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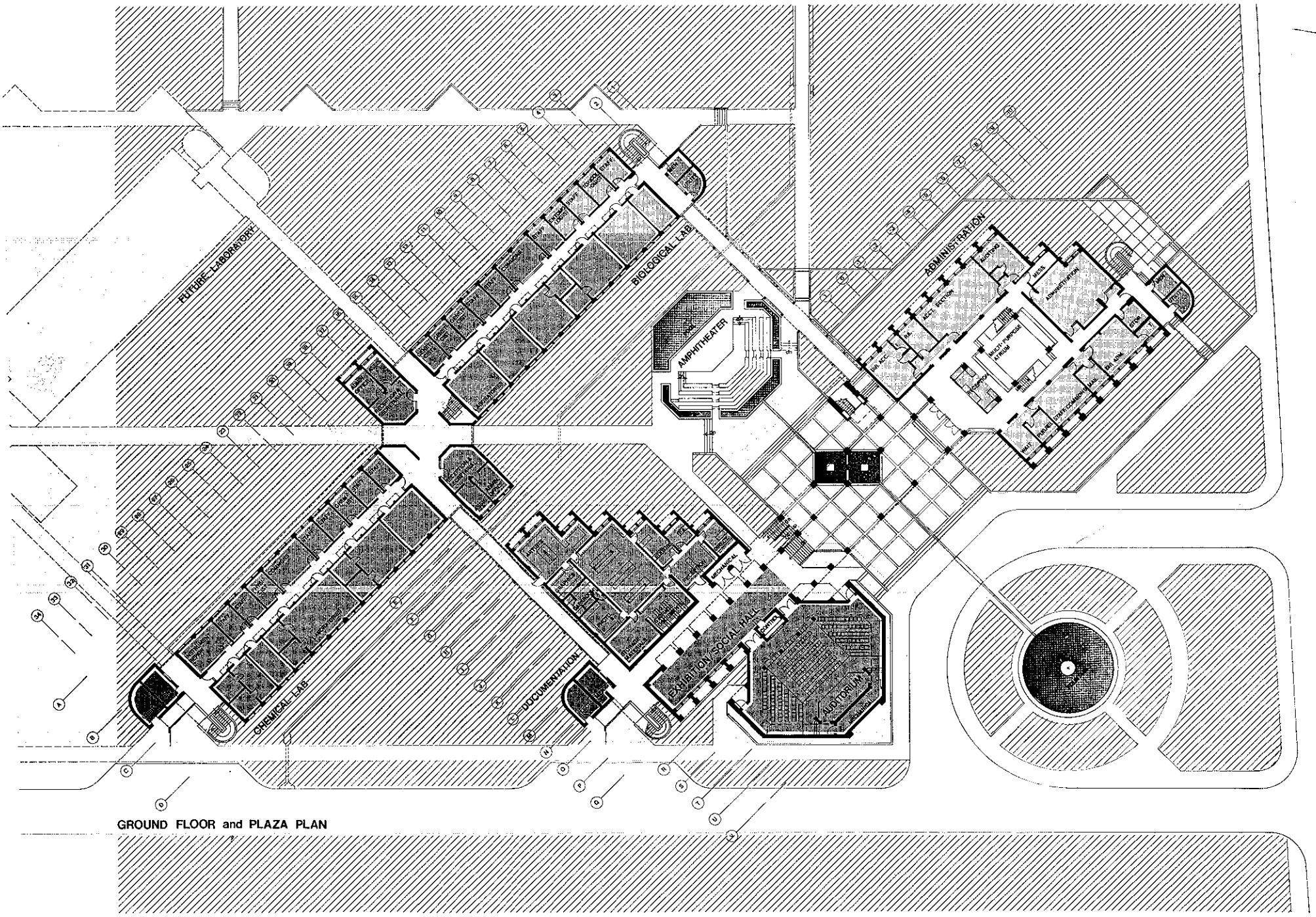

GROUND FLOOR and PLAZA PLAN

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A

ACKNOWLEDGMENTS

Since 1975, when planning for this project was initiated, numerous individuals from several agencies assisted the architects in many ways. Key individuals are acknowledged who were most involved in providing information, responding to concepts and participating through construction.

PARC
Pakistan Agricultural Research Council

Dr. Amir Muhammed, Chairman PARC
Dr. G. R. Sandu, Director General NARC
Dr. Haleemul Hasnain, Member Animal Sciences
Mr. Idrees Anjum, Director of Works

USAID
Agriculture and Rural Development Staff

Dr. Ray Carpenter	Project Officer	'80–84
Dr. Floyd Williams	Project Initiator	'75–76
Dr. Ed Rice	Project Officer	'77–79
Dr. Murray Dawson	Advisor to D. G.	'81–84
Mr. Don Minehart	Farm Develop Engineer	'81–84

MLC
McDonald, Layton, Costain, General Contractors

Mr. Liaqat Hayat
Mr. Syed Naeemuddin

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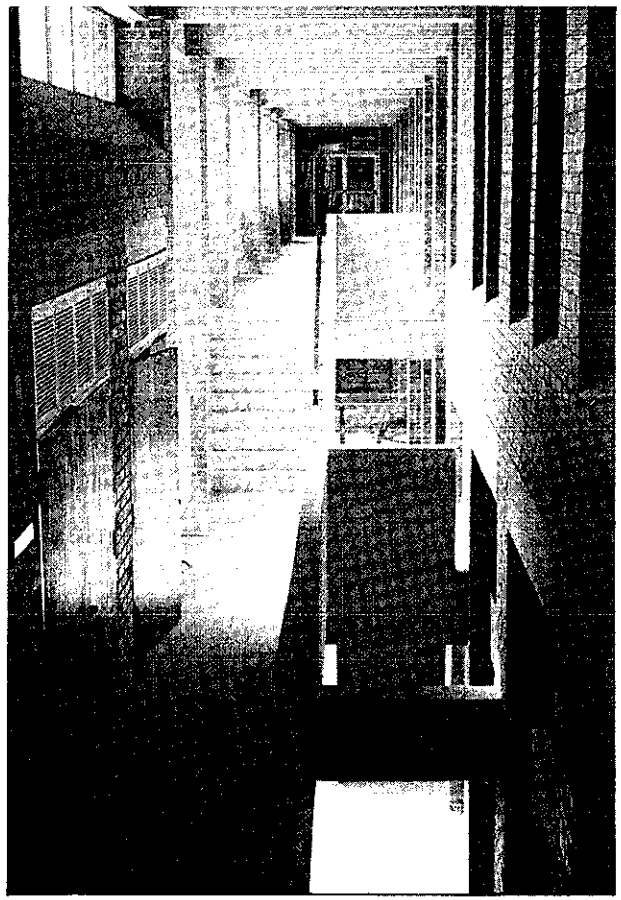


B

ARCHITECT'S SUMMARY REPORT — NATIONAL AGRICULTURAL RESEARCH CENTER — Islamabad, PAKISTAN

ABRIS LTD. ARCHITECTS and PLANNERS
214 West Main Street
Urbana, Illinois 61801

ARCHITECTURAL TEAM

H. James Miller	**Design Architect, Project Team Leader** Needs Analysis, Site Plan, Building Design
Bruce L. Hutchings	**Landscape Architect** Environmental Analysis, Landscape Design
Paul J. Casey	**Assistant Architect** Design Development, Construction Monitor
Perwez D. Shaikh	**Resident Engineer** Construction Monitor
Jon D. Reichard	**Assistant Architect** Design Development

CONSULTANTS

David Wickersheimer	**Structural Engineer,** Wickersheimer Engineers Structures Consultant
R. W. Russell	**Mech. Engineer**, Russell Engineering Systems Consultant
M. B. Russell	**Agricultural Scientist**, University of Illinois Program Consultant
John L. Rishling	**Lab Design Consultant** R.S.G.R. Architects
Christopher Moyer	**Construction Management Specialist**, University of Illinois
Don Bergeson	**Solar Engineering Specialist**, University of Illinois

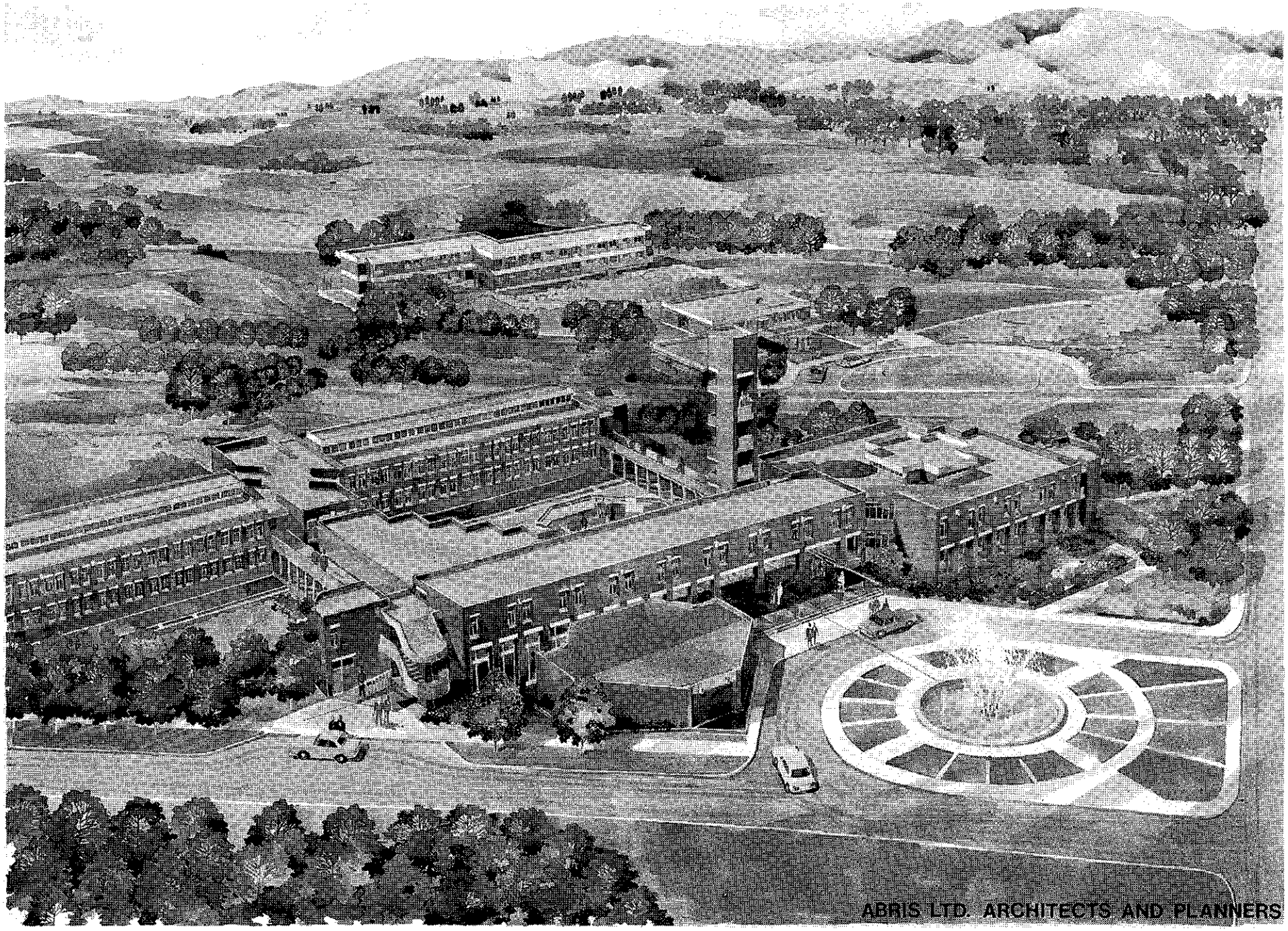
COLLABORATING ARCHITECTS

Zaheeruddin Consultants, Ltd.
Karachi, PAKISTAN
Working drawings, contract documents, site supervision

FINAL REPORT

H. James Miller
Paul J. Casey—Graphics Assistant
Lorena P. Neumann—Copy Editor
Janet A. Mackey—Word Processor

C



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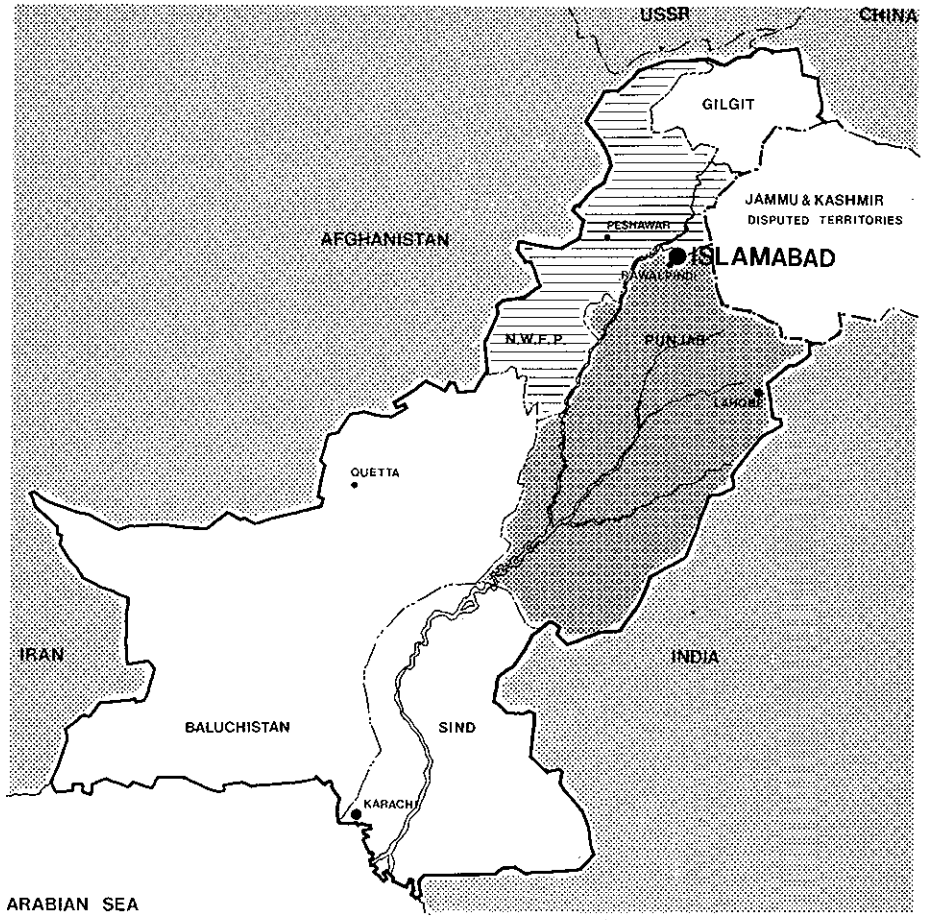
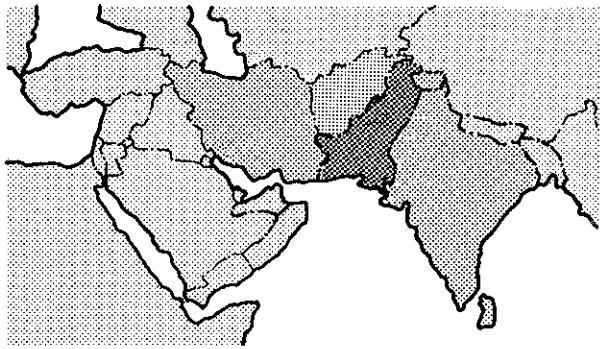
E

PAKISTAN





SOUTH ASIA

PREFACE

In March 1984, as envisioned, the National Agricultural Research Center (NARC) was inaugurated as the premier institution for agriculture in Pakistan. The vision, planning, financing, and development of the NARC were a partnership effort between Pakistan and the United States. Since this cooperative effort produced a successful product of considerable significance to Pakistan, it may be useful to address the following questions: How was the Center developed and what is its nature? What are the primary goals for using the Center, how important are its facilities, and do the benefits derived justify the costs? What lessons can be learned from a collaborative effort between professionals of two nations in a project spanning nearly a decade?

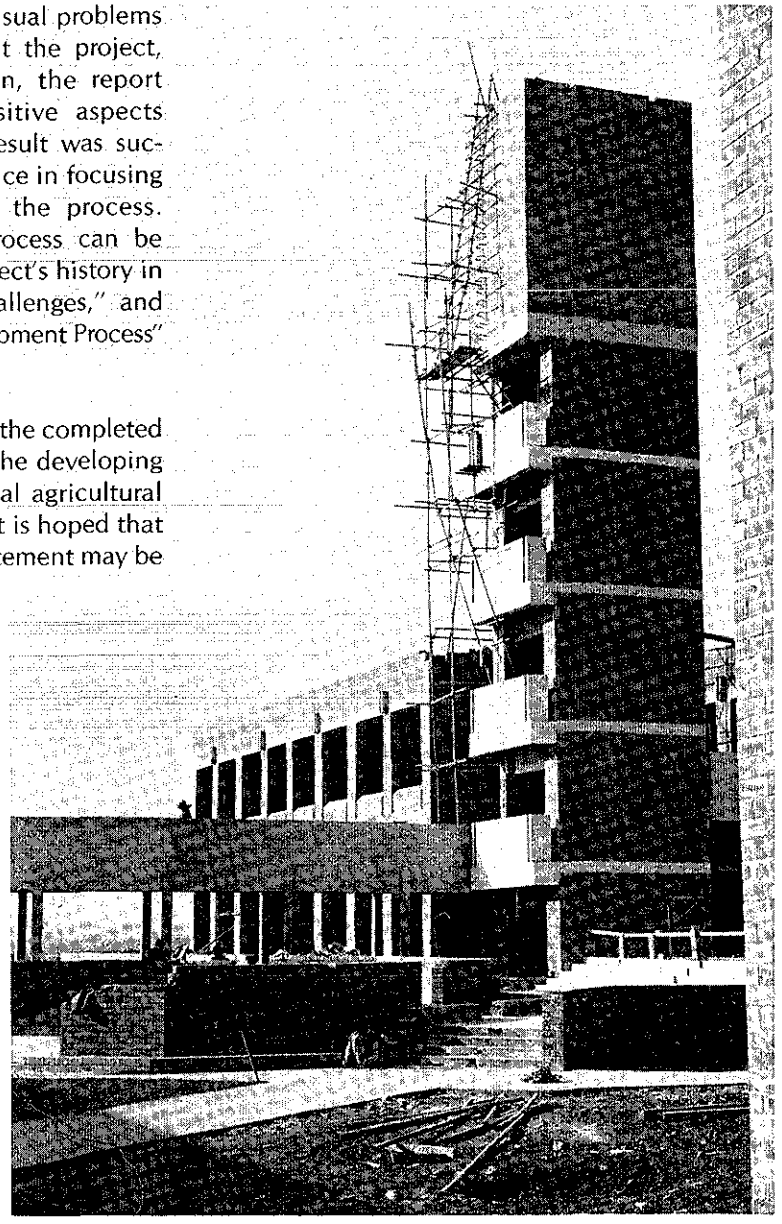
This final report, prepared by the American architectural team leader, addresses these and other questions, but its major emphasis is on the physical nature of the NARC and the design concepts that produced it. Beginning in 1975, the American team leader served as advisor in preparation of the "Development Guide" and in land acquisition. He was also responsible for confirming building and site requirements for the master plan, and for designing the Main Center Complex. The American architectural team and consultants prepared design development drawings and written guidelines, collaborated with Zaheeruddin Consultants Ltd. of Karachi, Pakistan, in preparing the working drawings, and advised in management of the construction process through completion. The intentions, experiences, and observations of the American team are the subject of this report, which fulfills a final contractual obligation to the Pakistan Agricultural Research Council (PARC) and the United States Agency for International Development (USAID).

F

CHALLENGES

Though perhaps more than the usual problems had to be overcome throughout the project, particularly during construction, the report is intended to emphasize positive aspects of the project. Since the end result was successful, there is greater significance in focusing upon the product rather than the process. However, a summary of the process can be gained from a reading of the project's history in the opening section titled "Challenges," and the brief "Lessons from the Development Process" in the Appendices.

An international scientist visiting the completed buildings stated, "Among all of the developing countries this is the best national agricultural research facility of any nation." It is hoped that this report will show why that statement may be correct.



WATER TOWER

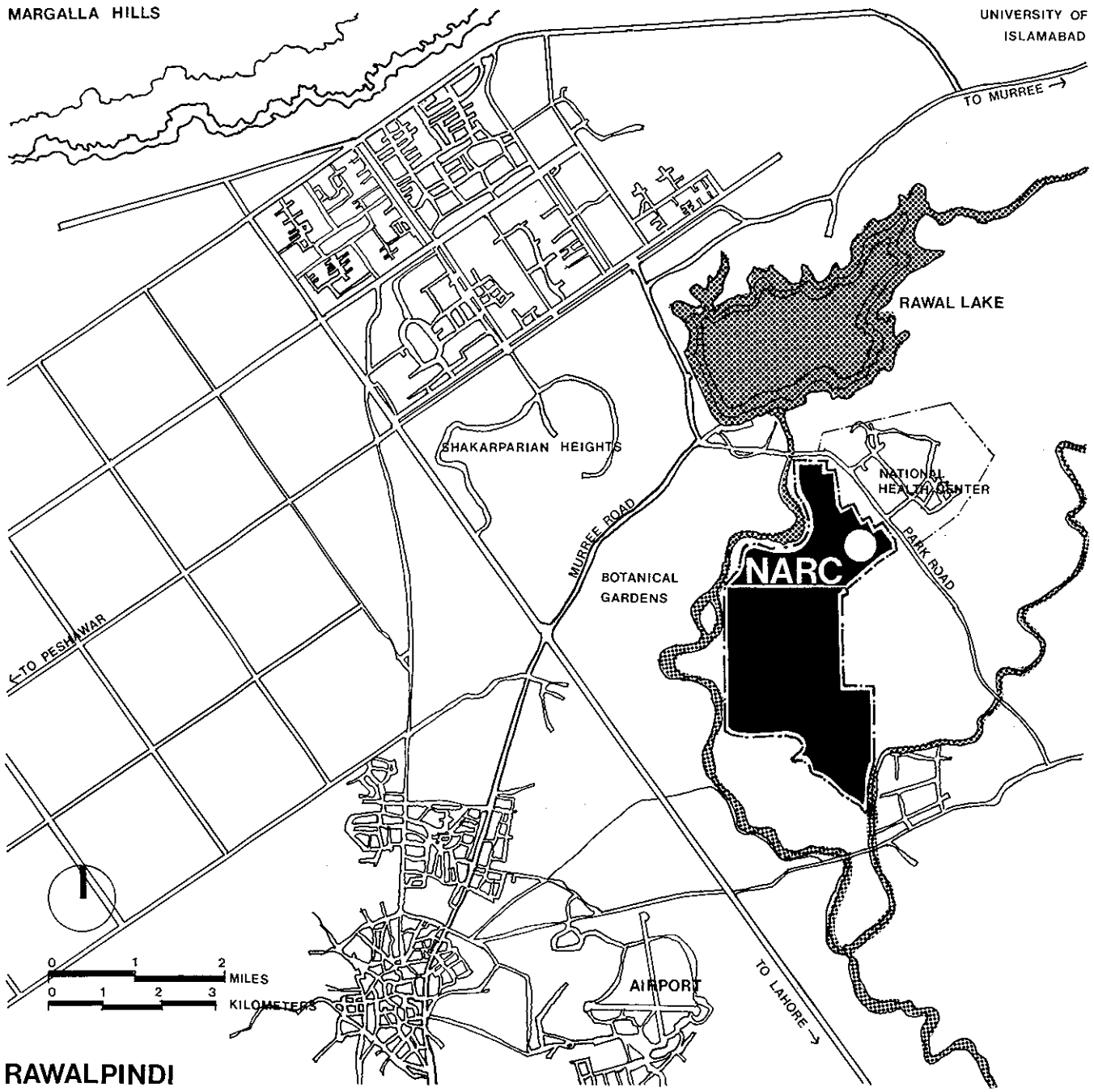
Setting and Site

Islamabad, the new capital city of Pakistan (since 1963), was selected as the most appropriate location for the National Agricultural Research Center (NARC). Now the political seat of the country, it is situated on the border between the Punjab and the Northwest Frontier Province, Pakistan's most economically important provinces, which include 70 percent of the population between them. Agriculture in these two provinces directly or indirectly supports over 90 percent of the nation's population.

Islamabad, a rapidly growing new city (planned for population 250,000), and its older, historically famous, twin city of Rawalpindi (population 600,000), sit astride the grand trunk road between Afghanistan and India. This is the old trade route having strategic importance since the time of Alexander the Great. There are rail and air links to all parts of Pakistan and air links directly to Europe and China.

The new city was laid out on a broad plateau at an elevation of over 1600 feet, nestled against the Margalla and Murree foothills of the Himalayas. This provides a most beautiful landscape setting and climatic conditions that are ideal most of the year. Clear, sunny days with moderate temperatures and cool nights, with intermittent rainfall, are typical. The temperature varies from a low of 35°F on winter nights during December through February to highs of 113°F during the summer months of May and June. For six to eight weeks of the summer the heat is accompanied by dry, dusty air movement, making this the most uncomfortable period of the year. By contrast, daytime winter temperatures

ISLAMABAD



RAWALPINDI
NARC

NATIONAL AGRICULTURAL RESEARCH CENTER

are usually in the low 60s. Monsoon winds bring rain beginning in July. This moderates the high temperature and reduces the dust. Annual rainfall averages over 36 inches and is spread over the entire year, but more than half of it comes with the monsoon in July, August, and September.

Blessed with such a climate, having an abundance of arable land, and lying astride the Indus River the length of the country, Pakistan has unrealized agricultural production potential. Challenging that potential is the critical importance of agricultural self-sufficiency for the continued well-being and stability of the country. It is in this context that the strategic importance of the new National Agricultural Research Center becomes obvious.

The site of 1300 acres of farmland is conveniently located approximately three miles southeast of Islamabad and five miles northeast of Rawaplindi, seven miles from the international airport. It lies within the beautiful park and garden region set aside by the Capital Development Authority. The Kurang River borders the length of the site on the west, the important and beautiful Park Road touches the eastern border, and the 1400-acre Rawal Lake and dam are upriver just to the north. Across the Kurang River there are nearly 2000 acres of park, botanical and zoological gardens, and large areas designated for the National Healthcare Center and other institutions are directly east along Park Road.

The soil on the site is deep and varied in type, with good drainage and an assured supply of water year-round. The primary Farm Center is located in the northern half of the farm near the Main Research Complex and the Training Center, which are situated on the highest point of the site near Park Road. The site could hardly be more beautiful or more appropriate for a strategic research center of national importance.

Project Historical Summary

A national agricultural research center for Pakistan was envisioned shortly after independence in 1947. Following formation of the Pakistan Agricultural Research Council (PARC) in the early 1970s, a joint research project was initiated in collaboration with the United States Agency for International Development (USAID), which included the intention to develop such a center.

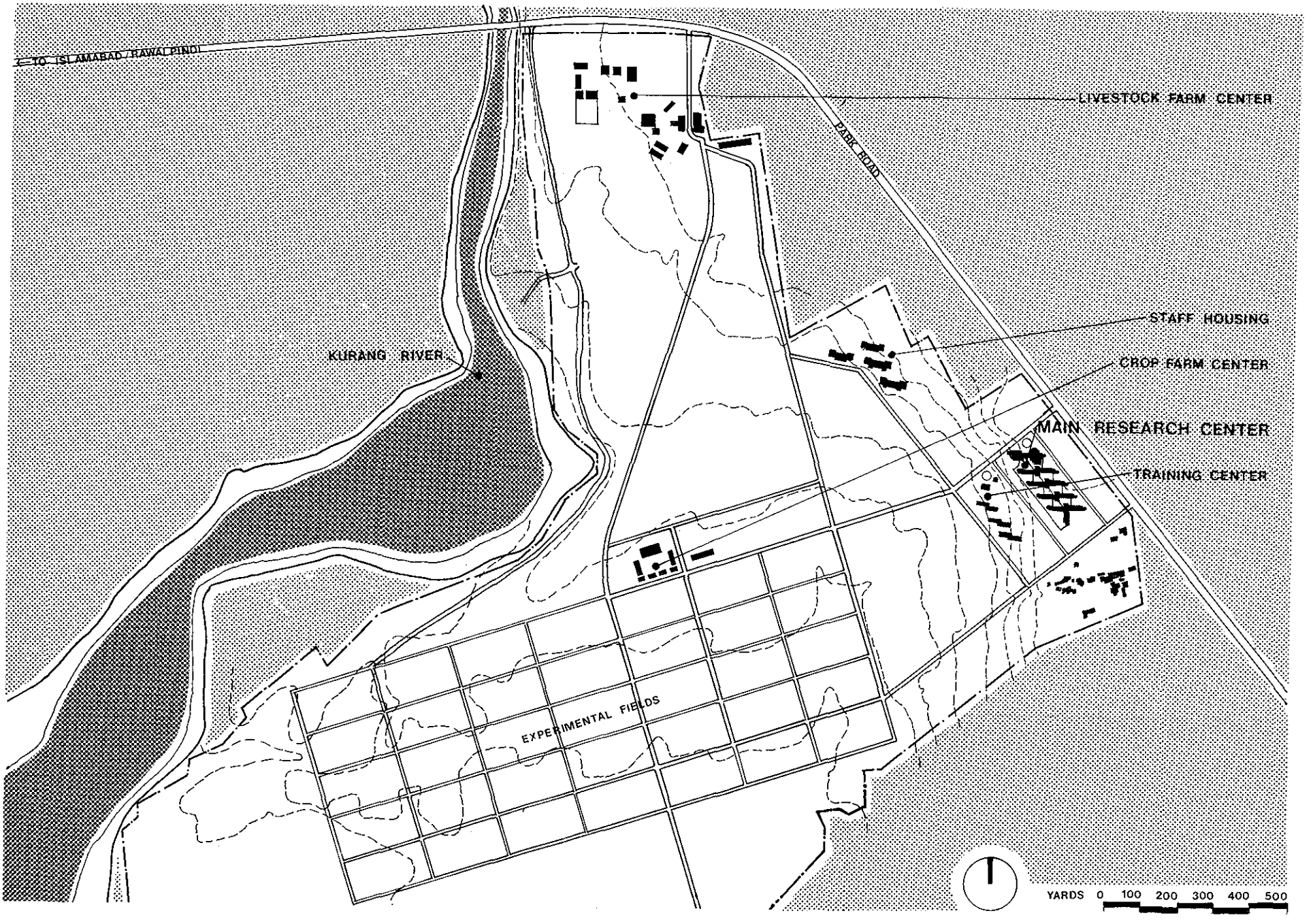
1975. Planning for the National Agricultural Research Center (NARC) began when Architect H. James Miller was commissioned to work with PARC and USAID in defining the problem and writing a program of requirements. This was compiled as the "PARC Development Guide". At the same time, the government granted about 1200 acres of undeveloped land for the research farm. Professor Miller advised the necessity of acquiring an additional 140 acres to permit access from Park Road and to provide the elevated site for the main research complex.

1977. Slow to organize, the PARC required two years to publish the Development Guide, which outlined the operational, physical, and financial requirements for the Center.

1980. Difficult national political events overshadowed the development process between 1977 and 1980. Late in 1980, Abris Ltd. Architects and Planners were asked to be responsible for the design of the Main Research Center and to collaborate with architects Zaheeruddin Consultants Ltd. (ZCL) of Karachi. Zaheeruddin had been commissioned to be responsible for the Training Center, Farm Center, and Staff Housing. They were also asked to collaborate with Abris in completing working drawings and bid documents for the Main Center, and to be responsible for construction supervision of all work at the NARC.

1981. Between January and June, 1981, schematic design and design development phases were completed by Abris Ltd. utilizing a team of American experts. It was during this period that a responsive combination of PARC and USAID officials became convinced of the importance of the architect's design objectives and gave their approval to the concepts that were presented to them. This was the most creative and formative period of the whole development process. During March 1981, construction of the Training Center began. The firm McDonald, Layton, and Costain (MLC), a most reputable general contractor, had already been selected through a bidding procedure using earlier plans prepared by ZCL. Because of their reputation, MLC were retained and asked to proceed with the Main Complex on a so-called fast-track basis. Construction of the Farm Center, staff residences, roads, and irrigation canal was already in progress by other contractors when Abris Architects undertook responsibility for design of the Main Center. During July 1981, construction began on the Laboratory Blocks of the Main Complex. Abris's initial contract responsibility was virtually complete by December 1981. Besides design, that included transfer of concepts and drawings to the local architect for use in producing working drawings and other tender documents, and review and approval of those drawings.

NARC SITE


TO ISLAMABAD / RAWALPINDI
LIVESTOCK FARM CENTER
PARK ROAD
STAFF HOUSING
CROP FARM CENTER
KURANG RIVER
MAIN RESEARCH CENTER
TRAINING CENTER
EXPERIMENTAL FIELDS
YARDS 0 100 200 300 400 500

1982. On the request of USAID and PARC, the Abris contract was extended through June 1982. The purpose was to continue the review and approval of incomplete contract documents and to periodically monitor construction. By this time it was recognized that PARC had no project management capability. Also, the local architects were unable to sufficiently influence quality control measures and were not properly advising the implementation of intended design details throughout the project. In June 1982, Abris was asked to enter into a new contract to provide virtually full-time monitoring service through to the end of the project. A full-time resident engineer was provided at site, with a rotating team of experts intermittently devoting from one month to six weeks, as required to solve the problems.

1983. June 1983 was originally targeted for completion of the project. The date realistically provided a period of two years for construction, and was the goal promised by the contractor. Unfortunately the target was not met for a multitude of reasons, which are summarized later in this report under the heading "Construction". In July it was decided to set March 1984 as a feasible inauguration date, and to use the incentive of a prestigious event to spur completion of the project. This proved to be a successful strategy. In December 1983, however, hope turned to despair when PARC ran out of funds at the most critical time (a financial management problem). The contractors ceased operations for nearly a month before a salvage funding operation brought them back again. The work pace increased to full capacity under the enlightened teamwork guidance of the PARC Director of Works and the Abris resident engineer.

1984. The project was successfully inaugurated by the President of Pakistan on March 27, 1984. However, full occupancy of the building was not implemented for another two months. At this writing, the incrementally designed air-conditioning systems have not been installed and elements of site work have yet to be completed. These and other "settling in" elements will be completed along with an expansion program already under way which is being funded by the World Bank.

Design Goals

In concept, the Center is designed to expand as may be required by adding laboratory blocks incrementally, and this is already being implemented by two follow-up projects. This feature and other design innovations were not at first fully understood; but now it is evident that they contribute to the uniqueness of the buildings and site development. Because the major thrust of this report is to explain and illustrate these design concepts, it is well to speak first of the challenge of the overall design goals of the project.

Public buildings universally tend to be ostentatious and formal. Particularly in developing countries there is a tendency for administrators to associate prestige and accomplishment with construction of a monumental building. Too often, architects tend to acquiesce in this desire, first to please their clients, and because the usually more costly buildings enhance their fees. The most important design goal should be *appropriateness of performance*, but unfortunately more emphasis is given to pretentiousness, formality, and grand scale. It is not generally understood that real beauty and the qualities of significant architecture lie in successfully meeting the needs of the user, while respecting the determinants of the site conditions.

Particularly where resources are scarce, and where a new building is intended as a strategic tool for carrying out specific national goals, appropriateness should be the predominant concern. Prestige comes as a by-product of recognizing the qualities of appropriateness and appreciating their significance. The development of the National Agricultural Research Center covered a decade, from when the planning process was initiated until the buildings were completed and occupied. Because the PARC and USAID officials involved in the earlier stages of planning changed several times, the design goals for the Center varied from the pragmatic to the ostentatious. Pakistani administrators tended to favor a more monumental approach, whereas USAID officials favored functionalism. The only continuity throughout the process was the intermittent but consistent advice of an American architect who strongly advocated appropriateness, and whose advice prevailed in the end.

The challenge of this project was to design a facility, within the framework of local construction cost norms, that would be energy-efficient and in other ways economical to operate and maintain. At the same time, the facility had to meet specific scientist user needs, including convenience and comfort, while convincing the administrators that it was sufficiently prestigious for a facility of national importance. With these design goals in mind, several alternative concepts were investigated and discussed with officials of PARC and USAID. The fortunate objectivity of these individuals at the time made it possible for the design architects to produce the uniquely "appropriate" building that now is being used and tested.

CONCEPT DERIVATION

Major Design Influences

Achieving appropriateness while investigating possible alternatives demands that building concepts be derived in direct response to two distinctly different sets of forces. Because these forces should be accepted as parameters for the decision-making process they can be called "design influences." Such influences were fundamental to the design of the NARC.

The primary design influences were derived from a studied and thorough understanding of user needs (scientists and administrators) translated into *facility requirements*. It was necessary to generate these needs and requirements in light of the following:

1. The national mission of NARC.
2. NARC organization and administrative divisions.
3. The NARC staff and their individual responsibilities.
4. Activities of each person defined for each room.
5. Comfort needs of the staff.
6. Operational efficiency requirements.
7. Building system and equipment needs.
8. Code and building safety requirements in Pakistan.
9. Initial and operating cost parameters.
10. Access and security needs.
11. Cultural imperatives and historical precedents.
12. Image objectives.

The secondary design influences stemmed from a comprehensive understanding of the *setting and site conditions*. These are existing conditions that simply had to be identified and analyzed for their inherent constraints or opportunities, including the following:

1. Land area and boundaries.
2. Topography.
3. Top soil and subsoil.
4. Land use.
5. Vegetation.
6. Drainage.
7. Accessibility.
8. Climatic factors of sun, wind, rain, and temperature.
9. Visual factors.

Ignoring, misunderstanding, or deliberately playing down such implicit determinants is the major cause of the creation of the large numbers of poorly designed buildings around the world. Thus the NARC was seen as an opportunity to demonstrate responsible architecture in a nationally important building, which will have considerable international exposure. As a research institution it should itself be a model of a facility that utilizes the latest knowledge and technology, applied within the constraints of the particular cultural and economic context of Pakistan—a thoroughly appropriate facility.

Facility Requirements

The analysis of user needs was unusually difficult and time consuming in the case of the NARC. Because the Pakistan Agricultural Research Council was not fully organized and there was only temporary leadership, the necessary understanding and commitment were missing. The analytical process extended over a two-year period, finally culminating in the PARC Development Guide of 1977. The process was important not because it generated the facility requirements for the new Center, but more fundamentally because it helped PARC define its purpose, its mission objectives, and how to achieve them. The Guide provided the operational, physical, and financial requirements for the NARC. A summary of the facility requirements as understood in 1977 follows:

	square feet
Secretariat—PARC offices and NARC administration	24,000
Training unit—classrooms and offices	3,000
Hostel for 40–60 trainees	5,800
Cafeteria to serve 80 people	2,200
Documentation unit	3,300
Library for 15,000 volumes expandable to 30,000	3,000
Auditorium to seat 200 conferees	3,000
Laboratory units (expandable)	29,000
Gross floor area	73,400

Additionally, the Guide specified facility needs for the Farm Center and other subsidiary service facilities. Those elements are omitted from this report since the American team was not involved in their development. The Training Unit, hostel, and cafeteria were also not designed by the Americans; however, periodic advice was given in their development.

In 1980, after much discussion, the Secretariat was removed from the program at this site and relocated at another place in the city. This was unfortunate for two reasons: first, the inconvenience now caused by the separation from the major research tool for the PARC; second, the unnecessary duplication of facilities and greatly increased initial and operating costs.

Prior to initiating the design process in early

1981, the Guide was carefully reviewed and a "supplemental rationale" was prepared for spatial distribution of the laboratories. This was a reaffirmation and refinement of the Guide and it illustrates the process followed to determine real needs and requirements for facilities.

The following is a paraphrase of the rationale prepared by Abris consultants:

> The PARC Development Guide 1977 recognizes the shortcomings of the traditional discipline-oriented approach which has characterized agricultural research in Pakistan and states that PARC will "utilize the multidisciplinary approach to problem-solving."
>
> Since the principal objective of each crop improvement program is "to determine and develop varieties and agronomic practices appropriate to the improvement of barani culture," it is not logical to separate from them the work on pest management, soil and water management, farm machinery, and production and marketing economics.
>
> The overall planning and evaluation of national research *programs* should involve participation of scientists from all relevant disciplines and from all of the participating research institutions. The research undertaken to meet the stated objectives of a national agricultural research program should be organized as a set of *projects* which usually (but not necessarily) would be unidisciplinary and would be conducted by the staff of one research institution.
>
> The investigations conducted would involve studies of the many physical, biological, and socioeconomic processes associated with the production of agricultural commodities. Therefore, the research staff would consist of scientists diagnosing the performance of the component parts of the production system and creatively investigating ways in which a particular component can be caused to function more satisfactorily. The exact nature of the phenomena and processes to be examined will depend on the training and experience of the investigator, on the relevance and importance of the phenomena, and on the state of knowledge concerning the particular process or phenomenon. Since all of these factors will change with time, it is essential that research facilities be flexible and adaptable.
>
> The techniques used in the laboratory studies of the many physical, biological, and socioeconomic phenomena encountered in agricultural research are, for the purpose of planning the NARC, grouped into five kinds, viz. (1) microbiological, (2) biochemical-physiological, (3) chemical-physical, (4) descriptive biological, and (5) socioeconomic. The choice of these units rather than the more traditional academic disciplines such as pathology, microbiology, soil physics, genetics, plant pathology, weed science, soil chemistry, and climatology, is made deliberately to deemphasize the latter as a basis of program management.

The preceding rationale formed the basis for programming the nature and relationships of the laboratories. The functions of each laboratory were further analyzed to determine the kinds and distribution of cabinets, special equipment, and utilities necessary to serve each laboratory. This process illustrates the needs analysis process leading to a complete set of facility requirements for the whole complex. the actual floor areas provided in the completed buildings are summarized below:

	square feet
NARC administrative block (18 offices and atrium)	15,000
Library (30,000 volumes and seating for 36)	3,500
Documentation unit	3,500
Auditorium seating 210	3,200
Multipurpose exhibition/plaza and service areas	4,200
Socioeconomic laboratory unit (including service areas)	5,300
Agricultural sciences laboratory units (including service areas)	27,000
Gross floor area	61,700
Training Unit	3,200
Hostel for 50 trainees	10,000
Cafeteria to serve 150	2,300
Gross floor area	15,500

Site Conditions

Accessibility, topography, and climate were the major site determinants. A special 140-acre elevated land parcel was acquired to connect the Research Farm to Park Road, providing the primary access and a commanding position for the Main Complex. Climatic characteristics of the location were perhaps the single most important consideration. Following is a summary of the general goals in design for comfort:

1. Minimize reliance on mechanical means for comfort control in buildings.
2. Minimize reliance on artificial lighting in buildings.
3. Limit effects of solar heat gain in hot seasons.
4. Maximize potential solar heat gain in cool season.
5. Utilize natural ventilation to its fullest potential in buildings.

General principles for achieving these goals for the NARC were:

1. Locate buildings on the highest ground with desirable exposure to prevailing breezes.
2. Orient buildings with major exposure directly south (or not more than 10° either side of south), to allow maximum exposure to winter sun with interior spaces and maximum control of summer sun with shading devices.
3. Develop configuration for buildings with longer axis in the east-west direction to minimize heat gain on east-west facing walls, and to maximize potential for building

spaces facing south. This configuration also facilitates better cross-ventilation due to the narrower north-south cross-section. Also provide raised clerestory, monitor, or central open courtyard to further improve ventilation.

4. Provide for generous openings on the north and south facades to afford optimum air flow thru interior spaces. This also maximizes natural lighting in rooms. Provide clerestories and courtyards to introduce natural light into interior spaces. Eliminate windows on east and west facades, as it is impossible to effectively control exposure to the sun in these directions.
5. Provide for closing up spaces and minimizing air infiltration during the cool season, so that supplemental heating is not required. Large window openings should have operable thermal shutters in order to reduce cool-season heat loss.
6. Provide sun-shading devices on the south to prevent the summer sun from entering interior spaces and allow the winter sun into the rooms.
7. The spacing and organization of buildings should not inhibit or block the natural air flow in, around, and through each building. Generally, the space between each building should not be less than five to seven times the height of the building on the windward side of the connecting space.
8. Other site elements should not inhibit air flow or create large thermal collection or reflection zones adjacent to buildings.
9. The landscape development of the site should be carefully designed to help reduce undesirable heat buildup on and near buildings, while not blocking the prevailing breezes. Generally, large canopy-type shade trees should be used on the south and west sides of buildings. Low shrubs should be avoided under trees or near buildings. Site surfaces immediately adjacent to buildings should be predominantly natural material (grass or low ground cover) in order to reduce glare and to improve evaporative cooling.
10. The building design should provide for separation of the external skin and internal room surfaces. This is especially important on roofs and east-west facing walls, where direct sun exposure (and resultant heat buildup) cannot be avoided. The separation between materials should be continuous, accomplished by a narrow 1" to 2" air space or rigid insulation infill, or both.

Design Objectives

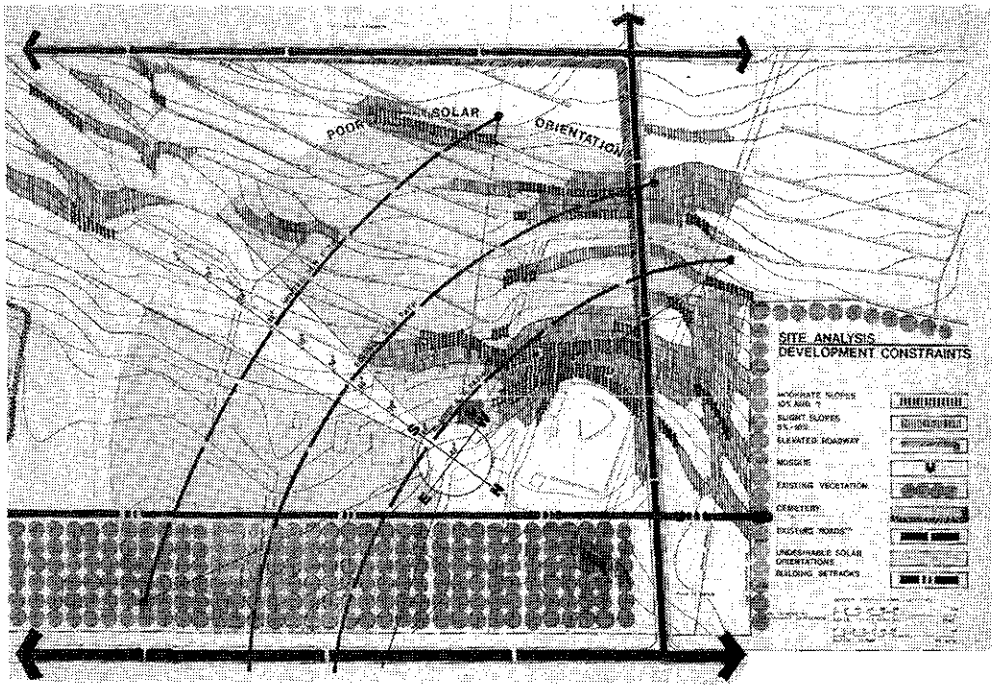
When the needs and requirements were delineated and understood, and the setting and site parameters were analyzed and combined with facility requirements, a set of design objectives became clear. The overall objectives used to guide the design process were as follows:

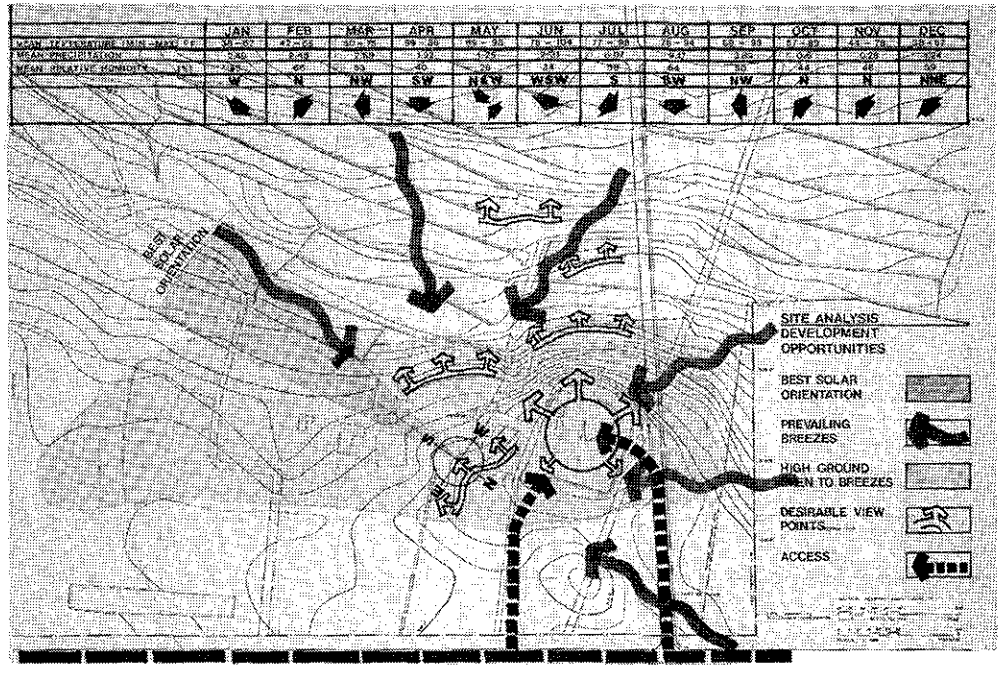
1. The image from Park Road should be prestigious yet businesslike, reflecting the Center's true nature.
2. Approach, entry, and arrival should be clear and direct.
3. The administrative unit should be the dominant element of the complex, with a particularly inviting reception for visitors obviously near the entrance.
4. As distinctly different functions, the administration, library, documentation, auditorium, and laboratory units should have their own individual expression of form derived from their nature.
5. To keep costs down and to maintain a human scale, no unit should be higher than two stories for convenience without lifts.
6. The separately expressed units should be grouped around an exterior court to provide a focus and amenity; but more importantly, to reflect Islamic architectural precedents, and provide improved ventilation and lighting.
7. Research facilities should best be grouped by functional needs, rather than by administrative division.
8. Research facilities should be flexible to accommodate change and growth; therefore a building system should be devised that is modular and expandable.
9. Offices for scientists should be conveniently near the laboratories where they work.
10. Building units should be designed for energy efficiency—that is, for minimum demand for mechanical heating and cooling, to achieve optimum comfort conditions.
11. Building units should be designed to provide maximum natural lighting, to avoid heavy power demand for illumination.
12. Convenient service access to each unit is imperative.
13. Respect for and preservation of the qualities of the natural topography would enhance the setting of the Main Complex on the highest point of the site.
14. As an added amenity, utilize a necessary water tower as a main feature, with an elevated viewing platform where visitors may view the whole research farm.
15. A simple reinforced-concrete frame structure is most appropriate, considering that it is permanent, fireproof, and technologically available locally.

16. An insulated brick exterior skin is dictated by the desire for permanence, low maintenance, and interior comfort. Maintenance concerns influence interior finish materials.
17. Landscape elements should be fully utilized, not simply as formal decoration but serving particular purposes such as shading, screening, softening, adding color and variety to complement the buildings.

The preceding design objectives and numerous additional specific objectives guided the investigation of a series of alternate approaches or concepts. These were documented and reviewed with officials of PARC and USAID. Cost implications and the functional efficiency of each were compared, and a final concept was selected for development.

The remainder of this report is concerned with illustrating and explaining the nature of the site plan and buildings that were designed. A more detailed description provides reasons for the design development decisions that produced the design drawings. An overview of the construction process provides insight into the difficulties of cross-cultural collaboration and of the inherent handicaps in working on projects of this kind in developing countries.





SITE PLAN

Description of the Plan

The Abris site plan includes the Main Research Complex and areas of expansion which they designed, as well as the Training Center buildings designed by ZCL. The twenty-seven-acre site is parallel to Park Road, providing entrance and introduction to the whole Research Farm. A 200-foot-wide border strip filled with Shisham trees along Park Road provides a beautiful screen and buffer from the road. A pleasing image of the all-brick Center can be seen from the 1200-foot frontage along the road. The trees open up to provide an inviting entrance for Central Road, which leads first to the forecourt of the Center and then continues down the hill to the Farm Center and other parts of the Research Farm.

The first phase of the Main Center is designed with linear building elements running east and west, and grouped around a courtyard in response to climatic considerations mentioned earlier. This caused the buildings to be placed at a 45°-angle to the road. In addition to the comfort advantages of this orientation, the diagonal enabled the buildings to fit on the narrow plateau of land. Also, the entrance forecourt with large fountain could be more invitingly placed relative to Central Road.

The narrow plateau is fifty feet higher than the rest of the farm. By cutting off a hump, the leveled plateau became sufficiently large to contain the whole Main Complex and all future expansion. A retaining wall defines the edge of this "plateau." The earth obtained from grading was utilized to form a gentle slope dropping the full fifty feet to the Farm level. The Training Center complex was placed on this slope and, like the Main Center, it was oriented diagonally for climatic reasons, and grouped on its own plaza with separate arrival road. Designed with space for additions, the Training Center and hostel units can be expanded incrementally, integrated parallel with the expanding units of the Main Complex. A service road with expandable parking areas runs parallel to and between the Main Complex and the Training Center, allowing it to serve both facilities conveniently and to grow as needed with the expansion of the buildings.

The focus of the landscaped forecourt of the Main Center is a large pool and spiral fountain, glazed with an Islamic blue tile. The entry drive goes around this fountain, arriving at wide, low steps leading upward to a sheltered plaza that is open under the second story of the building and into the central courtyard. From the covered courtyard, one can choose to walk various directions to virtually any element of the complex, including walking directly downhill to the Training Center plaza.

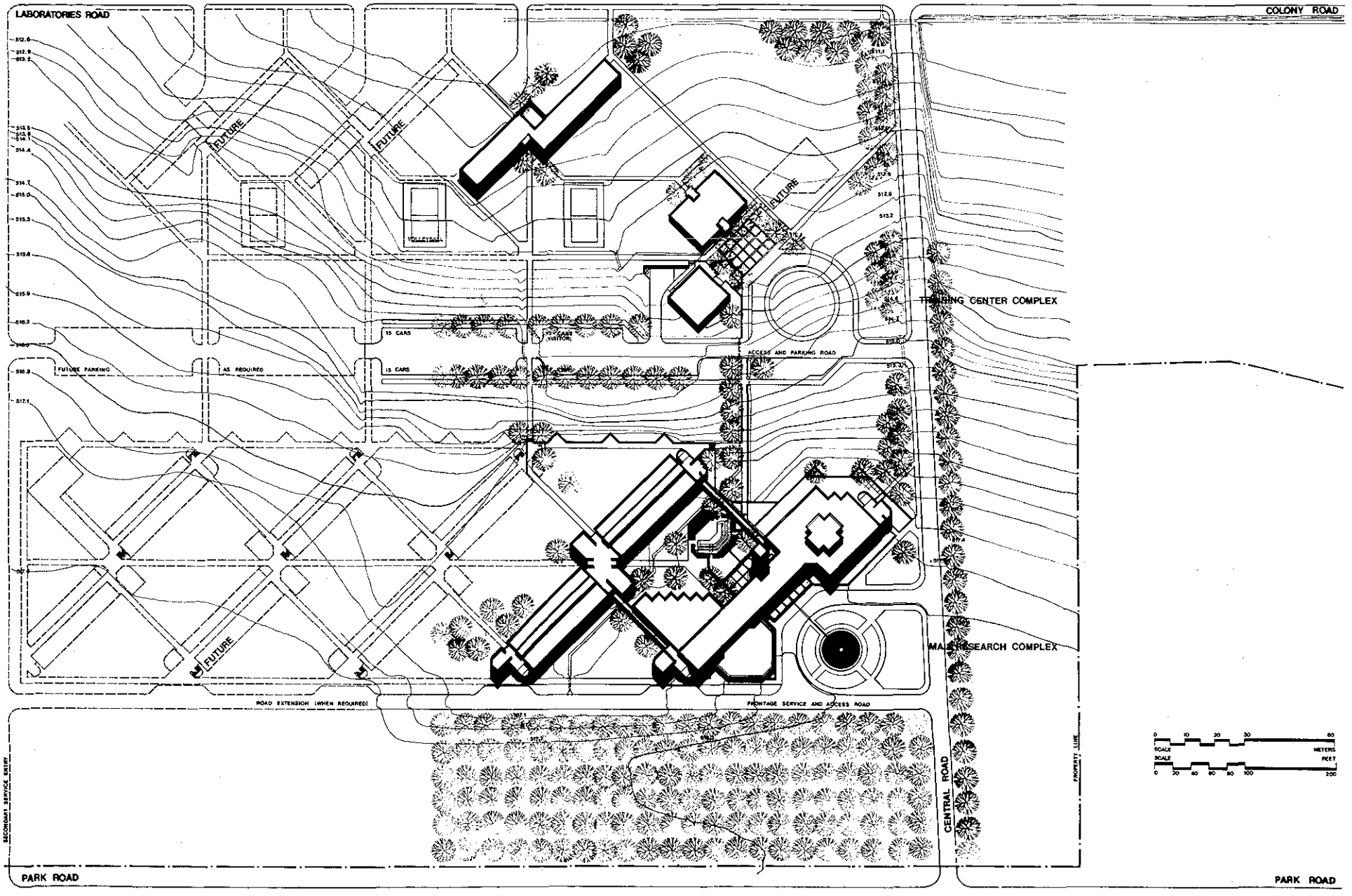
Inside the courtyard, an open amphitheater is provided with seats for one hundred. Two low fountains and pools on the plaza at higher level are interconnected with the main fountain and a water moat encircling the amphitheater. The water runs from the higher fountains in the plaza through runnels to the lower pools, then is pumped back to the plaza fountains.

Purpose of Landscape Design

The landscape design was intended to achieve clear objectives rather than formalistic ideas, of "avenue trees," for example. In conformance with the appropriateness theme of the whole project, landscape elements were chosen and placed to reduce heat buildup near buildings; to shade walls, paved areas, and walkways; to screen areas, define space, and reduce glare; to improve cooling effects; to soften the landscape; to provide accents, color, and transition from hard surfaces to the natural landscape. In short, the landscape design was intended to provide an informal, complementary natural setting to the man-made structures. Referring to the site plan and the list of landscape species in the Appendices will provide greater understanding of the design concept and the purpose of the various landscape elements.

Expandability

From the very beginning of the planning process it was established that a research institution, by its nature, will change over time and will undoubtedly grow. Though it is difficult to anticipate how that growth may occur, it is important to provide a framework for ordered expansion that will harmonize with what exists. An important aspect of the design concept for the NARC is the provision for predetermined parallel expansion of the Main Complex and the Training Center. In subsequent phases, the concept allows for the construction of six additional laboratory blocks and three additional hostels on the same pattern as phase one. It also anticipates addition of specialized training facilities to complete the Training Center plaza. This ensures that subsequent development will complement the original facilities, not detract from or compete with them. Even before phase one was completed, the World Bank financed the construction of two additional blocks of laboratories and another hostel according to plan. The infrastructure of roads and utilities is also designed for expansion and increasing demands.


LABORATORIES ROAD
COLONY ROAD
FUTURE
FUTURE
FUTURE
FUTURE
TRAINING CENTER COMPLEX
15 CARS
CARS (VISITOR)
ACCESS AND PARKING ROAD
FUTURE PARKING
AS REQUIRED
15 CARS
MAIN RESEARCH COMPLEX
ROAD EXTENSION (WHEN REQUIRED)
FRONTAGE SERVICE AND ACCESS ROAD
CENTRAL ROAD
PROPERTY LINE
SECONDARY SERVICE ENTRY
PARK ROAD
PARK ROAD
SCALE METERS
SCALE FEET

11

BUILDINGS

The buildings of the Main Research Complex of the NARC can be classed as "architecture" because of their significant qualities, already described. Most of the buildings in the cities of the world are merely buildings and not architecture because they are poorly conceived. They provide shelter and very little more, because no one gave adequate thought to user needs, site conditions, long-term maintenance, and the impact of scale, form, and character on the particular setting. Architecture can be found in the beautifully appropriate vernacular of domestic dwellings of villages and small towns, where the lessons of history are continually refined. When architecture is produced in the cities it comes from having an enlightened client, working with skilled professionals to discover what is really appropriate.

Appropriate Image

In the planning of the NARC, the image of the buildings grew out of the desire to provide facilities that would be efficient and comfortable for the users. There was a conviction that monumentality or pretentiousness were not good design objectives. Instead, it was anticipated that with sensitivity for the dual forces of user needs and site conditions, an appropriate image would emerge. Interestingly, a number of factors converged to contribute toward a building that is semiformal, with the attributes of a prestigious building, and a form that is monumental in feeling without being contrived.

The prestige factor is provided by the obvious unity, order, and efficiency, and by the linking and interaction of an interesting series of internal and external spaces. The suggestion of monumentality comes from the hilltop setting and the fountains, pools, and courtyards. However, it is well to re-emphasize that all of the elements have a particular purpose besides being beautiful; the real significance is the appropriateness factor in each element.

Appropriate Functions

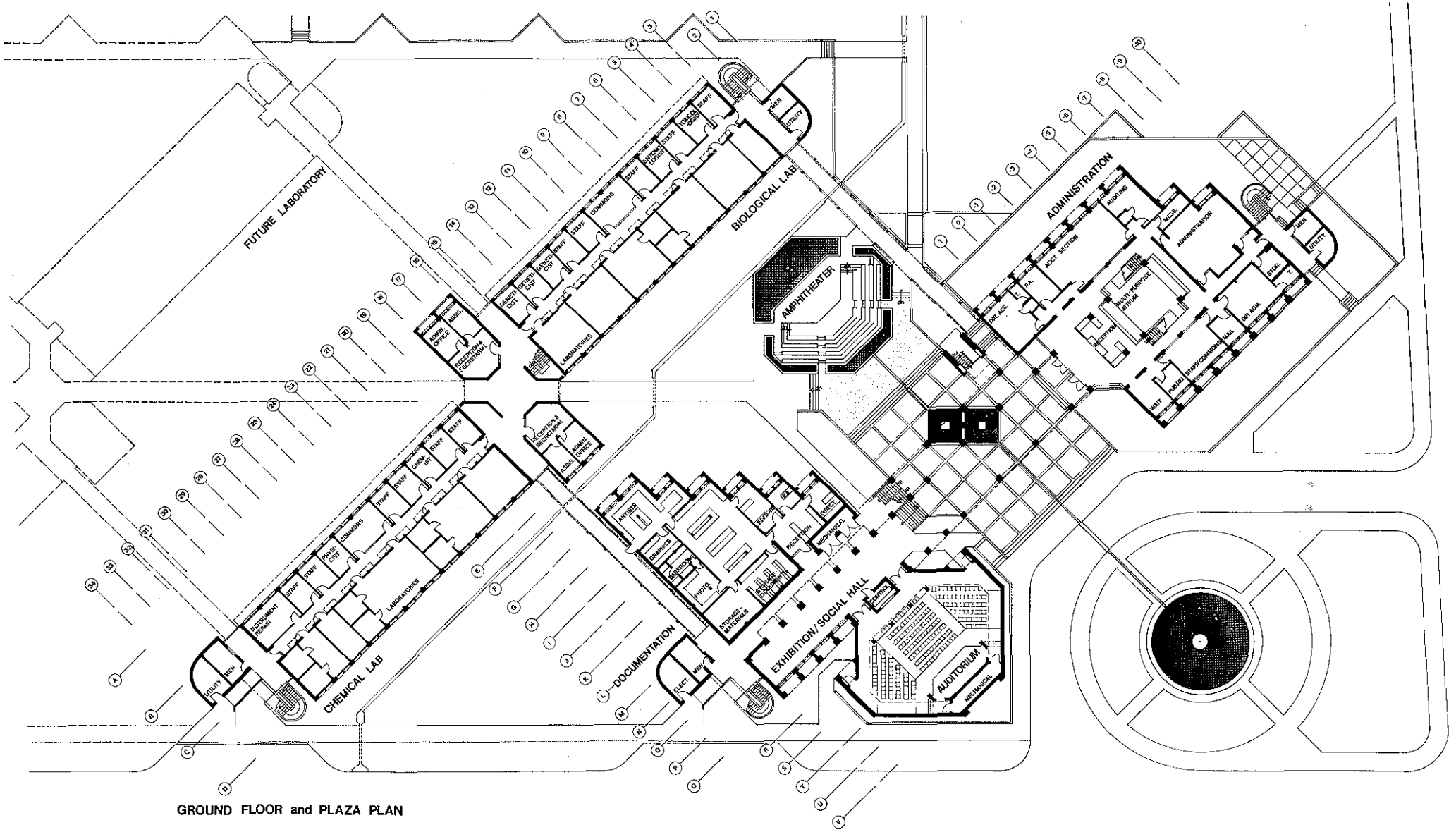
By carefully anticipating how the buildings would be used and the nature and number of individuals who would be involved, the rooms of the various NARC buildings were sized and arranged to function appropriately. (refer to floor plan across page)

As one arrives at the main entrance plaza, directly right is the Administration Building with its reception area visible through a glazed entrance wall. Directly left and down a half-level is the multipurpose Exhibition Hall, off of which is the 200-seat Auditorium and the Documentation Center. Also directly left and up a half-level is the Library (above Documentation), and the Socioeconomics Laboratories (above the Exhibition Hall and the open plaza). Directly ahead from the main entrance plaza is the courtyard with open amphitheater. Branching diagonally left, an open walkway leads through the center and down the length of the site, passes through the center of the first-phase laboratories, and proceeds to the second-phase laboratories. The walkway ultimately will directly link all of the laboratory facilities that are yet to be added to the complex. Laboratory staff support units are located in two stories of research laboratories that branch out from the central node straddling the walkway. Going diagonally to the right from the courtyard and directly down the hill 300 feet, one arrives at the courtyard of the Training Center Complex. From there, walkways lead to hostels, staff residential areas, and the Farm Center.

The building units are distinctly different in functional purpose and they have a variety of forms that express their uniqueness; nevertheless, the whole was designed to be greater than its parts. The use of a common concrete structural frame on a ten-by-twenty-foot grid, and the same exterior and interior materials throughout, gives unity to the whole, communicating the feeling that the complex is virtually a single building.

The south facing walls are designed to control the sun; therefore the window walls differ from the north facing walls, where maximum light is desirable. All east and west end walls are solid with no openings, to exclude the sunlight. The amenable climate permitted mostly open corridors and stairways, except where security in the Laboratory Blocks and Administration Building require internal circulation. Corridors conveniently link all aspects of the complex at both levels. Toilets, service areas, and stairs are located at the outer ends of corridors on the perimeter of the complex.

The *Administration Building* is unusual because of its central, skylighted, two-story atrium. Instead of being traditional rooms on a dark corridor,



GROUND FLOOR and PLAZA PLAN

the offices are grouped pleasantly around the atrium and receive some of their light and spacious feeling from it. A generous entrance and reception area is provided as the nerve center for the whole NARC. The telephone exchange is controlled from here so that any one of hundreds of staff can be contacted. Behind reception is a large, multipurpose, recessed area in the center of the atrium for use as a receiving area for important guests, as an exhibition area, or as an interior landscaped waiting area. On the upper floor a lounge for special guests is located outside the Director General's office, with a large viewing window into the Center's computer room. The group of administrative, secretarial, and general support offices includes a large executive conference room and two smaller ones.

Opposite the Administration Building, down a half-level, is the 1600-square-foot *Exhibition, Social Hall*. At the extreme end there is a large, abstract, ceramic-tile mural representing agricultural research and its benefits. The hall is designed for large exhibitions in conjunction with conferences being held in the adjacent Auditorium. The Hall also functions as a gathering area for teas between conference sessions.

The *Auditorium*, seating just over 200, is designed for intimacy. Conferees are seated around a large thrust stage designed specifically for scientific conferences. As no individual is more than thirty feet from the speaker, audio assistance is unnecessary. Designed for the comfort and convenience of conferees, the air-conditioned space is carpeted and has upholstered seating, an accoustically reflective ceiling, flexible lighting, and film projection facilities.

The *Documentation Center*, on the ground floor opposite the Auditorium, is a companion to the Library directly over it. The 3500-square-foot documentation space is dedicated to editing, reproducing, and distributing the papers and journals that record the work of the NARC scientists. The application and effectiveness of this work depends upon its communication to other scientists and to the farmers who will directly benefit from the new knowledge. A large work space is surrounded by art and photographic reproduction facilities; offices for the director, editors, and secretaries; a reception area; storage; and a workroom.

The *Library* is a half-level up from the entry plaza and is across the corridor from the Socioeconomics Laboratories. The 3500-square-foot floor area provides a central reading space for 36 people, stacks for 30,000 volumes and periodicals, a circulation area with adjacent workroom, a librarian's office, reference and conference rooms, and study carrels. Fully air-conditioned, the Library is conveniently located for easy access by scientists, conferees, and trainees of the NARC.

The *Socioeconomics Laboratories* provide 3400 square feet of space for research work involving data processing. Administrative offices and a work-processing area support socioeconomic specialists working in large workstation landscape offices. They also have access to a mini/micro computer center and their own conference room. Located in a second-story block spanning the open entrance plaza, this group of laboratories is conveniently placed, linking two major sources of information—the Administrative Planning offices at one end and the Library at the other.

The four other groups of *Research Laboratories*, requiring customized arrangement of analytical equipment and special utilities, are located in a pair of two-story linear blocks at the back of the courtyard. They are divided into four wings, with chemical and biological laboratories on the ground floor and biochemical and microbiological on the first floor. The blocks are connected at the center by a node with intersecting corridors, providing reception and support offices for each group of laboratories. Staff offices are arranged along the south wall across a double-loaded corridor from the research laboratories for maximum convenience. Being on the south wall permits sunlight to penetrate the offices in the winter and eliminates it during the hot summer. (See the illustration "Lab Building Response to Climate.")

The individual laboratories are provided with maximum north light plus borrowed light from a skylighted corridor monitor. The double-loaded corridors are full of natural light, bright, and cheerful, instead of the traditional dark and gloomy atmosphere. They provide for interaction and wall space for exhibition. In the middle of each block, open from the corridor, is a common room for use of the staff in that wing. It can serve for conferences, staff meetings, or tea time. Waiting areas, messenger rooms, toilets, utility rooms, and stairs are located at the ends of the blocks.

Chemical and physical laboratories are provided with analytical equipment for inorganic and organic chemical analysis. These studies usually involve the physical or chemical disintegration of samples of soil or plant material, followed by the separation and quantitative identification of its chemical or physical components. Because of the dirty nature of this work, and the number and bulk of samples to be brought in from outside, these laboratories were located on the ground floor closest to the Service Road access.

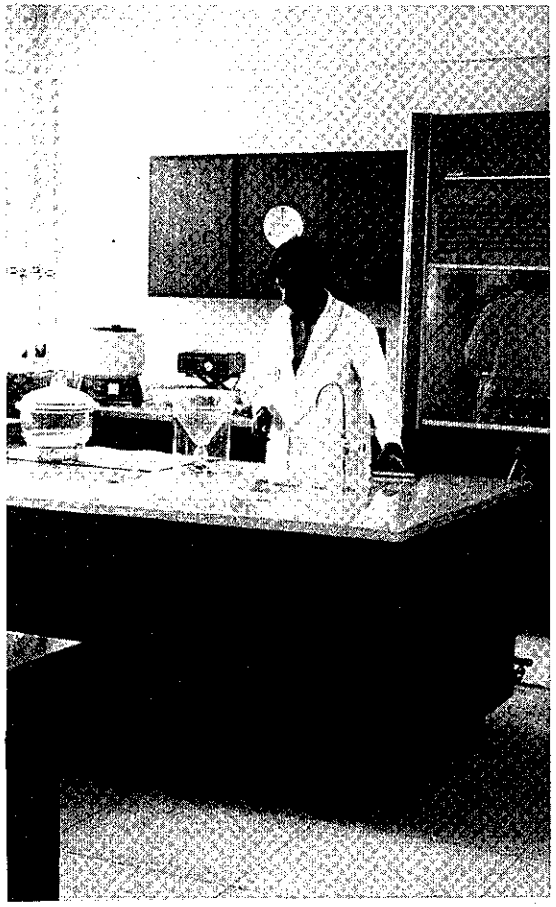
Descriptive biological laboratories support the nondestructive physical measurement of plants, plant parts, and insects for purposes of evaluation or classification. Such studies entail little or no preliminary treatment of the samples and usually involve counting, weighing, measuring, photographing, or subjectively describing the samples. Some of this work is done in the field or in a field workroom, leaving the more detailed measurements to be made in the laboratory. Because of the nature and number of samples it was decided to locate this group of laboratories on the ground floor of the other block.

Biochemical physiological laboratories support the investigation of the physiology of crops and livestock. This work consists of an incredibly complex set of interdependent biochemical reactions, employing specialized apparatus and techniques of the biochemist. Since no research program can effectively study more than a carefully selected small number of the metabolic processes or biochemical pathways, the choice of those to be investigated and the necessary laboratory equipment had to be carefully made. These facilities are located on the top floor above the chemical laboratories.

Microbiological laboratories support investigations entailing the use of microscopes, special media for culturing and identifying organisms, specialized equipment for sterilization of glassware and media, incubators for growing organisms under reproducible conditions, and facilities for aseptic transfer of organisms. Studies of metabolic processes of microorganisms require many of the same kinds of apparatus and techniques used by the biochemists and physiologists. Therefore the two sets of laboratories are located contiguously on the top floor of the Laboratory Blocks, directly above the biological laboratories.

Since research programs are ever changing and scientists come and go, a degree of flexibility was designed into the laboratories. Laboratory spaces and tables are modular and somewhat interchangeable. Service systems are designed for modification by being easily accessible. At the same time, the necessary degree of flexibility was carefully weighed against the increasingly higher costs which flexibility entails.

RESEARCH LABORATORIES



Appropriate Character and Scale

The character of a building grows out of its inherent nature as a kind of personality, whereas the scale of a building has to do with its overall size and proportional relationship to the human beings that use it.

During the process of designing the NARC, it was thought by several influential people that the building should have arched openings to contribute to a so-called Islamic character. This potential was seriously considered as a valid objective and a substantial amount of time was devoted to achieving it. The effort was finally abandoned, however, when a conflict of objectives became apparent. Arched openings are inappropriate for several reasons. First, they provide the traditional method of spanning openings through load-bearing walls. The Center has a reinforced concrete frame which supports its brick walls without resorting to more expensive brick arches. Also, providing devices for sun control on the south facades was in direct conflict with the arched openings, since the devices should be horizontal for maximum effectiveness. The final concern regarding the use of arches was the much higher costs involved.

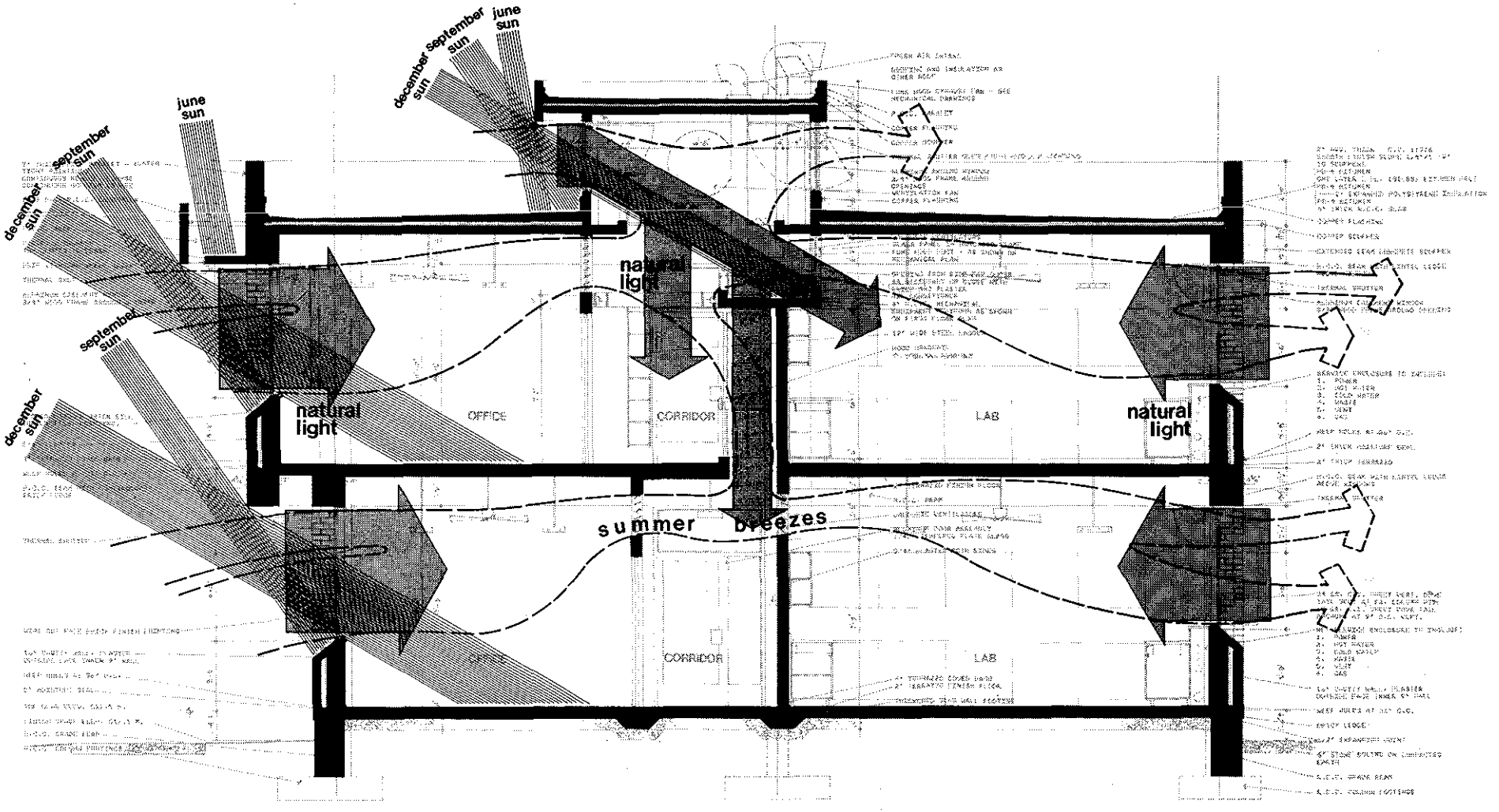
A friendly scale, compatible with human occupancy, was achieved by limiting the height of the buildings to two stories so that no one need climb more than a single flight of stairs. Corridor widths, ceiling heights, and window and door openings were all deliberately sized to the needs of those using the facilities. Offices and laboratories were carefully dimensioned for natural arms-length or one-step movement for maximum convenience. All of this was done by using a warm, reddish brick, made from the soil very near the site, to enclose the building. The same brick was utilized for the plaza and amphitheater.

Appropriate character and scale, then, are the result of the careful choice of materials, forms, and dimensions that are best suited to meet very specific user objectives. In the case of the NARC, the character and scale are not at all contrived, as is often true in a stylistic design approach.

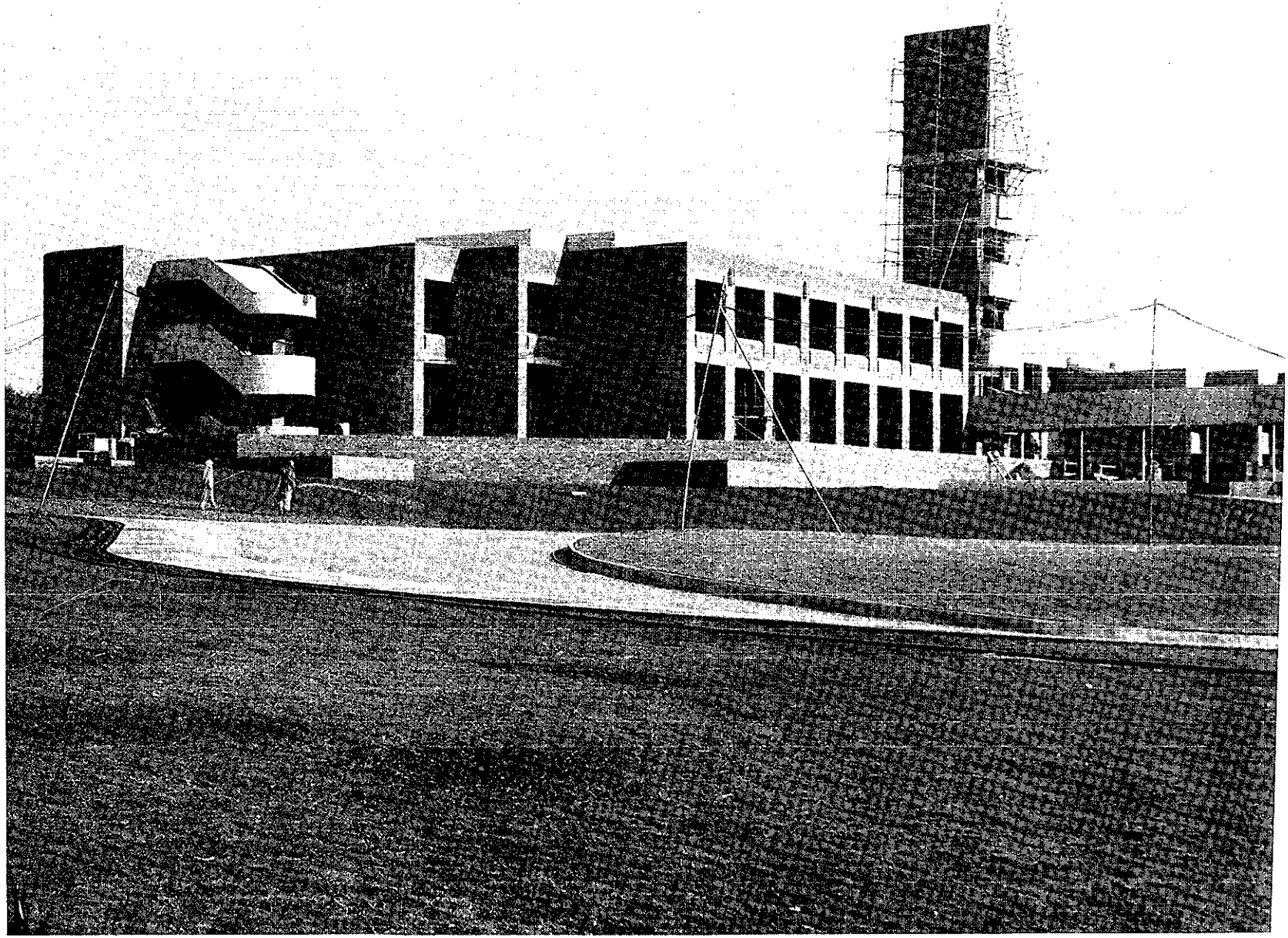
Appropriate Systems

More than any other aspect of buildings, the systems are supposedly the most appropriate feature because they are designed by engineers using totally objective mathematical formulas. That is not necessarily so, however, because the assumptions may have been incorrect, leading to wrong objectives. For example "air-conditioning" to many means that a room must be *cold*. Pakistani engineers insisted that the NARC should be centrally airconditioned, but the initial and operating costs would have been unreasonably high. By convincing everyone that the objective should be *comfort*, rather than *cold*, an energy-conscious building was created that was comfortable most of the year without an expensive system, thereby reducing initial costs by an estimated 70 percent and operating costs potentially by at least 50 percent. Incremental and small-package units were selectively introduced to provide flexibility and diversification, resulting in the dramatic cost savings while providing for more individual control.

High-voltage power is provided to a transformer at each building through a loop system designed for expansion of loads. Similarly, the water supply system and the septic tank system with leach fields are designed to provide adequate expandible and dependable service. Utility services in the laboratories, as mentioned earlier, were designed for easy access and flexibility. Plumbing, electrical, and other service lines are run in a horizontal chase in an accessible space on the inside of the outer wall, concealed by laboratory cabinets. The plumbing and electrical service systems were deliberately designed with excess capacity at greater initial cost as an investment in the future. The excess capacity reduces the risk of breakdown while the NARC becomes well organized with a good operation and maintenance division. The resultant ease and reduced costs of expansion will be more appreciated in the future.



LAB BUILDING RESPONSE TO CLIMATE
BUILDING SECTION A



MAIN RESEARCH COMPLEX LOOKING NORTHEAST

49.

CONSTRUCTION

Learners in a Fast Track

Discounting the long preliminary period full of unanticipated delays between 1975 and 1980, the total time required for the design and construction of the NARC Main Research Complex was just over three years. Compared to the development time required for other public buildings in Pakistan, that is a record. However, the construction could have been achieved in six months less time had there not been numerous unnecessary problems.

The commission for the design of the Main Research Complex was awarded to Abris Ltd. Architects and Planners in January 1981. Construction of the foundations of the Laboratory Blocks of the Main Center began just six months later, in July 1981—an unusually short period of time. A partial set of design development drawings was transmitted to the local architect, Zaheeruddin Consultants Ltd. (ZCL), in April, to make this possible. The complete set of design development documents was delivered to ZCL in July 1981. Construction documents for other aspects of the Center were being prepared by ZCL through November. This procedure is called "fast tracking," as opposed to waiting until all drawings and specifications are complete before bidding the work and beginning construction. Fast tracking has many drawbacks, which supposedly are outweighed by the potential advantages of reducing the overall development period. This method was adopted for the NARC since it is a common practice in Pakistan.

The rate system in building contracts, patterned after European methods, is utilized in Pakistan. In contrast to the American lump-sum or fixed contract, the rate system permits considerable flexibility (and also abuse). Since contractor's payments are based on measured quantities of work produced, multiplied by a tendered rate, construction can proceed for footings and foundations while architectural plans for later construction are being prepared. This all facilitates the fast-track concept. In the case of the NARC, architectural collaboration difficulties, problems of communication, and conflicting advice to contractors perhaps caused more delays than time saved by the method. However, other factors made it necessary for the contractor to begin construction at the time. Appropriated funds had to be spent by a certain date, and McDonald, Layton and Costain (MLC), the contractor, was already mobilized at the site, working on the Training Center buildings.

Very soon after construction began it became obvious that management skills commensurate with the potential time savings of the fast-track method were lacking in the project. Such skills are scarce, and available management tools are under-utilized in Pakistan. The primary reason seems to be that unpredictability of suppliers, subcontractors, labor, and payments cause contractors to despair. For example, making a critical path method (CPM) actually work for construction management purposes is virtually impossible. Exacerbating the situation is the cultural habit of setting unrealistic goals and making impossible promises to please a client for awhile, facing the consequences of failure at a later date.

Though the bulk of the contract documents were completed by the local architect and approved by Abris by November 1981, it was several months later before all mechanical drawings were completed. These unexpected delays affected the contractors' attitudes and were an important source of problems. However, the primary difficulty was the lack of management. The Pakistan Agricultural Research Council (PARC), the contractors, and the local supervising architect were not utilizing good management practices.

In May 1982, Abris Ltd. was asked to play a monitoring role in the project, providing advice and backing up the local architect at the site to improve quality control and communication. Abris also agreed to provide a monthly job-reporting service. A computerized scheduling and cost-reporting system was developed and used through the remainder of the project.

In June 1982, PARC was advised to adopt improved management procedures and appoint a new Director of Works. This advice was readily accepted, and the new policies and individuals selected provided the potential for the successful completion of the project. To work with the PARC Director of Works, Abris appointed a full-time resident engineer, and rotated U.S. experts onto the site for periods of two to six weeks through the remainder of the project. The combination of PARC and Abris staff, complementing the ZCL staff, provided the catalyst that spurred the project to completion, overcoming a multitude of problems along the way. A complete history of the problematic process can be obtained by reading the series of Abris assignment reports, beginning with RD-1 of August 1980, through RD-26 of January 1984. This final report is only a brief summary of the process.

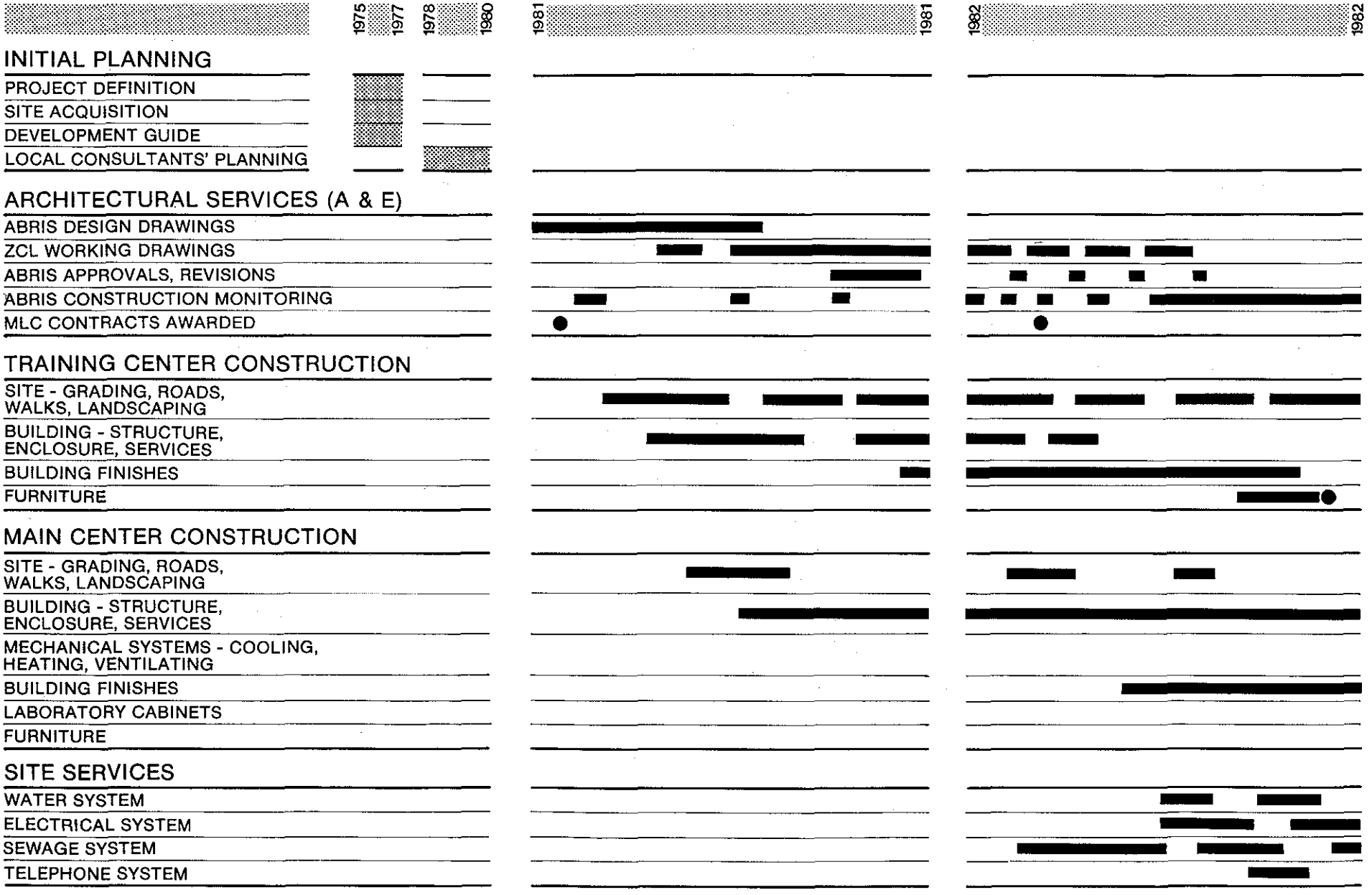
Development Schedule

By January 1983 the contractors (MLC) were promising that the project would be completed by June of that year. Abris pointed out that such promises could not be kept and that contractors hould be realistic. It is interesting to note the following excerpts from the Abris monitoring report RD-20 of June 1983:

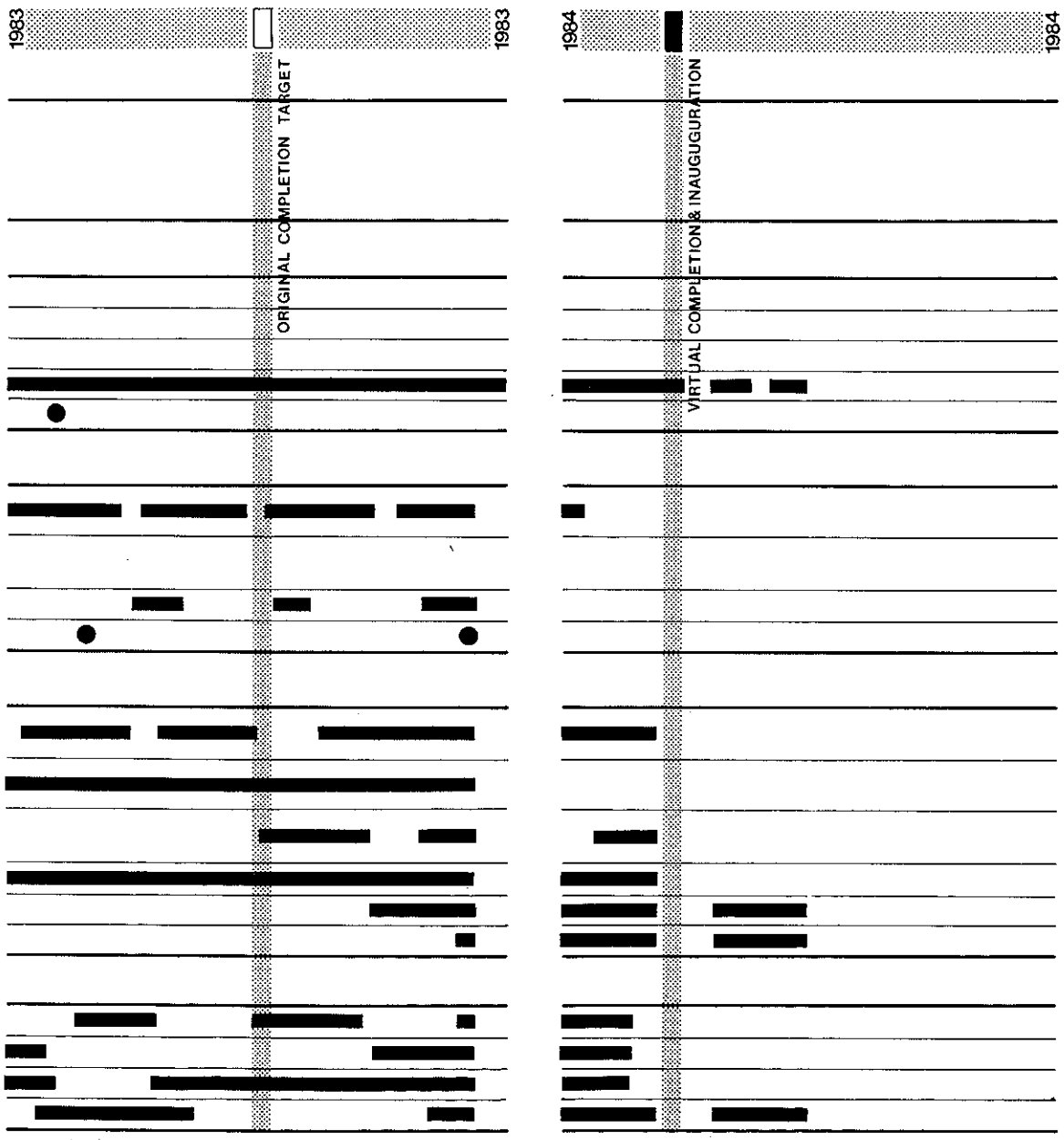
> This assignment was originally scheduled to be the wrap-up of Abris extended monitoring responsibility, coinciding with completion of the NARC Research Complex. The predicted target was not met—. The obvious question is, what is causing the delays, and when will the project be completed? An inauguration date has been set for March 1984. Is it realistic to believe that the Center will be completed, open and in operation by that date?
>
> The question can be answered in several ways. The Pakistani answer is "Yes, of course it will be completed in two months," (while knowing full well it will probably require at least two or three times that long.) The American answer would be "Yes, it is possible, but unless various hinderances and poor management practices are eliminated, there is reason to doubt whether it will be ready." Based upon experience with the Training Center Complex, ridiculously small issues can cause more than a year's delay.
>
> In January 1983, it was very obvious that the June 30, 1983, date was unrealistic. At that time Abris projections were extended to September 30, 1983. At the same time MLC was still predicting completion of civil work by the end of April. What were causes of completion delays beyond June 30?
>
> 1. The World Bank—funded additional work was introduced unexpectedly, diverting materials, manpower resources and the attention of MLC management. Concrete crews could have completed the USAID-funded facility 4-6 months earlier, which could have permitted completion of civil work by the June 30 date.
> 2. MLC instigated a deliberate slowdown for several months during late 1982 and early 1983, because they were not being paid for their work on the World Bank project.
> 3. Most of the month of May 1983 was lost due to a cement shortage. No concrete work was undertaken.
> 4. The single source of brick has been a chronic problem from the beginning. Because the plant changed ownership recently, the number of usable brick dropped from 15,000 per day to 3,000 per day, and at the time of writing this report the plant is closed altogether for an anticipated two-week period. With an estimated 300,000 bricks to lay for the USAID-funded work alone, it is obvious it could require at least four months just to complete the brickwork.
> 5. Most serious of all and of great concern is the quality of labor and engineering staff now running the project for MLC. There have been chronic personnel problems from the beginning. Repeatedly, trained staff have left for much higher salaries in the Middle East. There is a very obvious deterioration in quality control of concrete work and brick masonry.
>
> As was stated in meetings during this assignment, considering all of the problems and handicaps, including a rather restrictive budget and inadequate supervision; the progress of work at the Main Center is somewhat remarkable.
>
> The question remains, will the Center be complete by the March inauguration date? *It is possible, of course*; but no one dares promise that it will be, nor can anyone ensure that it would be. Only if an expatriate management team were given full responsibility and power of control to see that it happens, it probably will not be fully completed as hoped by everyone. The following difficulties must be overcome almost immediately, or several aspects will certainly not be ready:
>
> 1. MLC must provide more and higher qualified managers and project foremen to push the work to completion on parallel tracks.
> 2. ZCL must improve their supervisory staff. There is no one currently qualified to coordinate mechanical work. Problems of lack of coordination, poor management and no anticipation of required guidance until a crisis arises, have been evident in the past as causes of delay.
> 3. There are several aspects of the total project for which no contracts have yet been signed, such as lab cabinets and furniture. It is very possible that installation of cabinets and equipment could run right up until March 1984, unless decisions can be reached to expedite the tenders.
> 4. The rate at which PARC has been able to move toward appointing a qualified person to take charge of landscape development would suggest that landscape may not be installed by inauguration time. Landscape plans and plant lists, along with recommendations for implementation have been available for over six months, but little has happened.
> 5. The supply of brick, the color and size are uncertain. No one can ensure that there will be sufficient brick to complete the tower and retaining wall by March. If at least 3,000 brick per day can be supplied on an average, the brickwork could be completed by the end of November. MLC does not acknowledge this probability in their projections and the brick supply problem could not be anticipated by Abris schedules.
> 6. Any restrictions in cash flow from PARC to the contractors can also create conditions for a slowdown in work, since it has been clearly communicated this month that MLC is in a weak financial position.
> 7. Commissioning, testing, and punch lists for correcting flaws in the buildings and their operation, can go on for months due to controversy alone. To avoid this being a cause of delay, these activities should begin now, as various aspects of the complex are completed.
> 8. NARC administration must begin to organize for occupancy, operation, and maintenance of the facilities. A staff should be appointed very soon to begin training for the following important aspects of operation and maintenance:
>
> (a) Staff organization and job descriptions.
> (b) A center for operation and maintenance including offices, stores, workshops, vehicle control.
> (c) Compilation of complete sets of "as built" drawings for all aspects of the complex.

MASTER DEVELOPMENT SCHEDULE

HISTORICAL CHART OF PROJECT PLANNING AND CONSTRUCTION



NATIONAL AGRICULTURAL RESEARCH CENTER



(d) Collection of all manufacturers' manuals and instructions for operation and maintenance.
(e) Collecting, storing, cataloging, and managing spare parts for all equipment.
(f) Identification of paint and tile types, hardware, plumbing, lighting, fittings, and fixture manufacturers.
(g) Setting of objectives, establishment of an O and M budget matching tasks with qualified staff, and preparing a maintenance schedule.

There is important maintenance work that could begin now such as clearing of clogged drainage ways, cutting of weeds, repairing of broken window glass and other tasks. As of this date there is little evidence of any initiatives in the important operational activities listed above.

Progress can be seen as good, average, or poor, depending upon consideration of the many variable factors indicated. The targets established with the Abris Master Development Schedule have been realistic and possible; but the kind of unpredictable delays peculiar to Pakistan could not be anticipated. Evidence from other large and prestigious projects, such as the National Assembly and Aga Khan Hospital (years behind schedule), indicates that delays are the rule, not the exception.

Costs and Financial Management

The original budget of the "Agricultural Research Development Loan" for Pakistan, dated 1974, included facilities for a "National Research Center" totaling Rs. 8.6 million or the equivalent at that time of just over one million dollars. This was only about 5 percent of the proposed total agricultural research assistance package of close to twenty million dollars. However, an additional 20 million rupees, or about 3 million dollars, was included for PARC staff housing in the city.

The proposed building facilities for the Research Center included Central Laboratories, Administration Building, Library and Communications Units, a Training Unit, and Dormitories. Also included were farm buildings and other support facilities, such as warehouses and greenhouses, plus a few staff residences. Cost comparisons in this report are limited to the Main Research Complex and Training Center. For these facilities the floor areas assigned totalled 67,000 square feet, estimated to be built for less than Rs. 80 per square foot. The amount budgeted for these facilities at that time was only Rs. 5,170,000, or less than the equivalent of $600,000.

The official Pakistan proforma or "P.C.1", approving the project and providing a project digest and budget, was issued in 1975. The budgeted floor areas and costs were identical to the original loan paper. Due to the unrealistically low original estimates, and the inflation that occurred during the intervening years, the P.C.1 budget had to be increased several times. The floor areas for the Main Research Complex and the Training Center increased about 10 percent to 77,220 square feet; but the financial budget was increased 300 percent to Rs. 22 million, or the equivalent of $1,850,000.

Not included in the above figures were the costs of site development. Roads and parking, high-voltage electrification, water system, sewage disposal, telephone system, external lighting, and landscaping were separately budgeted. Also, building air-conditioning, internal telephone exchange, and the cost of architectural services were separately budgeted. It is nearly impossible to prorate these other costs across all components of the total project, including the new additions being funded by the World Bank. PARC cost accounting methods did not provide sufficient detail to permit such knowledge. However, it is estimated that these other costs prorated for the Main Complex and Training Center Phase 1 would amount to approximately Rs. 18 million, bringing the total cost for the Main Research Complex and Training Center to about Rs. 40 million or just over $3,000,000.

Without air-conditioning, and aside from site infrastructure and planning costs, the buildings cost approximately Rs. 280, or under $25, per square foot. Adding all other costs which could conceivably be prorated to these particular buildings, the square-foot cost rises to nearly $40, not including equipment and furnishings. This is less than one-half the cost of other important public buildings in Pakistan, such as the National Assembly building and the Aga Khan Hospital. It is also less than half the cost of similar buildings in the United States.

During the period of Abris monitoring responsibility (1982–1984) it was extremely difficult to obtain dependable cost data. Many of the chronic problems could be repeatedly traced to poor financial management practices by everyone involved. The following is excerpted from the Abris monitoring report RD-20 of June 1983:

> To accurately determine the status of project expenditures in Pakistan is often another exercise in frustration, and virtually as uncertain as trying to predict completion dates. There are contractor's figures, architect's figures, and PARC "financial position" papers released periodically. Financial planning and financial management are not well understood or followed in Pakistan. As a result, ad hoc exercises are conducted periodically to state the financial position. Based only upon available estimates and sometimes snap judgments, their procedures lead to sudden awareness that "we are running out of money."
>
> Complicating the problem is the contractor rate system, which means total cost in the end may not agree with the original estimates, because the final quantities will vary. In the United States, total costs are established at the contract signing stage. The budget and actual costs can be reconciled right at the start of a project. With the rate system, one must closely monitor actual expenditures and predict what the trends will do to the total.
>
> Another procedure that creates problems is the lumping together of all expenditures at the NARC that are funded by USAID. Apparently there is a practice of allowing cost overruns in one component at the expense of another. This is an acceptable practice if it is planned deliberately and is based upon clear objectives. Allowing this to happen by default is a very poor practice and can penalize one component at the expense of poor control in another component.

For awhile, this was a cause of concern that funds would not be available for completion of the Main Research Complex, because budgets for staff housing and other elements of the total project had already been exceeded, reducing the total balance available.

For the NARC a "Project Expenditure Status Report" was prepared by Abris staff each month during the last year of monitoring the project. Unfortunately, the process was completely at the mercy of financial officers of PARC who provided the figures. It could hardly be considered a financial management tool, though it might have been. Since financial manipulation of figures, or "jugglery" as it is usually called, is a common practice, there was reluctance to adopt a good financial management system. Payments to contractors were almost always two

to three months behind, with continual threats from the contractors that they would stop the work if not paid. On at least two occasions the project was held up for a month for this reason.

The chart on this page is the final version of the Abris cost monitoring monthly report of data made available to them as of January 1984. It does not represent an in-depth review of actual vouchers paid, or of an investigation of quantities and probable costs of completion. It does indicate a summary, as it is titled, of the "Project Expenditure Status" as of the date of the report. Complete financial information was not available at the time of writing this final report. However, the Director of Works was confident that there was enough flexibility in cost estimates for site work, such as completing surfacing of roads, adding a lawn irrigation system and other elements, to come within the budget provided.

Further capital projects will be needed to complete development of the farm, to provide additional staff housing, to expand the Main Research Complex and Training Center, and to provide necessary support facilities. It is hoped that the concepts of the Main Center will positively influence the nature of those facilities.

PROJECT EXPENDITURE STATUS (March 1984) **NATIONAL AGRICULTURAL RESEARCH CENTER**

(millions of rupees)

Construction Component or Planning Activity		PCI Budget	Tendered Price	Actual Cost	Budget Variation
BUILDINGS	Main Research Complex	16.556	21.656	16.478	+ .078
	Training Center	5.518	7.219	5.493	+ .025
	Crop Farm Center	4.846	3.783	4.942	- .096
	Staff Residences (Category II, III)	4.320	4.327	5.320	- 1.000
	Subtotal	31.240	36.985	32.233	- .993
FARM INFRA STRUCTURE	Roads, Canals, Drainage	5.471	3.599	3.039	+2.432
BUILDING UTILITIES	HVAC-heating, ventilating, airconditioning	7.850		3.000	+4.850
	Telephone system	2.000		2.407	- .407
	Fire alarm/fighting system	.500		.500	0
	Laboratory services	1.500		1.500	0
	Subtotal	11.850		7.407	+4.443
SITE DEVELOP-MENT	Roads, parking, water supply	1.207		1.207	0
	Water reticulation (U.S. and O.H. tank)	1.060		1.088	- .028
	Walkways, retaining walls, site drains	1.508		1.508	0
	External electrification (including substations)	*6.237		*6.237	0
	Sewage disposal system (septic leachfields)	*1.215		*1.215	0
	Fountains, amphitheater, landscaping	0		1.100	-1.100
	Subtotal	11.227		12.355	-1.128
ADDITIONAL WORK	Farm—sheds, water supply and tanks, reservoir, gates, drainage.				
	Buildings—various improvements in materials, services and equipment.				
	Site—road surfacing, main gates, curbing cost escalations, and other items.				
	Subtotal			9.041	- 9.041
CONSULTANCY	(Architects, Engineering Costs)	3.585		4.755	- 1.170
CONTINGENCIES		9.500			+9.500
GRAND TOTAL		72.873	40.584	68.830	+4.043

*Note: Site services are proportionally reduced to reflect only Phase one. The World Bank is funding Phase two additions.

APPENDICES

Lessons from the Development Process
H. James Miller, Architect and Planning Consultant

There seem to be two extremes in philosophy practiced by aid donors. On one hand are agencies such as the World Bank that provide loans with few strings, leaving the success or failure of a project to the local marketplace. There are many arguments in favor of this position. However, costly blunders and wasted resources are a common result, to say nothing of the corruption that is virtually unchecked in this situation.

At the other extreme are aid donors like Japan that provide a completed product, designed and built under the direction of that country's professionals. The results are appropriate, high-quality, efficiently produced products that will serve their purpose for a long time to come. They are usually completed on time and within established financial budgets.

The two extremes are the easier forms of aid-giving. The philosophy practiced by the United States is much more difficult to deal with. I have always believed that our role in aid projects was, first, to provide technical assistance only to the extent necessary to supplement local expertise; second, to eliminate corruption; and third, to try to ensure a good product. The idea is to provide technology transfer to those with whom one collaborates, and to promote good will in people-to-people relationships. These are worthy objectives of the world's greatest democracy, but they can be fraught with difficulty if not properly handled. I have experienced the successful achievement of these honorable objectives in numerous projects related to institution building (India, Kenya, Sri Lanka). There were instances where no aid funds were provided for capital development, only for technical assistance, yet the projects were successful.

In addition to technical assistance, the NARC development project provided aid funds for capital development through loans and grants. Without the financial impetus the project would not have been conceived; still there were many problems throughout the project. What lessons are to be learned that could help PARC and USAID avoid similar problems in the future, thereby lessening the pain of developing a successful project? The following ten observations or "lessons" may provide some insights:

1. **Product Qualitative Objectives Are Essential.** There is rarely a clear, mutual understanding and commitment regarding qualitative objectives of a project. Lacking this, the expectations of both nationals and expatriates often are not met because the necessary imputs were not designed into the project initially. The level of expatriate intervention should be directly related to qualitative objectives, and because this was never quite clear on the NARC project, there were many misunderstandings. The first farm structures and housing at the NARC were designed and built by the Public Works Department of the Pakistani government. The results were disastrous, both in quality and wasted resources, because USAID and PARC failed to establish qualitative objectives and ignored expatriate advice. Similar results, though somewhat higher in standard, occurred when roads, canals, and additional farm facilities were designed by a local consultant, again without following expatriate advice. Establishing qualitative objectives would increase the probability of correct decisions regarding the level of professional help and the procedures necessary to achieve the desired results.

2. **Expatriate Project Management May Be Essential.** Nonexistent or poor management practices are more often than not the cause of poor project results. The fatalism and adhoc procedures common to developing countries cause unnecessary bottlenecks and delays—which in the end greatly increase costs, reduce quality, and cause serious frustrations. It is well to include expatriate project management in the project. The seeming extra cost could be repaid several times over in savings to the overall project costs, and the enhancement in educational value is difficult to measure.

3. **Continuity of Project Coordination Is Critical.** Particularly in long-term projects such as the ten-to-fifteen-year Agricultural Research Project, some form of continuity of USAID/PARC coordination should have been ensured. Major problems and misunderstandings occurred on the NARC project because there were serious breaches in continuity of knowledge and understanding during the nine year development period. USAID engineering division chiefs changed at least four times, and local representatives at least five times. Agriculture division chiefs changed at least four times. PARC chairmanship changed at least four times. Largely due to the commitment of the USAID agricultural division throughout, the final result was successful despite many intervening difficulties.

4. **Overconfidence in Local "Experts" Is a Danger.** There is a tendency for USAID missions to patronize local employees and to implicitly trust their advice over that of American professionals hired to give objective and experienced advice. The trust may be correctly placed in most cases, and sometimes the instant experts from the United States do not have the right answers. However, too often there is a blindness to the limited experience, biases, and self-serving interest inherent in the advice of some local employees. This was a problem on the NARC project from the beginning. Early in the project USAID engineering failed to recognize and acknowledge serious corruption that resulted in inferior construction of USAID-financed housing. When it was uncovered and pointed out, there was a scrambling to undo the damage, but in the end it was probably covered up.

   During the redesign of the NARC, the tendency toward patronization of local personnel created serious conflicts within the Mission and frustrated the Abris staff to the point of walking away from the project. Heresay as to the source of the problems was accepted as fact by some Americans in the Mission because they had not personally confirmed the facts.

5. **Expatriate Evaluation of Local Expertise Is Critical.** To avoid political favoritism, and lack of knowledge in the selection of local professionals, it is critical that objective expatriate evaluation be obtained, and that the advice be followed. Too often USAID stands helplessly by while incompetent or corrupt locals are selected, sometimes ensuring the failure of a project. It is a fact that the services of the very best professionals can be obtained for the same cost as incompetents. It is foolish to accept anything less than the best.

6. **Establishment of Realistic Targets Is Important.** Lack of experience and wishful thinking on the part of donor agencies and local government authorities leads to establishment of unrealistic project targets. When overoptimistic targets are set, the necessary management and qualified expertise are not designed into the project that might make it feasible to meet such targets. Inevitably there are frustrating delays, cost overruns, and reduction of quality. The Asian culture is particularly susceptible to promising the unrealistic to make everyone "feel good." Throughout the NARC project, this was a common occurrence among local architects, contractors, and others. Abris staff were considered "negative" to point out repeatedly that the targets were unrealistic.

7. **Pre-agreed Expatriate Intervention Level Is Important.** Once qualitative objectives are established and the local expertise has been evaluated, the required level of expatriate intervention should become clear. That is the time to agree upon and contract for the services of whatever expertise is required, not after the project is under way. The NARC project was almost a case of "too little, too late" so there was some duplication of effort, and planning costs were not in proportion to the total project costs. Fortunately, this was also a case of "better late than never," and the cost savings and resultant product quality compensated for the additional investment.

8. **Authority Commensurate With Responsibility Is Critical.** A capital development project in bricks and mortar, intended to be built on a pre-agreed schedule, requires clear lines of authority to avoid confusion and delay. Those who are ultimately responsible for design decision-making should also have the authority to stop work, to dismantle poor-quality work, or to do whatever else is required to get the desired result.

   The NARC project was a classic example of responsibility without authority. The local architect, the contractor, and the representatives of PARC could choose to ignore Abris advice; and they did so on many occasions in the interest of expediency. Quality control was virtually impossible under such circumstances.

9. **Pre-audit Tender Procedures, Tender Documents, Contracts Are Needed.** As part of an expatriate project management package, to prevent "leakage" of resources it would be valuable for USAID and the local government to monitor all financial arrangements in a project. Too often the reduced quality of a product is discovered only after it is manufactured or installed, when it is too late to do anything to correct it. The so-called "commissions" spread around are a major cause of reduced quality.

10. **Preview and Pre-approval of All Products Are Essential.** All products to be provided in a project must have shop drawings prepared in advance and samples approved before the final order is given. Contractors and suppliers must understand in advance that if what arrives on the job does not meet specifications it will be rejected. Though repeatedly advised to do so, those responsible for the NARC project neglected to follow the requirement for shop drawings and sample approval. The results of the neglect are obvious.

In the actual day-to-day monitoring of the NARC project, literally hundreds of lessons were to be learned about the particular problems of building construction in Pakistan. A major cause of the difficulties encountered by the Abris team were conflicts with an inexperienced local staff that supposedly was responsible for supervision of the project. Trying to be diplomatic and helpful was not always successful. The contractor was often confused because of mixed signals, and PARC staff were never quite certain what position to take. It would have been easier, more efficient, and less costly—and productive of better results—if these "lessons learned" could have influenced the project from the beginning.

Energy-Conscious Design Parameters
Don Bergeson, Solar Energy Specialist

Keeping in mind the design for comfort goals of the project, the following observations and recommendations were made to guide the design process:

Three graphs were constructed from the results of a series of computer runs using a large computer program, Blast, which is designed to compute building energy performance.

One graph plotted the change in solar heat gain against percentage changes if the south wall were of single glass. It was noted that the rotation of the building to 45° off of a south-facing orientation very quickly lost efficiency. In fact, the change in the heating gain would clearly suggest a losing proposition.

Another graph plotted the change in solar heat gain against percentage changes if the south wall were double-glazed. Again it was noted that the rotation would cause a considerable loss or trade off in energy conservation.

Another graph was constructed using data for Rawalpindi. The months starting with January were plotted horizontally against mean maximum and minimum temperatures on the vertical scale. It was assumed that a zone of comfort of 65°F to 85°F as an annual swing was reasonable. People should be able to work with little concern for their environment and this should be possible at this range. (Tolerance may range from 60°F to 90°F in Pakistan.)

It was suggested that the heat could be partially satisfied with building internal heat generation (people, lighting, and equipment) and solar energy. The buildings were designed as passive solar systems using the direct-gain technique with internal masonry utilized for heat storage. The studies anticipated that air-conditioning could be supplied to the laboratories in the future, if required. To accommodate that option, it was felt that the introduction of a roof monitor could allow natural ventilation for the offices at the same time. Casement windows with hinges on the east side of the window would add a further element of variation in air movement control.

The summer season is of greater concern than winter. May and June are quite hot and sunny, indicating a profile angle of about 55°F for the overhang to control

the entry of sunlight into the buildings. The evening sun could be alleviated by using vertical shading elements during sunny periods in the summer rainy season when the sun shines. The roofs and east and west walls should be insulated to reduce the cooling requirements. The walls could be designed as cavity walls (1" to 2" cavity) using insulation. The wall cavities should not be larger, as that would enhance convection in the cavity, reducing the insulation value.

By calculating an alternative configuration using 1" of insulation in the 1" air cavity, a 60 percent reduction in energy loss through the opaque part of the wall is a small part of the cross-sectional configuration. This then translates into about 10 percent energy loss reduction in the window walls, but would show a considerably larger reduction in the end walls, since the east and west walls are shown as almost totally opaque. This would indicate that the least configuration would use insulation in the building end walls which would also reduce the cooling load in the summer.

Thermal shutters were suggested for the upper windows only because the architects had suggested that shutters on the lower windows would interfere with office arrangements or laboratory apparatus. The thermal shutters were meant to be operated by the building users to create a more comfortable interior climate.

In the summer the north shutters would be left open, using day lighting and natural ventilation as much as possible, to save electricity. Opening the south shutters would also facilitate natural ventilation and day lighting (the overhangs should protect from glare but some kind of curtain for diffused shade may be needed on lower windows in late fall, winter, and early spring.) If lower shutters could be accommodated in the offices they could be closed during the daytime, leaving the upper shutters open to allow ventilation. This arrangement would reduce the reflected solar intrusion in the summer, and allow additional savings in the winter when both upper and lower shutters could be closed. This would require using the electric lighting system for ambient and task lighting. Heat from the lighting system would contribute to the building internal heat generation. These shutters would also be open at night to facilitate radiation to the night sky which would help to cool the buildings.

Power ventilation might be necessary when there are no breezes to facilitate natural ventilation. Also, if air-conditioning were added to the laboratories, cross-ventilation would no longer function. Electric exhaust fans could be located in either end of the proposed monitor or ceiling fans could be provided.

During the spring and fall months, reference to the prevailing winds shown in the environmental analysis would indicate the buildings ought to operate with natural lighting and ventilation systems much of the time, and still maintain comfort conditions with very little energy expenditure. In the winter months the buildings would be operated with the shutters closed at night in both the offices and the laboratories. The laboratory shutters would also be left closed during the day to save energy. If the laboratory layout could be designed to accommodate shutters on the lower windows, additional energy savings would result.

The configuration showed that a solar savings fraction of about 25 percent for the buildings could be expected. Calculations for a clear January day showed an estimated average temperature of about 70°F for the first-floor offices, 66°F for second-floor offices, and temperatures below the 65°F comfort range in the laboratories. It was anticipated that the diurnal temperature swing would be in the range of 10°F to 15°F, indicating a maximum of 76°F during the day and a minimum of 64°F at night in the lower offices, with a day-time maximum of 72°F and a night-time minimum of 60°F in the upper offices.

The above estimates were based on average-year conditions and indicated the need for heating devices in the laboratories to maintain at least the tolerance temperature range (60°F) and preferably a 65°F comfort range during the winter. The offices would need heating devices for the colder years.

The largest share of the energy bill for comfort conditions would be generated from the laboratories in the winter season, and from the offices in the summer. Using an estimated 1500-degree day of heating season for Rawalpindi, an average annual energy usage for heating was estimated to be 18×10^6 BTU or about 300 KWH. No attempt was made to estimate cooling loads.

In summary, the building elongation in the east and west direction provided good solar access while the short west faces presented a minimum area to the summer sun and the January winds, helping the energy situation in both seasons. Using the wall insulation in the west, north and east walls of the buildings was recommended, to enhance the energy savings. Incorporation of the thermal shutters on the lower windows are strongly recommended as these would greatly affect the reduction of energy usage year-round.

Structural Concept
David Wickersheimer—Consulting Structural Engineer

All of the buildings in the complex were structurally conceived to achieve the following goals:

1. Achieve consistent expression of structure to coordinate and reflect the occupancy functions and unify the complex.
2. Simplify details to facilitate straightforward construction techniques and expeditious erection.
3. Repeat structural element types and sizes to maximize form reuse and overall project economy.
4. Minimize the concrete reinforcement requirements to permit efficiency in the placement of steel and concrete.
5. Select structural systems that efficiently and economically satisfy spatial and functional requirements.
6. Incorporate materials that are readily available locally and familiar to the construction trades. (It was decided that reinforced concrete could accommodate all structural requirements while providing economy and utilizing regional construction expertise.)
7. Utilize the attributes of local soil conditions to minimize the foundation structural requirements and simplify construction operations.

Structural planning for the Laboratories began with a comparison of one- and two-story schemes. This study proved conclusively that a two-story solution afforded many structural as well as architectural advantages. Structurally there was a negligible influence on beam and slab design, since roof and floor loads were fairly similar. Lateral loads controlled column design; however, due to the monolithic quality of concrete, frame interaction led to a similar column size for both the one- and two-story solutions. Soil bearing capacity in sand and gravel conditions is usually quite high, resulting in minimum foundation requirements with either scheme.

The two-story scheme provided overall economy in the use of material, minimized foundation work required, and involved no particular construction complexity.

Due to the long, rectangular shape of the buildings, one-way construction proved to be structurally more efficient than two-way design and inherently involved simplified construction operations.

A 10-foot module was established to facilitate laboratory and office functional requirements and proved to be an efficient and economical span for one-way design. A 20-foot beam span (also modular) provided a workable laboratory width and also accommodated an office plus corridor. Structurally, reinforced concrete beams of this span can be shallow, can utilize minimum reinforcing, and have excellent deflection control. Columns are located within exterior walls and along the corridor to provide maximum spatial flexibility. The columns are incorporated in the exterior expression and reflect the use of space within.

The 10-foot bay spacing minimized the size of spandrels, eliminating them in some instances, and provided support at consistent intervals for the sun shading details. All structural element cross-sections were simplified for ease in forming and placing of concrete, and to allow maximum form reuse.

Depth of foundation is not controlled by frost penetration, and was based solely on structural requirements related to soil bearing capacity, once that was established.

Lateral load resistance is shared by the frames in the short direction. Column-beam intersections were made moment resistant and no shear walls were required. In the long direction, infilled masonry was provided to distribute lateral forces to the foundation. Drift control is excellent, making the concrete frame compatible with masonry and glass, controlling movements to avoid cracking and maintenance problems.

Similar structural planning considerations, as reviewed for the laboratories, were incorporated to arrive at a two-story scheme for the Library, and Documentation units. Consistency of design and construction led to a continuation of the 10-foot module, and structural systems were compared on that basis.

Two possibilities, utilizing one-way construction, were considered feasible to carry the 150 p.s.f. library stack live-load requirement: (1) A beam and slab system, similar to that in the laboratories and (2) a one-way pan joist system. The joist system has a shallower depth, but unless prefabricated formwork is used it would be a time-consuming system to erect. The deeper one-way beam and slab system has the advantage of employing similar construction methods, as used for the laboratories, and it adds visual unity to the entire complex. Although slightly greater in material quantitites, it is still the most economical system, while satisfying architectural and mechanical requirements. Lateral load resistance can be accommodated by frame action and/or by concrete shear walls, without impairing expression or spatial functions.

Of all the two-way floor systems, only a waffle (two-way pan joist) system handles the heavy load requirements and satisfies all architectural parameters. It does require prefabricated formwork to be competitive. Reliance on in-situ constructed wood forms would be inefficient and time-consuming. Visually, little is gained by the waffle expression, and internal functions seem not to warrant its inclusion. It might still be a choice if depth were an important parameter, since this would be the shallowest system.

The auditorium had the largest span requirement of all the buildings. Either a one-way or two-way system was feasible, and cantilevering around the periphery could help to control deflections and system depth. The main space is basically square and two-way behavior appears appropriate and structurally efficient. However, a span of 40 feet puts a large premium on reinforcement requirements. A waffle system would be the logical choice if architecturally exposed, but acoustical considerations probably dictate a hung ceiling which would hide the structure. Formwork presents the same time problem as mentioned previously, making this system seem prohibitive.

Including more columns within the seating area permitted application of the one-way beam slab system incorporated in all the other buildings. Its construction familiarity and repetitive nature made it an economical choice. The overall structural depth is substantially increased for a 40-foot span and its relationship to height limitations had to be reviewed. Lateral load transfer was accomplished efficiently by shear walls and/or moment

resistant frames consistent with details already employed in the complex.

At the preliminary stage, the one-way beam slab system was favored for the reasons stated previously. This was the only long-span consideration in the entire complex which presented an opportunity for the system expression to be unique.

The Administration building was also designed as a two-story building for the reasons stated previously. Similar logic made this an economical decision. The 10-foot module again satisfied architectural requirements and lent itself to a structurally efficient and economical one-way system. Therefore, the framing and lateral load discussion were similar to that for the laboratories. Detailing similarity again prevailed, unifying this building with the rest of the complex. The atrium space has been defined by a trellis of beams spanning 30 feet in each direction. The structural character developed within this space was carried into the main complex entry area for visual continuity.

Site Landscape Design Concepts
Bruce Hutchings, Landscape Architect

Plants can perform numerous functions to achieve various environmental design objectives. These functions should be the basis for plant selection and use. Therefore it is essential to have a knowledge of plant characteristics and an understanding of how various species are suited to meet design objectives for solving specific problems. Besides the concerns for human comfort and energy conservation, there are cultural and psychological objectives. Functions of plants may be categorized in relation to their usefulness for design applications as follows:

1. Architectural uses—defining and modulating site spaces and functions.
2. Engineering uses—erosion, acoustic, and traffic control.
3. Climatic uses—solar, wind, and temperature control.
4. Esthetic uses—visual accent and decoration.

If their use is preplanned, plant materials can serve a wide range of functions simultaneously. Because of their complex nature as living, growing things, plants should be used with flexibility in mind. Their characteristics and features change continually with years of growth, with seasonal climatic patterns, and with level of maintenance.

The landscape master plan for the NARC was intended to delineate the general character of the overall site and provide a detailed plant material installation guide. The plan was based on several design objectives to serve specific purposes in the following ways:

1. Exterior spaces are defined by creating outdoor rooms or visually enclosed open spaces, usually in conjunction with or as an extension of building mass and space.
2. Views are controlled by enhancing good views, framing vistas, screening out less desirable views. Parking areas are screened to soften visual impact.
3. Site circulation is defined by using plantings to edge walkways, provide canopies along paths, and to accent intersections and outdoor activity plazas.
4. Shaded areas are provided to control microclimate in outdoor areas and near buildings. All plazas and outdoor people spaces need shade during the hot season to soften the sun's effects of temperature, glare, and radiation. The buildings have been designed to control sun directly with overhangs and proper orientation. Also, they are designed to take maximum advantage of natural breezes for cooling. Large numbers of trees next to and south of buildings is undesirable as they tend to block winter sun and desirable breezes in the summer. Where windows are on west and east facades of buildings, as in the Cafeteria and Training Center, trees are needed to control solar gain. Trees are necessary also as canopies for the main plaza spaces. If shaded in this manner the spaces can be pleasant, with soft breezes and the presence of water to assist in the oasis-like cooling effect.
5. Air movement is controlled by blocking cold winds and allowing desirable breezes. Some protection is desirable from cold winter winds which come primarily from the north and northwest. Plants serving as windbreaks should be as dense as possible and be mainly evergreen species. Plantings should not inhibit air flow to and through buildings. Areas to the south and southwest of buildings thus should be fairly open and unobstructed.
6. Esthetic qualities of plants should enhance the site and buildings by providing a visual continuity overall, and by providing accent and visual focus in selected areas such as entry courts and plazas. Detailed areas, with shrub and flower-bed plantings, can provide seasonal color, desirable fragrances, and variety of texture for human enjoyment.

Plant materials used for the NARC site, grouped into five basic categories in relation to size and general purpose, are listed in the guide that follows.

Large Shade Trees (For Accent and Canopies)

Name	Mature Size (feet)	Character
Alstonia scholaris	50	Large evergreen, fast growing, rounded form.
Bischoffia javanica	60	Rounded form, deep green, shiny foliage, fast growing.
Cedrela toona Chinese Toon	60	Open, spreading form, deciduous shade tree.
Ficus infectoria Fig Tree	30	Wide-spreading, compact form, glossy green foliage.
Jacaranda mimosifolia Jacaranda	25	Open habit, fast growing, feathery foliage and blue flowers.
Spondios magnifers Hog Plum	30	Erect trunk, umbrella form, moderate growth rate.
Salix babylonica Weeping Willow	40	Fast growing, graceful pendulous form.

Small Trees and Large Shrubs (For Accent, Visual Screening, and Circulation Control)

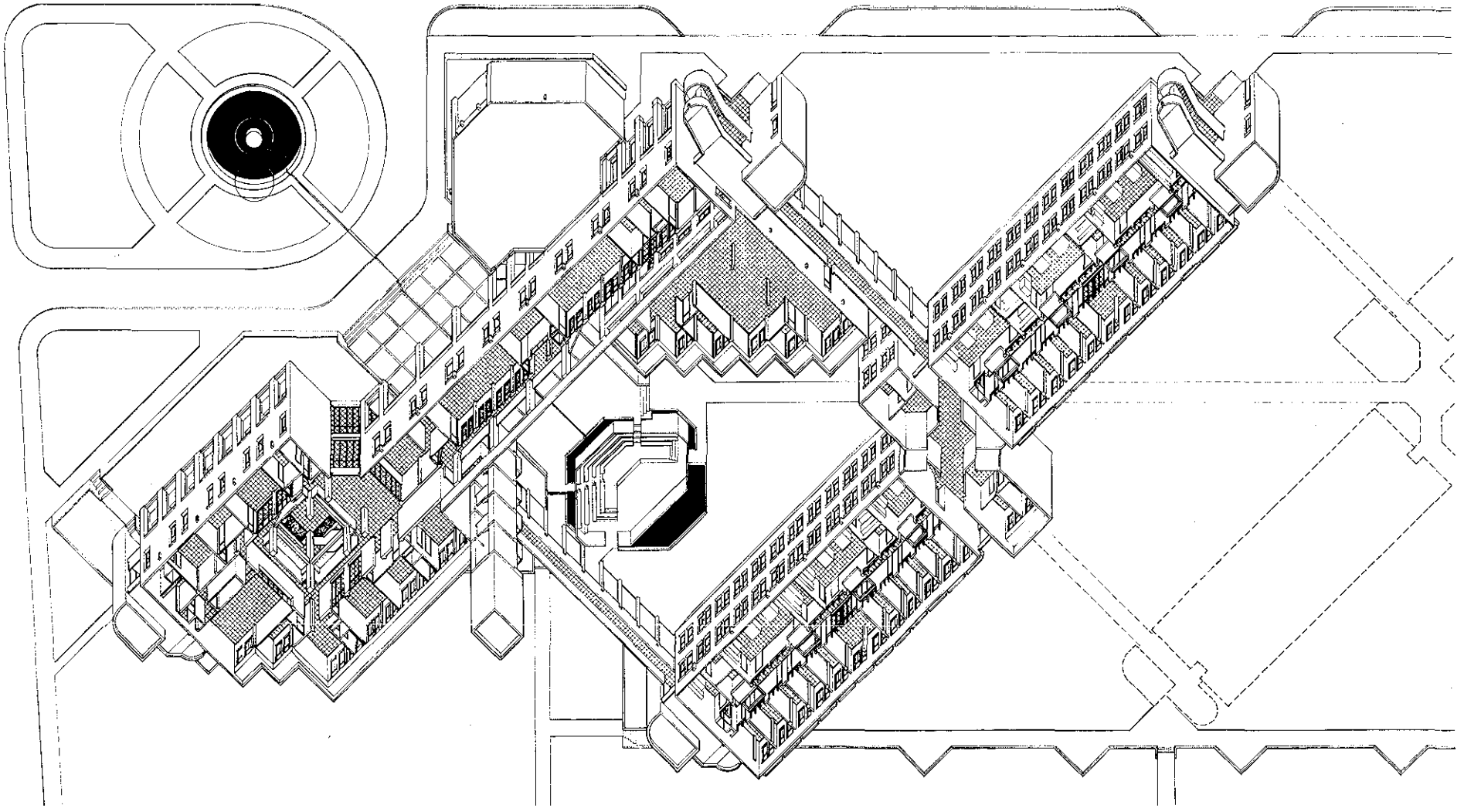
Name	Mature Size (feet)	Character
Artabotrys odoratissimus	8	Spreading, evergreen shrub, bright green foliage, good specimen.
Caryopteris Wallichiana Blue Mist	10	Erect form, handsome foliage, blue flowers.
Hamilea patens	10	Free habit, evergreen, orange flowers.
Hibiscus rosa sinensis Hibiscus	8	Flowers all year, many varieties, good hedge plant or specimen.
Jasminum sp. Jasmine	4–8	Many choices in size, foliage type, habit and flower color.
Lagerstromia indica	10	Large shrub, small tree, colorful and adaptable.
Murraya exotica	8	Bold, handsome evergreen shrub, useful specimen or grouped, white fragrant flowers.
Myrtus communis	8	Compact habit, evergreen, fragrant.
Pinus Roxburghii Pine	30	Long-needled evergreen.
Plumaria acutifolia Frangipani	20	Exotic multistemmed tree, large fragrant flowers.
Saraca indica Asoka	10	Small evergreen, compact tree, drooping foliage, orange-red flowers.
Sophora secundipiora Mescal Bean	12	Erect evergreen shrub, deep green foliage, blue-violet flower clusters.
Tecoma stans Yellow Elder	12	Ornamental evergreen, erect shrub, profuse yellow flowers.

Small Shade Trees (For Accent and Spatial Definition)

Name	Mature Size (feet)	Character
Barringtonia acutangula Indian Oak	15	Round, compact evergreen, slow growth, pink flowers.
Bauhinia variegata Orchid Tree	20	Compact, evergreen, fast growing, purple flowers.
Auraucaria excelsa	50	Distinctive needle evergreen, horizontal branching, formal character.
Callistemon citrinus Bottlebrush	15	Evergreen, fine texture, graceful, somewhat pendulous, crimson bottlebrush flowers.
Cassia fistula Laburnum	30	Open, graceful habit, somewhat pendulous, yellow flowers.
Grevillea robusta Silk Oak	25	Pyramidal evergreen, fine foliage texture.
Magnolia grandifolia Southern Evergreen	25	Pyramidal, compact evergreen, shiny green foliage, large white flowers.
Melia azedarachta Persian Lilac	35	Rounded form, fine texture, fast growing, profuse lilac flowers.
Nerium oleander Oleander	20	Variable-sized, shrublike, compact form, graceful foliage, varied flower color.
Prunus persica Ornamental Peach	15	Graceful, compact form, lanceolate leaves.
Sapium seliferum Chinese Tallow Tree	25	Informal character, redbud-like, yellow-rust fall color.

Small Shrubs (For Accent and Mass Planting)

Name	Mature Size (feet)	Character
Barleria cristata	3	Compact, fast growing, good in groupings, pruned, blue flowers.
Bougainvillea spectabilis Bougainvillea	varies	Rampant vine or shrub, many colors.
Cestrum parqui Lady of the Night	6	Handsome evergreen, fragrant flowers, long season.
Crossandra undulaefolia Crossandra	3	Vigorous, evergreen, red-orange flowers.
Cycus revoluta Dwarf Cycus	4	Palmlike, short trunk, deep green.
Eranthemum nervosum Eranthemum	3	Compact shrub, blue flowers, likes shade.
Euphorbia cotinifolia Red Euphorbia	6	Purple leaves, vigorous.
Gardenia florida Gardenia	5	Vigorous evergreen, likes shade, fragrant white flowers.
Holmskioldia sanguinea Chinese Hat Plant	6	Irregular form, orange flowers.
Hypericum chinensis	3	Rounded, compact, evergreen, yellow flowers.
Jasmimum sp. Jasmine	varies	Various habits, flower color.
Jatropha pondureafolia Jatropha	5	Distinctive foliage, scarlet flowers.
Nandina domestica Heavenly Bamboo	4	Delicate, graceful foliage, red berries.
Pittosporum tobira Pittosporum	8	Dense evergreen, deep green foliage, good specimen.
Tabernae montana coronaria	5	Dark green, shiny, evergreen, rounded form, white flowers.

Ground Covers

Name	Mature Size (feet)	Character
Crinum asiaticum Spider Lily	3	Bulbous plant, effective grouped, near water.
Lantana camara Bush Lantana	2	Multifunctional, wide spreading, multicolored flowers, good on banks.
Liriope platyphylla Lily Turf	1	Grassy clump form, spreading foliage plant.
Ophiopogon japonica Mondo Grass	1	Narrow grasslike clump plant, dense tufted.
Passiflora granadilla Passion Vine	1	Free-growing vine.
Philodendron lacerum	1	Climbing vine.
Plumbago capensis Cape Plumbago	2	Free-growing spreader, blue flowers.
Quisqualis indica Ragoon Creeper	1	Evergreen, climbing vine, crimson flowers.
Russelia juncea Fountain Plant	2	Feather-leaf, red flowers, good on banks.
Vinca major Periwinkle	1	Dense groundcover, lilac-blue flowers.