuan for the wasted water. This handling of the case rocked the entire commune, with very good results. (Shaoshan, 1979, p. 157)

6.36 The implications of the Shaoshan incident are that unauthorized withdrawals are common and that sanctions may not often be applied. It is particularly interesting that the culprit was a relatively well-paid "outsider." At Qianli (Sichuan) standing watch at the sluice gates to try to prevent people from blocking or releasing water on their own volition was termed guarding the "dragon's den" (Yikao, 1973, p. 66, in Nickum, 1981, p. 195).

6.37 There is no reference in the case studies to the existence of bribery. An allusion to it appeared recently in Renmin ribao, 12 December 1980, p. 2: "Sometimes the production teams cannot purchase the means of production, sell agricultural and sideline products or use water and electricity without providing entertainment and gifts [to state organs, departments, enterprises or units]."

6.38 Other abuse of privilege by people in positions of authority is implied, however, in the reporting of instances such as the following:
... This year, when some responsible comrades of the xian Party committee went to work in the fields, they found that the maize planted by their organ was stricken with drought and asked the Unified Management Committee to release some water. The comrades of the branch canal committee investigated and found that there was still adequate soil moisture and told the responsible comrades of the xian Party committee in person that they could not supply them with water. (Renmin ribao, 12 December 1963, p. 2.)

VII. CONCLUSIONS AND RECOMMENDATIONS

7.01 Generalizing about any aspect of the Chinese subcontinent is hazardous under the best of circumstances. In the area of water management, the available data base is narrow, selective and often conflicting. It covers projects which vary widely in size, ownership, history, location, energy source, degree of water scarcity and so on. As indicated in Appendix 3, a large majority of the case studies on which this report is based are owned and operated by the state whereas most of the irrigated land is watered by local collective-owned schemes. The North China Plain is virtually unrepresented by the case studies, yet it is the focus of great concern in water management, especially in the context of the potential effects of large-scale water diversion from the Chang Jiang (Yangtze). Impressive accomplishments have been achieved by the Chinese in their development and management of water. The case studies are only part of the testimony thereto. Yet there are continual and widespread complaints in China of unsound (or even nonexistent) management and of low water utilization rates.

7.02 The best PRC irrigation districts appear to operate very much like the oft-praised irrigation associations of Taiwan, albeit with a lower component of technical expertise. Water is recognized as a scarce factor which should be paid for and carefully husbanded, there are good two-way information (and possibly control) systems between managers and users of water, and irrigation is linked to crop requirements.

7.03 On the other hand, the PRC appears to have its share of the management problems listed by Bottrall for other parts of Asia:

... headreach farmers [in China, collectives] exceeding their water quotas, using water wastefully and leaving tail-enders short ...; illegal piping of water, obstruction of channels, etc., together with ineffective penalty mechanisms ...; low overall water use efficiencies ...; neglect of [operations and maintenance] in favor of new construction elsewhere ...; low water rates ...; weak agricultural extension and poor liaison between agricultural and engineering staff. 1/

Specifically, the following dysfunctions are common in the North China Plain (and probably throughout the PRC):

(a) Those in the upper reaches use too much water, while those in the lower reaches do not receive enough.

(b) Good results are achieved in experimental areas, but the peasants do not adopt the methods developed there. In particular, the peasants tend to feel that field drainage facilities are too expensive.

(c) There are too few irrigation management personnel for the area covered, and they are inadequately funded. Technical capabilities are weak at the county and village level. Repairs are frequently not made in time.

(d) Human actions and inactions have led to the spread of secondary salinization in some parts of the North China Plain due to the raising of the water table. Among the factors involved are the following:

(i) Because of the lack of ancillaries, improper design, poor construction, uneven land, flood irrigating techniques and seepage, the effective rate of utilization of canal systems is very low, usually below 0.4 for a new irrigation district. Seepage along the main and branch canals is particularly serious, although field losses are also significant. Among the sites we visited, seepage rates are 45% in the long-established People's Victory Canal system, which is large and flows through sandy soil; and over 50% in the channels of the Shijin Canal system.

(ii) The area watered by each cubic meter per second is too vast, up to 2,000 hectares. This means that water is in the main canals for up to 300 days a year, keeping the nearby water table high.

(iii) Some places irrigate too heavily and too often, applying up to twice as much water per season as is necessary for high yields.

(iv) Irrigation is emphasized to the neglect of drainage. Sometimes canals even cut off the natural drainage routes.

(v) Secondary and tertiary delivery systems are lacking. In Shandong's Dezhou Prefecture along the proposed eastern route, for example, only 10% of the irrigated acreage is served by a four-level canal system.
(vi) Cropping plans do not match water availabilities. 1/

7.05 An additional problem, but one with promise, is that the PRC is in the midst of the greatest transformation in its rural institutions in over 20 years. This makes it especially risky to extrapolate about the nature of China's water management, even on the basis of recent historical data. Yet at the same time this is an appropriate moment to sum up past experiences as a guide to future investigations and actions. 2/

7.06 In light of all these considerations, any conclusions presented there are perforce tentative or at a high level of generalization. They should be considered a first approximation to be refined in the course of future investigations, preferably including in-depth multidisciplinary field research.

7.07 In my original research paradigm for this report, I formulated a number of working hypotheses to guide my analysis of the Chinese materials. In the following pages, I use these hypotheses as a means of structuring some summary observations on PRC irrigation management.

**Hypothesis 1.** Larger projects require more organizational layers, greater specialization of function and more professional expertise (e.g., engineers).

7.08 Although larger projects do have more layers, the number is less than proportional to the area covered. Even the very largest irrigation districts appear to have no more than three professional levels.

7.09 Larger projects do tend to be more finely subdivided organizationally. In many large multipurpose projects, specialization appears to lead to fragmentation, with many masters at various levels in the political hierarchy.

7.10 Larger projects appear to be more able to acquire professionally trained staff, including engineers. This is because they belong to higher levels of administration which may make a claim through the state labor bureaus on the very limited (but poorly allocated) pool of academically trained personnel. The technical capabilities of basic-level staff are quite limited.

**Hypothesis 2.** The larger the project, the greater the problems of internal coordination and of accountability of management to end-user (evidenced by water use below the designed capacity).

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1/ James E. Nickum, "Institutions and China's Long-Distance Water Transfer Proposals," to appear in a volume edited by Zuo Dakang, Liu Changming, Asit Biswas and James E. Nickum. Primary references have been deleted.

2/ Interestingly, some features of irrigation management during the period covered by this report which were relatively unique at the time among PRC institutions are in accord with the recent reforms. These include in particular the specialization of function with earmarked budgeting and "economic responsibility" for much of the management body.
7.11 The evidence is mixed on water utilization. A significant number of both large and small projects appear to operate below capacity (this raises the question of the realism of the capacity ratings). Of the smaller projects, tube wells and possibly pumping stations are particularly prone to suboptimal utilization. This is probably due to financial and skill deficiencies, poor spare parts supply and the frequent lack of designated management personnel for collective-owned water installations.

7.12 High-level Chinese engineers indicated to me that while water utilization rates are generally not satisfactory for larger projects, they are better than in collective projects. This is surprising, since the burden of opinion among analysts of non-PRC areas is that smaller projects are generally more efficient within their constraints. Perhaps these constraints (such as more primitive technology) are not given adequate consideration in the PRC. Certainly the relative efficiency of large and small, state and collective schemes is a matter which bears further investigation.

7.13 As for the general problem of accountability, the Chinese model descriptions concur with Coward's observation cited in chapter IV that the "style of articulation" needs to change from an "agency-directed" scheme to one actively involving the water users in providing information, labor and management skills. The model units have succeeded, by and large, in providing water users with active roles (in PRC parlance, "relying on the masses"). Yet other evidence suggests that "agency direction" is so imbedded in the PRC institutional system as to be surmountable only on a case-by-case basis, or possibly via large-scale and general organizational reforms such as are being attempted at present.

Hypothesis 3: Projects with more mechanical or technical components do not require more organizational layers, but do necessitate greater specialization and more professional expertise. This adds to the potential for alienation between management and end-user.

7.14 The first part of this hypothesis appears to be true, although not very interesting per se. The second part is quite possibly false, for two reasons.

7.15 One reason is that projects with more mechanical or technical components tend to have higher operating costs and therefore greater water fees. This makes management more dependent on end users than in gravity schemes with more elementary technology, and therefore perhaps less alienated from them. Mitigating factors include state subsidy, which is total in some cases such as the Jiangdu Pumping Stations (in Jiangsu), and multiple operations. In addition, multipurpose projects such as Shaoshan rely primarily on fees levied on nonagricultural end-users.

7.16 The second reason works the other way. The level of alienation between at least some production teams and virtually all higher level administrators, even those as close as the production brigade, may be high enough to defy exacerbation:
In [the three-tiered commune system] there is a contradiction between ownership and management rights which is evidenced as follows.... [Although] the production team is managed independently and is responsible for its own profit and loss, the commune and brigade cadres can order it about. If their direction is mistaken and causes losses, they do not bear any economic responsibility. In particular, cadres at the commune level are appointed by the state and paid wages by it, yet they are to look after the affairs of the collective economy. More often than not they are responsible only to the state, that is the higher levels, so they are quite prone to direct things blindly. (Jingji guanli [Economic Management], 1/1981, p. I-12.)

7.17 The separation of water management from the unified state budget may make its personnel more dependent than most cadres on the end-users for their income, at least in the smaller state-run districts. Nonetheless, they have to work through the existing Party and administrative structures to ensure compliance (see below).

Hypothesis 4. Projects which are subdivided for operations and maintenance along lines other than that of the basic administrative structure (especially xian, commune, production brigade) place a greater administrative burden on project management and have difficulties in obtaining user compliance. Projects which are subdivided along basic administrative lines tend to have more conflicts over water use and their maintenance burdens are not shared equitably.

7.18 The discussion and examples presented in chapter IV indicate the validity of this hypothesis. Decentralization of maintenance to "mass organizations" which are coterminous with the administrative structure allows more people to be used in management (because they are paid in work points) and is said to improve the self-reliance and sense of responsibility of the lower-level units. It also undoubtedly leads to more direct day-to-day involvement by local Party and government units.

7.19 On the other hand, the case of Chaoyang xian presented at the beginning of chapter IV indicates that total decentralization may lead to irrational water distribution and irregularities in fee collection. The Qianli project in Sichuan "deprofessionalized" to channel-based "mass" committees. These provided a localized mechanism wherein downstream production teams could out-vote upstream teams in determining water allocations. This type of local organization does not appear to be widespread, however. Nonetheless, there appears to be a tendency to decentralize maintenance and sometimes water release along administrative lines (e.g., Shaoshan and Yeyuan).

7.20 In virtually all of the cases considered, the terminal agricultural water-using unit was either a production brigade or team (or in a very few cases, a state farm). This runs counter to most "traditional" Asian irrigation systems, which are channel-based (Coward, 1980, pp. 208-210). It is probably
also at variance with pre-1949 Chinese systems as well. 1/ The use of existing village administrations at the most basic level may lead to an excessive cellularity which compounds the difficulties of coordinating the use of a water system.

**Hypothesis 5.** A larger staff allows greater centralization; a smaller staff requires greater decentralization.

7.21 This issue only came up in the context of determining who is to maintain the main structures. In those discussions (e.g., Shaoshan, Meichuan), the reverse line of causation appears to hold: greater centralization requires a larger staff. Even relatively large professional management staffs have encountered difficulties performing maintenance chores in the absence of a mass component (see chapter IV).

**Hypothesis 6.** The responsiveness of project staff to user demands is directly related to the proportion of project income collected from water fees.

7.22 This is probably true. Unfortunately, the materials consulted provide no evidence on it one way or the other.

7.23 Other factors involved in the responsiveness of individual staff members include their skill levels and job incentives. The evidence, mostly indirect, is not very encouraging in these regards.

7.24 Quite frequently, irrigation district management staff do not appear to have previous training or even experience in water management. If they are like workers elsewhere in the PRC economy, they probably also have little prospect for advancement and little risk of being dismissed—the worst of both worlds from the standpoint of motivation. Remuneration levels appear to be low, even in the professional management structure. The occupation appears to have low prestige. There is a tendency, even in the mass management organizations, for crew members to become "divorced from [field] production."

7.25 Recent reforms may have improved matters somewhat, although little information is available. Further investigation into staff origin, training, remuneration, career prospects and attitudes may be necessary to develop an understanding of the nature of irrigation management and its prospects.

**Hypothesis 7.** Part-time staff are vulnerable economically and therefore open to corruption and extortion.

7.26 In the PRC, state enterprises often hire off-list part-time staff as a way of holding down the wage bill and the number of workers reported while retaining flexibility in operation. Because it is a grey area, not

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1/ Ramon H. Myers, "Economic Organization and Cooperation in Modern China: Irrigation Management in Xing-tai County, Ho-bei Province," in *The Policy and Economy of China* (Tokyo: Toyo Keizai Shinposha, 1975), pp. 189-212, argues that interfamily cooperation independent of village leadership was characteristic of sites with intervillage irrigation works.
always officially condoned, little appears in the literature on the use of part-time labor. This applies to irrigation management as well (here referring to the professional bodies—"part worker, part peasant" mass management personnel are quite legitimate). The only significant reference to part-time staff which I have found is one line from a description of a corrupt director of a state-owned pumping station in Anhui Province who "told part-time station workers to deliver hog feed to his house" (FBIS, 17 April 1978, p. G 2). In this case, however, part-time workers appeared no more vulnerable than the other station workers who were ordered to make doors, windows and pot covers for the director's house.

Hypothesis 8. The collective system permits decentralization of decision making with intravillage equity of water distribution. It does not per se relieve the problem of intervillage inequity. The integration of economic functions in a collective facilitates information flows and basic-level coordination.

7.27 The first part of this hypothesis is almost true by definition. "Almost" because even within a collective there are various possibilities for actual land use, as has been demonstrated in the latest reforms in the "rural responsibility system." In some cases, specific plots of land have been contracted to small groups or even households for a number of years. This has the potential for leading to inequities of water distribution within a given production team. Recent intrateam water disputes have been revealed (Renmin ribao, 7 July 1981, p. 2). Areas with developed water conservancy facilities appear to have been less likely than others to subdivide land use, however.

7.28 There was no indication in the literature of the presence of conflicts over water distribution within a given production team. Neither was reference made to conflicts between production teams within a given production brigade or village, although it would not be surprising to find some in practice. There are a number of cases mentioned of conflicts between "upstream" and "downstream" and between villages. As noted previously (in the discussion of Hypothesis 4), the village-based subdivision of the people's commune system may, if anything, intensify the potential for intervillage inequity and place a greater burden on coordinating organs.

7.29 Recent criticisms indicate that the integration of economic and administrative functions in a three-tiered collective has led to excessive bureaucratism in the collective sector. The lack of accountability of brigade and commune level cadres was noted in para 7.16. The two higher collective levels are also accused of extracting labor, financial and material resources from the production teams to build up their own economic enterprises and heavily staffed contingents of "managers" and "specialized technicians," "most of whom are actually young commune members who got their jobs through connections and who are sometimes even illiterate" (Jingji guanli [Economic Management], 1/1981, pp. I-10 to I-13). In this kind of a collective system, information flows appear to be verticalized nearly as much as in the state-planned economy. The capacity of the higher levels of collective to interfere
In the economy of the production teams and "equalize and transfer" their resources could also be used beneficially to coordinate the allocation of water between teams, but it is not clear that this has been the case.

**Hypothesis 9.** The ability of a management organ to impose and enforce rules is linked to its connection with the regular Party and governmental apparatus.

7.30 This point is continually stressed, and rightfully so, in the literature. A typical but especially clear and concise example is that of the commune-operated Jiulong Reservoir in Jiangxi Province:

... The commune Party committee pays utmost attention to reservoir management work and regularly enters it on the committee's daily agenda.... The committee forcefully supports the work of the reservoir management office and fosters its prestige. When problems arise, the Party committee lets the management office handle them and backs it up. The management office is responsible for solving problems of irrigation district project maintenance and repair and water use disputes. At the same time the commune Party committee regularly convenes various kinds of meetings of cadres to induce upper and lower reaches to yield to each other and to educate them to observe the water use system. The Party committee regularly improves the ideological education of the staff of the management office while tending to the solution of some of their problems of livelihood so that they can work with their minds at ease [emphasis added]. (NTSL, 3/1964, p. 28.)

7.31 The functional separation of water and agriculture noted in chapter III, in combination with the notorious "departmentalism" of China's bureaucracy and the reliance on existing administrative boundaries at the basic levels to govern irrigation management, means that proper water management must rely on certain coordinating agencies, in particular the Party and the democratic management committees. Of these, the Party is the most important, as the above citation indicates.

7.32 Even where irrigation management is financially self-reliant, it is necessary to have the active participation of the Party in coordinating divergent interests and enforcing discipline, for the Party has had a virtual monopoly of authority in the PRC except for a short period during the Cultural Revolution when it was in disrepair. This has made the question of the "agenda" extremely important, since limitations of time, information and policy have restricted the number of areas to which the Party committees can turn their attention.

7.33 Recent reforms have aimed at retaining the ultimate primacy of the Party in policy making and implementation while allowing greater specialization and freedom of decision making by economic units such as industrial enterprises and production teams. To the extent that these changes eventuate in the depoliticization of decision making at least for those items off the Party agenda, it may be possible for the professional management of an irrigation district to forge more direct links with the terminal users.
7.34 On the other hand, it is unlikely that water allocation or project maintenance will become purely economic or technically administrative processes. A good coordinating authority with vertical and horizontal linkages of communication and control will be necessary.

7.35 One non-Party organizational mechanism already exists which, at least in the larger case studies, plays an important role in coordinating the efforts of different interested parties and which provides a forum for communication. This is the "democratic management" structure of congresses and committees. This is an existing non-Party source of formal authority over the use of the waters of a given irrigation district.

7.36 Nonetheless, the actual role of the present democratic management bodies is unclear. The experience elsewhere in the PRC polity is that the executive organ tends to dominate the proceedings and decision making of similar "legislative" bodies. At Shaoshan, for which we have the greatest amount of detail on the democratic management bodies, the irrigation district congress and management committees are limited in a number of important ways. They have little say over the choice of their ex officio leadership; they are "top heavy" with higher-level officials; and they do not include members from the agricultural departments. They do seem to be an important channel of multilateral communication, but one which may be open to improvement through such means as the free election of officers.

Hypothesis 10. There is no single optimum rule for administrative allocation of water.

7.37 On the face of it this hypothesis is self-evident. My purpose in using it was to investigate the conditions under which different rules are adopted. This exploration occupies the largest part of chapter VI. Here I will only raise a couple of points about the specific sequencing rules for surface schemes when they have been presented in the literature. Their most remarkable feature is their similarity. Their primary determinants are the relative scarcity of water (establishing continuous vs. proportional vs. rotational distribution) and the objective of even distribution of water. The latter is expressed in "first/later" slogans which undoubtedly serve well in a situation where many of the water releasers are illiterate or semi-literate. Equitable allocation requires the centralization of water rights in the hands of the professional management structure. In addition, special consideration appears to be given to the allocation rights of prior users in areas with previously existing irrigation.

Hypothesis 11. The problem of matching water supply to cropping patterns is reduced but not solved by state and collective planning of major field crops.

7.38 One distinctive feature of by far most of the case studies is that the water is provided to monocultures at any given time of the year, although there are usually at least two crops grown over the course of the year. At Yeyuan the cropping system was simplified after the introduction of irrigation.
Until the past two years, crops in the collective sector were grown according to a state-determined plan. Greater freedom by the production teams to determine cropping may have made water supply more difficult in some areas, although rice, wheat and cotton remain the predominant crops.

7.39 Most of the model units have investigated the differing water requirements of local crops over their entire period of growth. One problem appears to be to elicit mass compliance in the scheduling. For example, at Meichuan, "frequent, shallow watering" of rice encountered resistance from those who were concerned about the additional weeding which would be necessary.

Hypothesis 12. Water rights tend to be appropriative in nature and are therefore likely to lead to inefficient decision making.

7.40 "First in time, first in right" appears to apply in the PRC as elsewhere, although these rights can be mitigated somewhat by centralization when they create conflicts between an individual user and an entire system. As noted in chapter III, rights to water use are not very clear at the macro level, leading to a call for new laws. At a project level, however, existing guidelines appear to provide a clear and reasonable set of water rights principles. More important than the water rights per se is the means of adjudicating conflicts over water use. This has hitherto been done administratively in the PRC. The formal legal and court system is still aborning.

Hypothesis 13. Economic incentives are relied on at least as extensively as in noncollective systems, and perhaps more so.

7.41 The evidence on this is mixed, as noted in chapter V. Some places (for example, Jiangdu Pumping Stations in Jiangsu) do not charge, even for pumped water. In general, charges do appear to be more likely and higher for pumped water than for that delivered by gravity. Charge levels reported are nonnegligible although it is not clear how high the collection rates are.

7.42 It is not mentioned in the literature consulted, but certainly one factor involved in a production team's willingness to pay for water fees is the return it receives in grain. Grain prices are set by the state at a relatively low level and are not enough to cover costs in marginal growing areas. Further investigation into the financial and social productivities of water should prove to be fruitful in assessing irrigation management.

Hypothesis 14. Volumetrically based water charges elicit more efficient on-field application than fixed charges, but have significant other costs (e.g., higher variance, metering).

7.43 As noted in chapter V, volumetric pricing bases are widely considered in the PRC to be a means of reducing waste in irrigation, but they do not appear to be common, except perhaps in the water-rich southeast. Usage-based pricing is more likely to be used for pump irrigation and for nonagricultural water utilization. Volumetric pricing appears to be a useful supplement to
good organizational management, but it is definitely not a substitute for it. For example, many of the collectively owned projects such as tubewells have costs which increase with usage, yet their management is considered to be especially poor.

**Hypothesis 15.** The most successful instances of water management are those which integrate the principal project components with those owned by the beneficiary units. To function well, such a system requires a high degree of communication and a good correspondence of objectives between the professional management and the end-users.

7.44 This hypothesis appears to be true. Most of the leading model cases have set up such "melons on a vine" systems when topographic conditions allow. The degree of direct communication between professional project management and end-user appears to diminish with the size of the irrigation district and the specific form of arrangements made appears to vary from project to project. A common feature of the descriptions in the literature, however, is the dovetailing of objectives of the professional management (expanding the total water supply) and those of the end-users (security of water supply), usually through some sort of specification of the rights of the latter. Further specifics may be found in chapter VI.

**Hypothesis 16.** The collective system has allowed rapid development of tubewell irrigation without exacerbating intravillage income or tenancy differentials. Planned conjunctive use of surface and groundwater by a professional management body is rare.

7.45 The first part of this hypothesis is almost true by definition, although the rapid expansion of tubewell irrigation which occurred in the early 1970s on the North China Plain was also prompted by significant state subsidy. The second part of the hypothesis is not true. Yinjing, Yeyuan and to some extent the Renmin Shengli Canal in Henan, all report some integrated development of both kinds of water sources. On the other hand, the scope for further joint development of surface and groundwater appears to be significant, especially on the North China Plain. 1/

7.46 As befits the subject matter, these hypotheses cover a wide range of territory. The case studies and recent revelations have provided some answers but more importantly, they have given some focus to areas which need to be investigated further. A far from comprehensive list of these is the following:

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1/ Pingyuan jing guanqu dixia shui kaifa liyong [The exploitation and utilization of groundwater in plains well irrigation districts] (Beijing, 1977, pp. 24-25) lists many of the problems that have been encountered in this region when irrigation districts which have the proper conditions for combining wells and canals rely exclusively on the one or the other.
(a) The reasons why local projects are not better run. This includes investigating how well they are operated in light of external conditions and specifying what those constraints are, including the pricing system (affecting the returns to field crops), the availability of manufactured inputs such as spare parts, and the nature of Party and government involvement.

(b) The technical level of managers at various levels and the possibilities for technical training or, alternatively, the possibilities for selecting technologies which are relatively low in their requirements of special skills.

(c) The impact of recent reforms in the rural "production responsibility system" on irrigation management.

(d) The relative efficiency of irrigation schemes of various sizes and levels of ownership.

(e) The relationship between technical design and organization in irrigation management.

(f) Staff origin, prior training, remuneration, career prospects and attitudes.

(g) The actual role of democratic management organizations and possible improvements therein to make the leadership more accountable to the terminal users and to integrate irrigation and agriculture.

(h) The financial and social returns to (and costs of) irrigation and the degree to which these are reflected in the pricing system.
SOURCES CONSULTED

Case Studies

The most important collections of case studies consulted for this report are the following:

1. *Shuili guanli gongzuo jingyan huibian* [Collection of experiences in water management work] (Beijing, 1973) [SGG]. This is a collection of 18 case studies drawn from the materials presented at the National Water Management Conference held in December 1972. Of these pieces, six are on reservoir management, four on irrigation district management, four on gate management, two on embankment management and two on pump well management.

2. *Yikao qunzhong guanhao shuili* [Rely on the masses to do a good job in managing water] (Beijing, 1973) [Yikao]. This collection of 24 “experiences” is from the same period and is drawn largely from articles originally appearing in the official press, both central and provincial. The recounts are usually briefer than those in SGG, and each focuses on a limited number of management aspects, commonly in the context of some sort of problem-solving behavior.

3. *Nongtian shuili yu shuitu baochi* [Farmland water conservancy and erosion control] (July 1964 to October 1965) [NTSL]. Microfilm copies of all issues of this monthly journal are available from its inception to its apparent demise in the initial stages of the Cultural Revolution. One of the journal’s aims was to reduce inefficiency in irrigation management by providing practitioners in the field with information in the following areas: the construction and management of small-scale "farmland capital construction" projects; irrigation management (including the organizational and business management of an irrigation district, project operations and maintenance, water use management, watering techniques and experimental research); mechanical and electrical irrigation and drainage (including the "business management" of pumping stations); erosion control; and basic science and technology. In the 16 issues there are 19 articles on 17 different projects, plus a number of articles on instances of pump irrigation and drainage, regulations on irrigation management, and summaries of experiences in larger regions (e.g., the Qunzhong Plain in Shaanxi Province) and on specific topics (e.g., volumetric charges).

4. *Shaoshan Guanqu* [The Shaoshan Irrigation District], Vol. 3, Management of Operations (Beijing, 1979) [Shaoshan]. This 400-page volume is the final part of a series on the large, multipurpose Shaoshan Irrigation District and includes much useful and specific information on irrigation district management (organizational, financial, water use and project), reservoir control operations, farmland capital construction and scientific research.
5. *Yeyuan Shuiku Guanqu* [The Yeyuan Reservoir Irrigation District] (Beijing, 1977) [Yeyuan]. This is a shorter, less technical book describing a large reservoir-based irrigation district, part hills and part flatlands, which is known for its well-articulated organizational structure.

6. *Meichuan Shuiku Guanqu di guanli* [Management of the Meichuan Reservoir Irrigation District] (Beijing, 1974) [Meichuan]. This is the earliest of the three books which provide an extensive and detailed description of a single project. A full translation into English is available (Nickum, 1981, pp. 77-159).

In addition to the volume on Meichuan, a limited number of other readings have been translated and are published in James E. Nickum, ed., *Water Management Organization in the People's Republic of China* (Armonk, NY: M. E. Sharpe, 1981). These include an introductory piece from the manual *Guan’gai guanli*; two readings on Shaoshan; one each on Qianli Canal (Sichuan), Yinjing Canal, a Shandong floodgate, a section of the Huang (Yellow) River dike and on pump well development in a suburban Beijing xian; and copies of three regulations, on planned water use, water fees and water project management. Whenever these materials are referred to in the text, the translation is cited as well.

**Translation Services**

Materials in English have also been used from the following translation services:

- Chinese Economic Studies, published by M. E. Sharpe, Inc. (formerly International Arts and Sciences Press), Armonk, NY.
- U.S. Hong Kong Consulate, *Survey of China Mainland Press* [SCMP].
- British Broadcasting Corporation, *Survey of World Broadcasts* [SWB].

**Chinese Periodicals**

The following periodicals and collections published in China have contained materials used in the preparation of this report:

- China Reconstructs (in English), *Dili zhishi* [Geographical knowledge], *Guangming ribao* [Guangming daily], *Jingji yanjiu* [Economic research], *Kexue shiyan* [Scientific research], *Renmin ribao* [People's daily] and Zhonghua Renmin Gongheguo fagui huibian [Collection of laws of the People's Republic of China], Vol. 7 [Laws].
Manuals Referenced

Guan'gai yongshui guanli [Irrigation water use management] [GYC] (Beijing, 1974).

Shuili guanli [Water management] [SLGL] (Shanghai, 1975).

Zhou Zhiyuan and Liang Yongshun, eds., Guan'gai guanli [Irrigation management] [GGGL] (Beijing, 1965).

Other Materials Published in China

Bishihang Guanqu xinxin xiangrong [The Bishihang Irrigation District is thriving] (Beijing, 1977).

Changteng jiegua shi di ziliu guan'gai wang [Melons-on-a-vine type gravity irrigation networks] (Beijing, 1958).

Conquering the Yellow River (Beijing, 1978) (Huang Wei, author).

Guan'gai jihua yongshui shili [Examples of planned use of water for irrigation] [GJYS] (Beijing, 1958).

He Zhi, "Shui ziyuan di heli kaifa liyong ji dai jiejue" [The problem of rational exploitation and use of water resources urgently needs to be solved], Guangming ribao, 14 September 1979, p. 4.


Huanghe zaí qianjin [The Yellow River is moving forward] (Beijing, 1972).

Hua Zhuxi zai Hunan [Chairman Hua in Hunan] (Beijing, 1977).

Hongqi Qu [Red Flag Canal] (Beijing, 1976).

Li Changfang and Zhang Yichang, "Bian shuihai wei shuili di hongwei gongcheng" [A magnificent project which has changed water harms into water benefits], Guangming ribao, 28 October 1980, p. 2.

Li Yupu, "Cong jinnian nan lao bei han kan shui ziyuan di tiaojie liyong" [The regulation and use of water sources as seen from this year's flooding in the south and drought in the north], Renmin ribao, 29 October 1980, p. 2.

Pingyuan jing guanqu dixia shui kaifa liyong [The exploitation and utilization of groundwater in well irrigation districts in the plains] (Beijing, 1977).
Materials Published Outside the PRC


Abbreviations Used for References

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PROJECT DESCRIPTIONS

Notes: A full listing of sources cited is in Appendix 1.

15 mou = 1 ha.

Case Studies (listed by province)

ANHUI (AH) PROVINCE

1. Bishihang Irrigation District (BSH)

Location: Jinzhai, Huoqiu, Liuan, Feixi, Shucheng, Lujiang, Feidong, Changfeng and Hefei xian (counties) and shi (municipalities) in Anhui Province, plus Gushi and Shangcheng xian in Henan Province; an area extending more than 13,000 km².

Data Sources: Bishihang; Huaihe xinpian, pp. 54-58; Guangming ribao, 28 October 1980, p. 2.

Irrigated Area: Designed area 10,960,000 mou, of which 8,000,000 mou now irrigated, but only 5,000,000 mou guaranteed (1980); 8,000,000+ mou, of which 90% gravity (1975); 4,000,000+ mou (1966); 2,200,000 mou (1962); 970,000 mou (1959).

Project Components: 5 large reservoirs, with a total catchment area of 6,400+ km² and a capacity of 6.5 billion m³; 3 large irrigation networks, with a total daily capacity of 47+ million m³; 13 feeder and main canals totaling over 1,000 km; 358 branch canals each irrigating at least 10,000 mou, totaling over 3,900 km; 80,000+ subbranch and farm canals, totaling over 42,000 km; 120,000+ canal system structures; 48 embankments 10+ m high; 900+ small counterregulating reservoirs and 200,000+ ponds; 500+ pumping stations; 40+ hydropower stations, total capacity 30,000 kw.

2. Guniubei Reservoir (GNB)

Location: Tongcheng xian


Irrigated Area: 185,000 mou (1972); 50,000+ mou (1964); 20,000+ mou (1962).
Project Component: Medium-sized reservoir, built 1962, capacity 74.7 million m³.

Grain Output: 180 million jin (90,000 T) (1971); 120 million jin (1963).

FUJIAN (FJ) PROVINCE

3. Dingxi Reservoir (DX)

Location: Tongan xian

Data Sources: Yikao, pp. 31-33 (orig., Fujian ribao, 12 June 1972); NTSL, 5/65, pp. 22-24.

Irrigated Area: 180,000 mou, of which 120,000 mou are stable, high-yield fields (1972); 110,000 mou, of which 20,000 mou gave stable, high yields (1964).

Project Components: 13 reservoirs, each 100,000+ m³ capacity; 28,641 small works, including 314 big wells, 135 gates off of streams; 1,131 sets of mechanized (diesel) irrigation machinery, 72 of electrical.

Crops, yields: Paddy rice and peanuts. The xian grain yield in 1971 was 928 jin/mou (6.96 T/ha).

Remark: A "melons on a vine" system.

4. Dutang Reservoir Irrigation District (DT)

Location: Yunxia xian

Data Source: NTSL, 2/64, p. 7.

Irrigated Area: "Guaranteed" irrigated area went from 34,300 mou to 43,300 mou (no dates).

Project Components: Reservoir, built 1958, capacity 15,000,000 m³.

Remark: Declared FJ's provincial model 1 Apr 1964.

GUANGDONG (GD) PROVINCE

5. Dongyin Irrigation District (DY)

Location: Dongkuan xian; in 13 communes, 2 towns

Data Source: Dili, 8/77, pp. 6-7, 5.
Irrigated Area: 200,000 mou (design, but basically realized).

Project Components: East River Diversion Canal (Dongjiang Yinshui Yunhe), 100 km long, built Jan 1970-Mar 1971; 70+ gates, culverts, bridges along the canal; 1 experimental tidal power station.

Remarks: The article cited has a map of the project, which has three distinct sections. The text contains little on management.

6. **Heqi Reservoir (HQ)**

Location: Chaoyang xian

Data Source: NTSL, 2/64, p. 7.

Remark: Declared GD’s provincial model end Mar 1964; no details given.

7. **Leizhou Youth Canal Irrigation District (LZ)**

Location: Lianjiang, Suixi and Haikang xian, Zhanjiang shi, and parts of Huazhou and Wuchuan xian.


Irrigated Area: 1,400,000 mou (1973), up 200,000 mou in spring 1973 over previous year.

Project Components: Large Hedi Reservoir; 170+ km long Youth Canal; main and 4 distributary canals, 236 km long; turbine station for return flows; total flow 1.2 billion m³/ann.

Cropping: Rice, 1972 yield 700+ jin/mou (5.25+ T/ha); sugarcane, peanuts, radish, pepper.

**GUANGXI (GX) PROVINCE**

8. **Ling Canal (LQ)**

Location: Xing’an xian; passes through 4 communes.

Data Source: Yikao, pp. 49-51.

Irrigated Area: 32,300 mou (1972); 10,000+ mou (1966); 2,500 mou (early post-liberation).
Project Components: North Canal, South Canal, over 2000 years old; 1 water diversion dam; 1 diversion, 2 spill "balances," 28 turnout gates. Cultural Revolution (ca. 1966) to 1972, 25 canals were added, total 110+ km long; 20 aqueducts; 310 gates; 4 storage projects; 60+ small mountain ponds; 2 hydropower stations built by commune sector.

Cropping: A shift was made from single-crop rice to double-crop rice in the early 1970s. Grain yields: 950 jin/mou (7.125 T/ha) (1972); 849 jin/mou (6.3675 T/ha) (1971); ca. 500 jin/mou (3.75 T/ha) in the benefited area (1966); ca 300 jin/mou (2.25 T/ha) (1949).

9. Qingping Reservoir (QP)

Location: Binyang xian; in at least 9 communes.

Data Source: Yikao, pp. 28-30.

Irrigated Area: 160,000 mou (1972); 120,000 mou (original design, reached 1965).

Project Components: Reservoir, built 1958, with ordinary inflow equal to its effective capacity of 60,000,000 m³; since the Cultural Revolution, 42 barrages, 54 melon-on-vine ponds and reservoirs (capacity 15,000,000+ m³), 16 branch canals (612 km long), 1,162 turnout gates.

Crop Yields: Grain, 810 jin/mou (6.075 T/ha) (1972), 15% higher than in 1971.

HEBEI (HEB) PROVINCE

10. Xingtai Baiquan Spring District (BQ)

Location: Ren, Julu, Longyao and Ningjin xian; in 18 communes.

Data Source: Dili, 12/78, pp. 1-3, 11.

Irrigated Area: 390,000 mou (not clear if total or just the Heilonggang portion) (1978); after 1949 the irrigated area was expanded from several 10,000 mou to 200,000 mou, but salinization and marshification were serious.
Project Components: In 1975, they began to change the original spring-fed district into a well irrigation district, and then move the well water into a water-deficient area in Heilonggang, having resolved to do this in 1963. By 1978, they had enlarged 3 river channels for irrigation and drainage, dug 5 main "spring pits" and 75 gravity wells, and built 80+ structures and 57 main and branch canals.

Remarks: This article has a map, but no management details.

11. Huimin Bei Canal (HMB)

Location: Zhuolu xian; in 5 communes.

Data Sources: Yikao, pp. 78-83 (orig., Guangming ribao, 11 May 1973); Renmin ribao, 13 Dec 1963 (SCMP #3140).

Irrigated Area: 100,000 mou (1972); 110,000 mou (1963); 99,000 mou (1948).

Project Components: 7 main canals; 61 branch canals. From 1969 to 1972 the intake capacity was enlarged by 25 m³/sec over the previous 10+ m³/sec, and 229 wells providing 7+ m³/sec were dug.

Cropping: Rice has less than 20% of the area, requires over 50% of the water; consumption has been reduced from 1,200 m³/mou/ann. to 800 m³/mou/ann. Kaoliang, beans and rice are intercropped. Grain yields: 707 jin/mou (5.3025 T/ha) (1972); 701 jin/mou (5.2575 T/ha) (1971), up 10% over 1970; 492 jin/mou (3.69 T/ha) (1968).

Remarks: This project is 500 years old. Although it grows rice, it is north of the Great Wall.

HENAN (HEN) PROVINCE

12. Baisha Irrigation District (BS)

Location: Yu xian

Data Source: NTSL, 9/65, p. 32

Project Components: Canal, built in 1955.
13. **Dandong Irrigation District (DD)**

**Location:** Boai xian; in 8 communes, 156 to 165 brigades.

**Data Sources:** NTSL, 10/65, pp. 16-18; NTSL, 4/64, pp. 14-16.

**Irrigated Area:** 169,000 mou effectively irrigated, 114,000 mou guaranteed (no date); 30,000 mou before 1949.

**Project Components:** Yueshan Reservoir on upper reaches; feeder canal; 15 branch canals.

**Crop yields:** Grain, 610 jin/mou (4.575 T/ha) (1963); 710 jin/mou (5.325 T/ha) (1957); maximum before 1949 was about 250 jin/mou (1.875 T/ha). In 1965 wheat was grown on 130,700 mou, with a single-crop yield of 341 jin/mou (2.56 T/ha).

**Remark:** This is an "ancient" irrigation district.

14. **Hongqi (Red Flag) Canal (HQ)**

**Location:** Lin xian, with headworks in Pingshun xian, Shanxi Province and extension into Anyang xian (managed separately).

**Data Sources:** Nickum, 1977, pp. 83-95; Hongqi Qu, 1976.

**Irrigated Area:** 600,000 mou for the system, ca. 470,000 mou for the canal (1974).

**Project Components:** Built Feb 1960 to Jul 1969: 6.4 m high overflow diversion dam; 70 km trunk canal, Q=25 m³/sec (finished 5 Apr 1965); 3 branch canals, total 203 km (finished 20 Apr 1966); 500 auxiliary canals, total ca 1,230 km; 300+ reservoirs; 134 tunnels, total length 24 km; 150 aqueducts, total length 6.5 km. Included in the system are the Hero (Yingxiong) Canal, Q=8 m³/sec, built Dec 1957 to May 1958, and 3 large reservoirs, built during the Great Leap Forward.
Crops: Wheat, maize, millet, sweet potatoes, beans, rice, cotton, peanuts, sesame. Wheat-sown acreage in the xian is ca. 520,000 mou in the xian; rice acreage expanded from 2,300 mou in 1969 to 12,300 mou in 1974; cotton acreage is ca. 50,000 mou. Annual grain yields: 638 jin/mou (4.785 T/ha) (1974); 516 jin/mou (3.87 T/ha) (1971); 468 jin/mou (3.51 T/ha) (1966); 410 jin/mou (3.075 T/ha) (1964); 334 jin/mou (2.505 T/ha) (1958); 220 jin/mou (1.65 T/ha) (1949).

15. Nanwan Reservoir Irrigation District (NW)

Location: Xinyang shi, Xi and Zhangyang xian.

Data Source: Huaihe Xinpian, pp. 26-27.

Irrigated Area: 800,000+ mou (1975).

Project Components: Reservoir, built in early 1950s, with 1,058 km² drainage basin; 2 large main canals (south, north), built after 1959; thousands of main, branch, subbranch, farm canals, total length 2,300 km; 1,600+ structures; 60+ electrical irrigation stations; hydropower station at reservoir (built 1958).

16. Renmin Shengli (People's Victory) Canal (SL)

Location: Wuzhi, Huojia, Yuanyang, Yanjin xian, Xinxiang shi; in 25 communes.

Data Sources: Yikao, pp. 52-55 (orig., Henan ribao, 25 Oct 1972); Huanghe zai qianjin, pp. 6-7; Conquering the Yellow River, pp. 77-78.

Irrigated Area: 600,000 mou (1978, 1972).

Project Components: Canal (built 1951 to May 1953); irrigation and drainage network, 7,500 km total length; 3,000+ pump wells (1978); 6 branch canals. The trunk canal is 50 km long.

Crops: Wheat, cotton, corn. Annual grain yields: 850 jin/mou (6.375 T/ha) (1974); 616 jin/mou (4.62 T/ha) (1971); 177 jin/mou (1.3275 T/ha) (before irrigation); 70-80 jin/mou (0.525-0.6 T/ha) (before 1949). Annual cotton yields: 106 jin/mou (0.795 T/ha) (1971); 29 jin/mou (0.2175 T/ha) (before irrigation); 10-20 jin/mou (0.075-0.15 T/ha) (before 1949).
17. Taohuadian Reservoir (THD)

Location: In the southern part of Yanshi xian.


Irrigated Area: 21,000 mou (1972); original design, 15,000 mou.

Project Components: Reservoir, catchment area 230 km², capacity 18,800,000 m³, of which effective is 6,900,000 m³; 5 km-long canal linking reservoir with Yidong Canal, diverting 8 to 12 million m³/ann. into the reservoir.

Crops: Wheat, cotton.

HUBEI (HUB) PROVINCE

18. Meichuan Reservoir Irrigation District (MC)

Location: Guangji xian

Data Sources: Meichuan; Yikao, pp. 19-23 (orig., Renmin ribao, 23 Mar 1973); KXSY, Mar 76, pp. 23-25; SGG, pp. 24-29.

Irrigated Area: 120,500 mou (1974); 120,000 mou (1973); 115,000 mou (1971, 1972); 107,000 mou (1970); ca. 48,000 mou (1968); 80,000 mou (1967); 96,000 mou (1966); 93,000 mou (1962, 1963); 85,000 mou (1961); 50,000 mou (1960); 45,000 mou (1959). The planned area was 70,000 mou. There is a total of 126,000 mou of farmland within the Meichuan district.

Project Components: Meichuan Reservoir, built Aug 1957 to Jan 1959, total capacity 35,000,000 m³, beneficial capacity 27,000,000 m³, average beneficial storage 16,000,000 m³; 2 main canals (east, 31 km long; west, 30 km long); total canal length from mains to field: 646.5 km; 5 Type I small reservoirs (1,000,000-10,000,000 m³); 16 Type II small reservoirs (100,000-1,000,000 m³); 5,983 ponds, storing 12,880,000 m³ (1974).
Crops: 106,000 mou of double-crop rice, requiring ca. 3/500 m\(^3\) of water per mou per annum; up to 20,000 mou of cotton; some triple cropping: wheat, rice or oilseeds, rice. Annual grain yields: 1,026 jin/mou (7.695 T/ha) (1973); 910 jin/mou (6.825 T/ha) (1972); 1,017 jin/mou (7.6275 T/ha) (1971); 871 jin/mou (6.5325 T/ha) (1970); 769.4 jin/mou (5.7705 T/ha) (1967); 687.1 jin/mou (5.153 T/ha) (1962); 547.7 jin/mou (4.108 T/ha) (1961); 591.6 jin/mou (4.437 T/ha) (1960); 503.1 jin/mou (3.773) T/ha (1959); normal before the project ca. 400 jin/mou (3.0 T/ha).

Remarks: A national model. Has "melons on a vine."

19. Silong Reservoir (SL)

Location: Yingcheng xian


Irrigated Area: 13,000+ mou (1972); originally, 8,000 mou.

HUNAN (HUN) PROVINCE

20. Ouyang Hai Irrigation District (OYH)

Location: 5 xian and shi in southern Hunan.

Data Source: Hua Zhuxi, pp. 36-46.

Irrigated Area: 720,000 mou.

Project Components: Double-arch, thin concrete dam (first in China--high technology, saves on building costs); 650 structures (e.g., aqueducts, tunnels, siphons); 4 electrical pumping stations. Built between Oct 1966 and summer 1970.

Remark: "Hunan's second largest water conservancy project."

21. Qianjin Reservoir (QJ)

Location: Qianjin Commune, Shuangfeng xian.
Data Sources: SGG, pp. 30-45; Yikao, pp. 14-18 (orig., Hunan ribao, 26 May 1973); NTSL, 2/64, p. 7; NTSL, 7/65, pp. 6-7; Shuili guanli, pp. 10, 12-16; Renmin ribao, 16 April 1964.

Irrigated Area: 7,684 mou (1972); 6,421 mou (1963); 1,700+ mou (1954); designed for 4,400 mou.

Project Components: Small reservoir, built 1954, catchment area 3-4 km$^2$, capacity 720,000 m$^3$; 3 smaller reservoirs, total capacity 980,000 m$^3$; 2 main canals (south, north), 20 branch canals, 48 km total length; numerous mountain ponds (over 400); over 85 river barrages; total pond catchment area 20+ km$^2$; 11 km in canals added in 1964.

Crops: Mostly double-crop rice, with a small amount of mid-season rice. The cropping and water requirement plan in 1972 was: early rice, 7,016 mou (367 m$^3$/mou); mid-season rice, 52 mou (414 m$^3$/mou); late rice, 7,672 mou (421 m$^3$/mou). Annual grain yields: 1,280 jin/mou (9.6 T/ha) (1972); 1,170 jin/mou (8.775 T/ha) (1970); 1,000+ jin/mou (7.5 T/ha) (1967); 800+ jin/mou (6.0 T/ha) (1966); 660 jin/mou (4.95 T/ha) (1964); 601 jin/mou (4.51 T/ha) (1963); 300-400 jin/mou (2.25-3.0 T/ha) before the reservoir.

Remarks: A national model in the middle 1960s. Has "melons on a vine."

22. Shaoshan Irrigation District (SS)

Location: Shaoshan, Xiangxiang and Xiangtan xian; Ningxiang, Changsha and Xiangtang shi; Shuangfeng xian (the reservoir district); in 83 communes.

Data Sources: SGG, pp. 69-78; Hua Zhuxi, pp. 25-35; China Reconstructions, Oct 1977, pp. 9-12; Renmin ribao, 24 Jan 1977 (FBIS, 1 Feb 1977, pp. E6-8); Yikao, pp. 56-59; Shaoshan, Vol. 3.

Irrigated Area: 1,000,000 mou (1976); 830,000 mou (1972); 400,000 mou (1966).
Project Components: Yangtang Diversion Dam on the Lianshui R. (can divert 46 m³/sec) (built 1 July 1965 to Apr 1966); navigable feeder canal, with 2 main canals (south and north), 240 km total length; branch canals with total length 1,600-2,520 km; 193 electrical pumping stations, total capacity 10,000+ kw; 100,000 mou surface area of ponds and reservoirs; a 1,500 kw. hydropower station at Yangtan; 183 km of flood dikes along the Lianshui, plus 60+ km flood diversion canals, freeing 150,000 mou from flood.

Crops: Rice, cotton, oilseeds, tea, fish, Hunan lotus. Double-crop rice area went from 20% in 1965 to 95% of the farmland in 1976. Annual grain yields: 1,100 jin/mou (8.25 T/ha) (1976); 1,000+ jin/mou (1973); 957 jin/mou (7.1775 T/ha) (1971); 800+ jin/mou (6.0+ T/ha) (1970); 480 jin/mou (3.6 T/ha) before construction.

Remarks: The village of Shaoshan is Chairman Mao Zedong's hometown. The director-general of the project construction was Hua Guofeng, Chairman Mao's successor. The Shuifumiao Reservoir upstream is not part of the irrigation district, but appears to regulate the flow of the Lianshui.

23. Shizhu Reservoir (SZ)

Location: Hengyang xian; in 4 districts (qu), 14 communes, 1,180+ teams.


Irrigated Area: 92,000+ mou (1972); 82,000+ mou (originally).

Project Components: Medium-sized reservoir, capacity 21,500,000 m³, surface area 1,800 mou; 1 main (zhu gan) and 3 branch (zhi gan) canals, total length 84 km.; 2 hydropower stations, total capacity 248 kw; 5 electrical pumping stations.


24. Yachaochong Reservoir (YCC)

Location: Shimen Commune, Changsha xian.

Data Source: NTSL, 7/65, pp. 4-5.
APPENDIX 2
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Irrigated Area: 10,500 mou, of which 5,500 mou are stable, high-yield fields (1964); 3,000 mou of which 2,000 are stable, high-yield fields (1963); designed area, 5,000 mou.

Project Components: Small reservoir, built 1958, capacity 2,030,000 m³; 2 main canals, 5 branch canals, 240+ structures, built winter 1963-64.

Crops: Double-crop rice was 39% of paddy acreage in 1963, 52% in 1964, 65.1% in 1965.

Remarks: Cited as an example in learning from Qianjin.
A "melons on a vine" system.

25. Yangjiachong Irrigation District (YJC)

Location: Yongxing and Chen xian; in 3 xiang (appx. same as later communes), 10 agricultural producers cooperatives (appx. same as later brigades).

Data Source: GJYS, pp. 69-81.

Irrigated Area: 5,366 mou (1957).

Project Components: 1 reservoir, built spring 1954, 4.9 km² catchment area, maximum storage 22,040,000 m³; 51 ponds, 4 old gang (regional term) and stone dams which can store 180,000 m³/ann.; 2 main and 29 branch canals, total length 31 km; 72 structures.

Crops: Single-crop rice on 3,326 mou, double-crop rice on 2,040 mou.

JILIN (JL) PROVINCE

26. Hailong Reservoir (HL)

Location: Hailong xian; in 13 communes, 108 brigades.

Data Source: SGG, pp. 55-60.

Irrigated Area: 160,000 mou (1972); less than 80,000 mou before 1965; designed area 144,000 mou.

Project Components: Reservoir, built 1958, capacity 234,000,000 m³; 2 main canals (north, south) and 1 river channel, total length 112 km; 59 small storage works, total capacity 10,000,000+ m³; 14 barrages; 120+ electrical pumping stations.

JIANGXI (JX) PROVINCE

27. Baita Canal (BT)

Location: Yujiang xian.

Data Sources: SGG, pp. 87-93; Yikao, pp. 60-64 (orig., Renmin ribao, 21 Dec 72); Renmin ribao, 8 Nov 1974, p. 4.

Irrigated Area: 158,000 mou (1974, 1972); designed area, 72,000 mou.

Project Components: 3 main canals, built in the early 1950s; 17+ gates and embankments for return water; 70+ small, medium-sized reservoirs. The Baita Canal is 100+ km long; the New Baita Canal (built 1964), 60+ km long, with its headworks in Guixi xian.

Crops: Mixed, including rice and cotton. Annual grain yields: 1,015 jin/mou (7.61 T/ha) (1971); 190 jin/mou (1.42 T/ha) (1950).

Remark: A "melons on a vine" system.

28. Jiulong Reservoir (JL)

Location: Shanlin Commune, Gaoan xian.

Data Source: NTSL, 3/64, pp. 27-28.

Irrigated Area: 10,062 mou (1963); 9,975 mou (1962); 7,459 mou (1961); 3,542 mou (1960).

Project Components: Small reservoir, storage capacity 3,770,000 m³; 1 main canal; 44 branch, subbranch canals; ponds and fields with a storage capacity of 650,000 m³ (ca. 15 days drought resistance).

Crops: Annual grain yields: 410 jin/mou (3.075 T/ha) (1963); 371 jin/mou (2.782 T/ha) (1962); 326 jin/mou (2.445 T/ha) (1961); 284 jin/mou (2.13 T/ha) (1960); 192 jin/mou (1.44 T/ha) before the reservoir was built in 1959.
29. Ziyunshan Reservoir Irrigation District (ZYS)

Location: Fengcheng xian.

Data Source: NTSL, 6/65, pp. 11-13.

Irrigated Area: 64,388 mou (1964); 46,200 mou (1962); 44,100 mou (1961); 42,000 mou (1960, when began irrigating). In 1963 there was a big drought and the area irrigated fell.

LIAONING (LN) PROVINCE

30. Helong Reservoir (HL)

Location: Donggou xian: in 3 communes and one state farm.

Data Source: SGG, pp. 94-99.

Irrigated Area: 22,000 mou, 69% over designed area (1972); 19,000 mou (1959); several hundred mou (before 1949).

Project Components: 1 pre-1949 reservoir; 3 branch canals.

Crops: Paddy yields: 600+ jin/mou (4.5+ T/ha) (1971 or 1972); 500 jin/mou (3.75 T/ha) (1959 and after 1964 or 1965); after 1959, it fell to 300+ jin/mou (2.25+ T/ha).

31. Panjin Irrigation District (PJ)

Location: Southern Liaoning, drawing water from the Daliao R. and Shuangtaizi R.; in 18 state farms, 117 brigades, 787 teams.

Data Source: NTSL, 2/64, pp. 8-11.

Irrigated Area: 540,000 mou effectively irrigated (1963); 75,000 mou (1957-1960); 270,000 mou (1956); 140,000 mou (1949).

Project Components: 4,556 canals for water use at levels from main to farm and 4,879 drainage ditches at comparable levels, all with total length of 6,200 km; 5 canal-head pumping stations; 3 medium-sized reservoirs with a total effective capacity of 50,000,000 m³; 2 pumping stations with 1.3 sets of machinery, total capacity 1,550 kw, Q=18 m³/sec.
Crops: Mostly rice on the (unspecified) portion of land which has been reclaimed. Developing rice-dry crop rotation. Rice yield in 1956 was 430 jin/mou (3.225 T/ha).

Remark: Irrigation district was established in 1928.

NINGXIA HUI (NX) AUTONOMOUS REGION

32. Hetao Irrigation District (HT)

Location: 11 xian and shi in the Yinchuan Plain.

Data Sources: Conquering the Yellow River, pp. 70-76; Huanghe zai qianjin, pp. 34-39; Dili, 10/78, pp. 11-13.

Irrigated Area: 2,850,000 mou (of which 590,000 mou is on the Weining Plain and 2,260,000 mou is the Qingtongxia Irrigation District--of the latter, Hexi is 1,835,000 mou and Hedong is 405,000 mou) (1978); 1,500,000 mou before 1949.

Project Components: Qingtongxia Dam, concrete, 697 m long, 43 m high, begun in 1958, head for 2 irrigation canals, Q=560 m³/sec, which began watering in 1960; 4 ancient canals; since 1949, the two new feeders were built and 28 large main canals extended or built, total length 1,370+ km; 2,990+ branch, subbranch canals dug, total length 7,000+ km; 30+ main drainage canals dug, total length 970+ km; 5,000+ structures, including mechanized gates.

Crops: Wheat-millet double cropping on 400,000 mou (1977); other double-dry crops (wheat-beans, wheat-sorghum, wheat-miscellaneous); since 1970, changed from single-crop rice to double-crop dry-rice on 10-20,000 mou. Annual grain yield 400+ jin/mou (3+ T/ha) (mid 1970s).

SHANXI (SAX) PROVINCE

33. Fen R. Irrigation District (FH)

Location: 7 xian in Jinzhong Basin; 325 water-using units (brigades, state farms).

Data Source: NTSL, 1/64, pp 17-19.

Irrigated Area: 1,000,000 mou (1963).
54. **Hougengchuan Irrigation District (HGC)**

Location: Hongdong xian.

Data Source: NTS, 2/64, pp. 4-6.

Irrigated Area: Ordinarily effectively irrigated area 8,600 mou, of which 3,600 mou are basically stable, high-yield fields; if mountain floods are added, the area is 10,000+ mou. The irrigated area was once 4,000+ mou.

Project Components: 13 springs, 28 storage ponds.

Crops: 3,000+ mou of double-cropped wheat, maize, watered in spring, summer, fall; 5,000 mou of cotton, watered in winter.

**SICHUAN (SC) PROVINCE**

35. **Qianli Canal (QL)**

Location: Yingshan xian.


Irrigated Area: 140,000+ mou, ca. one third of the xian's paddy.

Project Components: Qianli Canal, begun 1958; 300+ canals, total length 600+ km; 9 reservoirs, 300+ ponds; 3 main canals, total length 200+ km.

Crops: Rice, requiring 300 m$^3$ of water per mou.

Remark: A "melons on a vine" system.

**SHANDONG (SD) PROVINCE**

36. **Yeyuan Reservoir Irrigation District (YY)**

Location: Linqu xian; in 6 communes, 154 brigades; the reservoir district includes 16 brigades.

Data Sources: SGG, pp. 15-23; Yikao, pp. 24-27; Jingji yanjiu, 2/78, pp. 53-58; NTS, 5/65, pp. 25-26; Yeyuan Shuiku guanli.
**Irrigated Area:**
221,000 mou, of which 77% irrigated by machine (1977); control area 205,000 mou, effectively irrigated area 164,000 mou, with comparable figures for the reservoir district of 9,900 mou and 6,000 mou respectively (1973?); guaranteed area 170,000+ mou (1972); control area 169,000 mou (end 1966); control area 93,000 mou, of which 22,000 mou was a former irrigation district built in 1952 (1965); effectively irrigated area 57,000 mou (spring 1960).

**Project Components:**
Yeyuan Reservoir, completed in 1959, with catchment area 786 km² and total capacity 165-186.3 million m³, flood capacity 112.02 million m³, beneficial capacity 68.1-74.3 million m³, dead storage 6.18 million m³; 3 main canals, total length 70 km; (to 1972): 1,600+ branch, subbranch canals, 11,000+ structures, 53 pumping stations, 360+ pump wells, 50+ small reservoirs or ponds.

**Crops:**
Wheat, sown on 145,000 mou in 1972; tobacco; maize; silk cocoons.
Annual grain yields: 1,127 jin/mou (8.45 T/ha) (1976); 1,000+ jin/mou (7.5 T/ha) (1975); 880-900 jin/mou (6.6-6.75 T/ha) (1972); 812 jin/mou (6.09 T/ha) (1971); fell to 700 jin/mou (5.25 T/ha) during the Cultural Revolution; 800+ jin/mou (6.0 T/ha) (1965); 750 jin/mou (5.625 T/ha) (1964); 600 jin/mou (5.25 T/ha) (1963); 510 jin/mou (3.825 T/ha) (1962); 460 jin/mou (3.45 T/ha) (1961); 410 jin/mou (3.075 T/ha) (1960); 360 jin/mou (2.7 T/ha) before irrigation began in 1960; 200 jin/mou (1.5 T/ha) before 1949. Yellow tobacco yields: 360 jin/mou (1976); 320 jin/mou (1972); 310 jin/mou (1964); 250 jin/mou (1963); 180 jin/mou (1962); 215 jin/mou (1961); 205 jin/mou (1960); 150 jin/mou before Irrigation began.

**Remarks:**
Conjunctive use of canals and wells on 55,000 mou in 1972 (and 1976). The present irrigation district began operation in 1960, incorporating the Laolongwan Spring Diversion Irrigation Project built in 1952. The irrigation water utilization rate went from 20% to 59% by 1972. This irrigation district is treated as a de facto administrative unit in the Jingii yanjiu article.
SHAANXI (SEX) PROVINCE

37. **Linghui Canal (LiH)**

   **Location:** Nanzheng and Chenggu xian; in 1957, was in 3 qu, 7 xiang and 38 agricultural producers cooperatives.

   **Data Source:** GJYS, pp. 124-144.

   **Irrigated Area:** 43,486 mou (1957).

   **Project Components:** 2 main canals, built 1951, total Q=8.0 m³/sec: East, 21.7 km long, West, 5.08 km long; 17 sub-branch canals, each with water measuring equipment. Four levels of canal: main, subbranch, farm, field.

   **Crops:** Double cropping, with rice from late March to beginning or middle September and then wheat, green trumpet creeper, oilseeds or beans. The rice yield was ca 600 jin/mou (4.5 T/ha) in the 1950s; the wheat yield, ca 230 jin/mou (1.725 T/ha).

38. **Longhui Canal (LoH)**

   **Location:** Lintong xian

   **Data Source:** NTSL, 4/65, pp. 1-3.

   **Irrigated Area:** 3,000+ mou (1965); originally, 1,000 mou.

   **Project Components:** Longhui Canal, built in 1958, 6 km long, Q=0.04 m³/sec, circling mountains and prone to silting.

   **Crops:** Wheat, yielding 420 jin/mou (3.15 T/ha); maize, yielding 650 jin/mou (4.875 T/ha); and cotton, yielding 100+ jin/mou (0.75 T/ha) (ginned).

   **Remark:** Operated by a commune.

39. **Luohui Irrigation District (LuH)**
   (also known as Yinluo)

   **Location:** Dali, Changcheng and Pucheng xian; in 20 communes, 2 state farms, with 1,028 basic irrigation units.

   **Data Sources:** NTSL, 5/64, pp. 30-32, 18; NTSL, 2/65, pp. 17-23; GJSL, pp. 5-32; NTSL, 2/64, p. 7; Greer, p. 49.
Irrigated Area: 500,000 mou (1964); 420,000 mou (1958); 320,000 mou planned, 264,791 mou actual (1955); 355,755 mou planned, 203,912 mou actual (1954--a wet year); original designed for 500,000 mou.

Project Components: 1 feeder canal, 27.345 km long; 4 main, 4 branch, 1 branch-distributary (zhi fen) canals, total length 124.782 km; 3,566 subbranch, farm, field canals, total length 2,413 km. Irrigation system completed in 1953. In 1957, drains were added, affecting 59,000 mou: 1 main, 5 branch, 3 subbranch (fen), total length 37.95 km. Also there are 453 structures on the main and branch canals and 5,496 structures on the subbranch, farm and field canals, including 195 measuring weirs of various kinds.

Crops: Cotton and maize (furrow irrigation); wheat and beans (check irrigation). Wheat and peas had 58.5% of the area in 1956; cotton, 38.6%; and maize and coarse grains, 30%. The multiple cropping index was 137. That year, the wheat yield was 280 jin/mou (2.1 T/ha); the ginned cotton yield, 57.58 jin/mou (0.432 T/ha); and the maize yield, 203 jin/mou (1.522 T/ha).

Remark: This project was a model for neighboring Shanxi Province in 1964.

40. Shuangquanyan Irrigation District (SQY)

Location: Nanzheng xian.

Data Source: NTSL, 3/64, pp. 29-30.

Irrigated Area: 18,128 mou (1963); 4,500 mou before 1949.

Project Components: Embankment headworks; 4 small reservoirs, 560 ponds on slopes, 5,500 mou of winter paddy (for water storage), 85 temporary reservoirs, with a total storage capacity of 3,600,000+ m³; 3 main canals (east, west, central); 17 farm canals; 130 field channels. 2 springs, ave. Q=0.165 m³/sec.

Crops: Double cropping, with rice in the summer and wheat, barley, oilseeds, broadbeans, green trumpet creeper, etc., in the winter.
Remarks: This is a relatively large spring water irrigation district. The flow from the springs is 5,000,000 m$^3$ below requirements in an average year. This is a "melons on a vine" system.

41. Weihui Canal (WH)

Location: North of the Wei River, west of the Jing River.

Data Sources: GJYS, pp. 105-123; Greer, p. 49.

Irrigated Area: 223,109.4 mou actual (1956); 600,000 mou (1930s--planned?).

Project Components: Main components built 1935-1937: canal 172 km long with Q=30.0 m$^3$/sec at head, dam 3.2 m high; 6 main canals, including 2 feeders; 195 subbranch canals.

Crops: Maize, 1956 yield estimated at 385 jin/mou (2.888 T/ha); cotton, ginned yield estimated at 75 jin/mou (0.562 T/ha).

42. (People's) Yinjing Canal Irrigation District (YJ) (also known as Jinghui)

Location: Guanzhong Plain, including Gaoling, Jingyang, Sanyuan xian.

Data Sources: SGG, pp. 79-86; Yikao, pp. 47-48 (orig., Renmin ribao, 4 Feb 1973); GJYS, pp. 33-55; Greer, p. 49.

Irrigated Area: 2,160,000 mou, including 1,270,000 mou surface and 880,000 mou from wells (1972); 1,050,000 mou (1958); 500,000+ mou (1949); original design was 730,000 mou.

Project Components: Main components built 1930-1935, with 252 km long canal, Q=16.0 m$^3$/sec, dam height 9.2 m; 12,000 pump wells dug to 1972, with 9,800 outfitted; 100+ ponds and reservoirs in the upper reaches with total capacity 1,700,000 m$^3$, irrigating 20,000+ mou; 109 small pump stations, irrigating 60,000 mou; ditch system added after 1949: 5 ditch systems, 35 main and branch ditches, 285 farm and field ditches, total length 790+ km.; 454 subbranch canals; 8,300 new structures.
Crops: Grain, 700,000 mou; cotton, 500,000 mou in early 1970s. In 1958; wheat, 560,000 mou; cotton, 390,000 mou. Annual grain yield in 1971 was 770 jin/mou (5.775 T/ha); 500+ jin/mou (3.75 t/ha) since middle 1960s; before that, hovered around 400 jin/mou (3.0 T/ha). Cotton yield was 73 jin/mou (0.548 T./ha.) in 1971; before middle 1960s, it hovered around 50-60 jin/mou (0.375-0.45 T./ha.).

Remarks: Planned diversion of water in 1958 was 180,900,000 m$^3$; in 1972, 490,000,000 m$^3$ were diverted from the head, up nearly 100,000,000 m$^3$ over previous year.

XINJIANG (XJ) UYGUR AUTONOMOUS REGION

43. Keriya River Kunlun Canal Irrigation District (KL)

Location: Yutian xian.

Data Source: Dili, 11/78, pp. 11-12.

Irrigated Area: 410,000 mou effective (1978).

Project Components: 7,200+ main, branch, subbranch, farm canals, total length 3,076 km; 13 reservoirs, total capacity 41,250,000 m$^3$; 13 hydropower stations, total capacity 766 kw.

Crops: Grain: mainly wheat, maize, rice; economic crops: mainly cotton, oilseeds, tobacco; orchards: mainly grapes.

44. Manas River West Bank Big Canal Irrigation District (MRW)

Location: In northwest Xinjiang, including Shawan xian.

Data Source: NTSL, 5/64, pp. 7-10.

Irrigated Area: No absolute figure given; area in 1963 was 320% of that in 1957.

Project Components: Construction began in 1954. 3 reservoirs, 4,708 km of permanent earthen canals at various levels: 1 feeder canal, 113 km long; main canals, total length 279 km; branch canals, total length 613 km; sub-branch canals, total length 1,328 km; farm canals, total length 2,375 km; 3,500 gates.
YUNNAN (YN) PROVINCE

45. **Huilong Reservoir (HL)**

- **Location:** Yanshan xian; in 38 production teams.
- **Data Source:** Yikao, pp. 10-13 (orig., Renmin ribao, 22 July 1972).
- **Irrigated Area:** Not specified.
- **Project Components:** Huilong Reservoir, storage 2,500,000 m$^3$ normally, 3,700,000+ m$^3$ in 1972; 3 canals; 23 embanked ponds collecting an average of 110,000 m$^3$.
- **Remark:** A "melons on a vine" system.

ZHEJIANG (ZJ) PROVINCE

46. **Zhengtian Reservoir (ZT)**

- **Location:** Fengqiao qu, Zhuxi xian.
- **Data Source:** SGG, pp. 61-68.
- **Irrigated Area:** 21,500 mou (1972)—reaching designed benefit; 18,000+ mou (1963); 8,000+ mou (1960).
- **Project Components:** Zhengtian Reservoir, medium-sized, built 1958 to 1960 (capacity in summer 1960 was 10,320,000 m$^3$); spillway, built 1960 to 1963; 70+ canals, total length 75 km; 88 structures.
- **Crops:** Annual grain yield: 1,056 jin/mou (7.92 T/ha) (1972); 1,000+ jin/mou (7.5+ T/ha) (1965); 860 jin/mou (6.45 T/ha) (1963).
Pumping Stations

1. (Wuxiahe) Drainage and Irrigation Station
   
   **Location:** He xian, Anhui.
   
   **Data Source:** FBIS, 18 April 1978, pp. G1-G2.
   
   **Remark:** The director of this station was guilty of speculation.

2. Luocun Commune
   
   **Location:** Nanhai xian, Guangdong.
   
   **Data Source:** NTSL, 4/65, pp. 6-7.
   
   **Characteristics:** 32 electrical pumping stations, total capacity 1,599 kw installed; irrigated area, 27,600+ mou.
   
   **Water Fees:** 0.9 yuan/mou (1963); 0.6 yuan/mou (1964).

3. Hubei Province
   
   **Data Source:** FBIS, 12 October 1979, pp. P3-P4.
   
   **Characteristics:** 7,800 electric pumping stations have been built since 1949 with a total capacity exceeding 5,000 m³/sec, providing irrigation and drainage for 1,400,000 ha. Most of these are along the Chang and Han Rivers. Fourteen new large electric pumping stations are under construction; they will be able to serve 270,000 ha.

4. Nan xian, Hunan
   
   **Data Source:** NTSL, 2/64, pp. 12-15.
   
   **Characteristics:** 266 sets of mechanical pumps with a total capacity of 10,986 hp (end of 1963), of which 10,030 hp were in normal use during the year; total benefited area, 449,275 mou. Average service, 31 mou/hp in 1962, 44 mou/hp in 1963.
   
   **Costs:** 4.9 yuan/mou in 1962; 2.6 yuan/mou in 1963. In the five state-operated stations, 1963 costs were 2.15 yuan/mou.
5. **Taihetang District Electromechanical (Irrigation and Drainage) Station**

   **Location:** Qidong xian, Hunan.

   **Data Source:** NTSL, 6/65, pp. 4-5.

   **Characteristics:** 20 pumps, total capacity 400.5 hp, with a lift ca. 15 meters. Irrigated area is 9,333 mou, yielding a grain output of 787 jin/mou (5.9 T/ha) in 1964.

6. **Yueyang xian, Hunan**

   **Data Source:** NTSL, 6/65, pp. 1-3.

   **Characteristics:** 557 sets of electromechanical equipment with a total capacity of 10,180 hp, responsible for irrigation and drainage on 276,000 mou in 1964. Before 1962, each horsepower served 10-20 mou or less, with costs of 5 to 6 yuan/mou. In 1964, each horsepower served 27.2 mou, with costs of 1.998 yuan/mou (1.75 yuan/mou for the state station).

7. **Jiangsu Province**

   **Data Source:** NTSL, 8/65, pp. 11-13.

   **Costs:** Electrical irrigation: 1.8 yuan/mou in 1964, 10% less than in 1963, 36% less than in 1962. Mechanical irrigation: 3.1 yuan/mou in 1964, 6% less than in 1963, 35% less than in 1962.

8. **Changshu xian, Jiangsu**

   **Data Source:** NTSL, 5/64, pp. 11-13.

   **Characteristics:** 15,000 hp. in electromechanical equipment in 28 commune-run pumping stations.

9. **Yihe Commune Management Station**

   **Location:** Hanjiang xian, Jiangsu.

   **Data Source:** NTSL, 2/64, pp. 15-17.

   **Characteristics:** 18 sets of pumping equipment, total 582 hp. In 1962, 29.4 mou watered per hp; in 1963, 38.5 mou.

   **Costs:** Electrical, 3 yuan/mou in 1961, 2.8 yuan/mou in 1962, 1.5 yuan/mou in 1963; mechanical, 5.6 yuan/mou in 1961, 4.8 yuan/mou in 1962, 2.75 yuan/mou in 1963.
10. **Gaozuo Electromechanical Management Station**

   **Location:** Jianhu xian, Jiangsu.

   **Data Source:** NTSL, 8/65, pp. 14-15.

   **Characteristics:** 29 sets of mechanical pumps, total 562.5 hp; 17 electrical stations, total 561.2 kw; guaranteed irrigation and drainage on over 70,000 mou. In 1964, 51 mou were irrigated and drained per horsepower (a total of 27,600 mou); 60 mou were irrigated per kilowatt (total of 33,200 mou), an average of 5.9 kwh used per mou.

   **Water Fees:** 1.75 yuan/mou average for mechanical; 0.81 yuan/mou for electric in 1964.

11. **Wujin xian, Jiangsu**

   **Data Source:** NTSL, 5/65, pp. 21-22.

   **Characteristics:** 445 electrical irrigation and drainage stations, governing 10,500 mou.

12. **Shidu Electric Irrigation Station**

   **Location:** Yangxi commune, Yixing xian, Jiangsu.

   **Data Source:** Yikao, pp. 89-91.

   **Characteristics:** Irrigates over 2,600 mou of paddy in four brigades.
PROJECT CHARACTERISTICS

Forty-two of the 46 case studies of irrigation districts identified in Appendix 2 are located in Figure 1, together with their relative orders of magnitude. Figure 2 shows the location of examples of pumping station management. Figures 3 and 4 and Table 1 depict some of the characteristics of the set of irrigation district cases.

The following observations may be made about these figures and table and the cases they represent:

1. The four cases which are not shown in Figure 1 are in outlying areas. They are the Hailong Reservoir (10,700 ha) in Jilin Province (northeast China); the Keriya River Kunlun Canal (27,300 ha) and the Manas River West Bank Big Canal (no size given) in Xinjiang Uygur Autonomous Region (far northwest); and the Hulong Reservoir (no size given) in Yunnan Province (near southwest).

2. With only one or two exceptions, all 46 case studies are in piedmont or mountainous areas. This is partly because a high proportion of China’s farmland lies on slopes. More significantly, projects in these areas are more likely to rely on storage or large diversions from variable flows, although the latter are also common along the lower reaches of the Yellow River. The only irrigation district located on the North China Plain is the People’s Victory Canal in Henan, and there is little organizational detail in the materials available for it. Many of the pumping station sites are located in the southern part of the North China Plain, in southern Jiangsu.

3. Flatland irrigation in the PRC relies on the pumping of either surface or subsurface waters. In some places, notably the Jiangdu Pumping Stations in Jiangsu, this is done on a large, even massive scale. By and large, however, pump irrigation and drainage is small scale, usually managed by the end-users. Of the nine studies available on pump irrigation of surface flows, only four deal with the operation of a specific station. The remainder discuss xian or commune-wide management of a large number of stations (see Figure 2). In addition, there are two pieces on pumping stations in entire provinces, Hubei and Jiangsu, and one on a commune in Guangdong. The information in all 12 works is incorporated into the present report where appropriate, as are the even more limited data on the independent pump wells scattered throughout the North China Plain. It should be noted too that pumping installations are often incorporated into larger, primarily gravity-flow irrigation districts. For example, 41% of the irrigated area of the Yinjing Canal Irrigation District in Shaanxi was watered by wells in 1972.

4. The management of polders, reclaimed from Chang River lakes and to a lesser extent from the sea, has been a significant factor in state-local relations throughout most of Chinese history. There is little information in these sources on polder management, however. Also, nothing is presented in this report on sprinkler, drip or underground irrigation, which have become
increasingly significant in some very disparate areas of the PRC. The technical manuals go into much detail on these techniques, but such forms of irrigating do not appear to present significant organizational problems.

5. The irrigated areas indicated in Figures 1 and 3 are taken from the most recently reported figures available (see Appendix 2). In all but one case (Huimin Bei Canal in Hebei Province), this is the maximum as well. Irrigated areas in different districts cannot be compared too precisely, however. The figures are from many different years, sometimes over a decade apart. In addition, I have not found any single clear definition of "irrigated area" (guan'gai mianji) in the PRC literature. The US Water Resources Delegation was told by a spokeswoman of the then Ministry of Water Conservancy and Electric Power that irrigation standards differ from area to area and over time, and are based on the minimum number of days of drought which can be withstood through supplemental watering without reducing crop yields. Those which meet the highest standard (e.g., 100 days in Guangdong) are said to have "guaranteed irrigation" (Nickum, 1977, pp. 51-52). Among the case studies in Appendix 2, there are figures not only for "guaranteed irrigation" (e.g., FJ/DT), but also for "effective irrigation" (apparently not as strict as "guaranteed"—see HEN/DD), "control area" (less strict than "effective"—see SD/YY), "stable, high-yield fields" (e.g., FJ/DX) and "actual irrigation" (e.g., SEX/LuH). In most cases, the figure reported is simply entitled "irrigated area"; where a choice was presented between categories, this is the one I chose to draw up Figures 1 and 3. The problem of multiple categories and comparability is attenuated somewhat by the use of an orders-of-magnitude measure for Figure 1 (and Table 1) and a log-linear scale for Figure 3.

6. As shown in Figure 1 and even more clearly in Figure 3, there is a wide variation in size (and therefore complexity) among the case studies, with a median slightly above 10,000 hectares. The five studies on which there are relatively more data (discussed in the text) are marked with stars on Figure 3; these, too, exhibit considerable differences in irrigated area. The Bishihang Irrigation District in Anhui is one of the largest in the PRC at present (over 530,000 ha), and is included here because there is a fairly large pamphlet describing the project and its construction in popular terms (Bishihang, 1977). Unfortunately, surprisingly little is revealed therein about project management. This may be due to the absence of a unified management body (Li and Zhang, 1980, and text). There is little information on the organization of management of the very largest irrigation districts, including the Lixia River District in Jiangsu governed by the Jiangdu Pumping stations (467,000 ha gravity, 167,000 ha pump); the ancient Dujiangyan Irrigation District in Sichuan (467,000 ha); and the two Yellow River Hetao Irrigation Districts in Nei Monggol and Ningxia Hui Autonomous Regions (400,000 ha and 190,000 ha, respectively). The lacuna may be due in part to the limited usefulness of projects of this size and complexity as models for propagation to smaller, more locally administered irrigation districts. The largest irrigation district on which there is a significant amount of useful detail on management is the Yinjing (Jinghui) Canal Irrigation District (144,000 ha), one of several provincially administered canal districts along the Wei River in central Shaanxi.
7. Other data on the case studies are summarized in Figures 3 and 4 and Table 1. By far the predominant crop watered is grain, and the most important grains are rice and wheat. With few exceptions, districts in areas receiving less than 750 mm of precipitation per year concentrate on wheat production, while those with more than 750 mm focus on rice. The main non-grain crop is cotton, particularly significant at the Houguangchuan Irrigation District in Shaanxi (58% of cultivated area) and the Yinjing Canal Irrigation District in Shaanxi (ca. 40% of cultivated area). Figure 4 is a schematic of the maximum and minimum annual grain yields reported over time for the case studies, with individual patterns for three of the principal models traced individually. The growth trend indicated is much higher than for the PRC as a whole, where official figures indicate approximately 160% growth in grain yields between 1949 and 1976 (from ca. 1.0 T/ha to ca. 2.7 T/ha).

8. Figure 4 also reflects an uneven intertemporal distribution of data points, true of other aspects of performance of the case studies as well as grain yields. Although typically reference is made to the full history of a project, especially in the most publicized cases, some bias of presentation is inevitable due to the limitation of materials which themselves are not chronologically continuous or comprehensive.
FIGURE 1. Location of case studies
FIGURE 2. Pumping Station Sites

1 Taihetang Station, Qidong xian
2 Nan xian
3 Yueyang xian
4 (Wuxiahe) Station, He xian
5 Yihe Commune, Hanjiang xian
6 Gaozuo Station, Jianhu xian
7 Shidu Station, Yixing xian
8 Wujin xian
9 Changshu xian
Figure 3. CASE STUDIES--IRRIGATED AREA, PRECIPITATION
Figure 4. RANGE OF ANNUAL GRAIN YIELDS REPORTED IN CASE STUDIES.
### Table 1. DATES AND TYPES OF PRINCIPAL COMPONENTS OF IRRIGATION DISTRICTS

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**Notes:**
- The precise dating is slightly arbitrary, especially for projects with several major components or which were built over a number of years. An attempt was made to identify the year in which the core project (reservoir, main canal) was completed.
- Some districts rely on both diversion and storage headworks, e.g., HUN/SS and GD/DY. In these cases, the district was identified by its principal or most direct headwork.
- Size classes are the characteristics of the common logarithms of the maximum reported irrigated area; e.g., 5 corresponds to 100,000+ ha, 4 to 10,000–99,999 ha, etc.; n.a. = not available.