Community Involvement

It is clear that public attitudes towards major projects are becoming increasingly important. The public response is probably directly related to the number of people affected by a project. Their political clout is surely another factor. The role of media is very important in this regard and often thought to be shaping (or otherwise) the public opinion. Dealing with media, requires a skill and becomes necessary for the people dealing with large projects. This requires due consideration on the part of the project team to pay attention on the public relations.

CONCLUSION

It appears from the foregoing, that project success is a complex phenomenon. With so many different dimensions often conflicting with each other, it appears unlikely that any project can be a complete success for all stockholders during the entire life of the project, even though the project objectives are met in the first instance. Therefore referring to project as being a success or failure without quantification is nothing but a misnomer.

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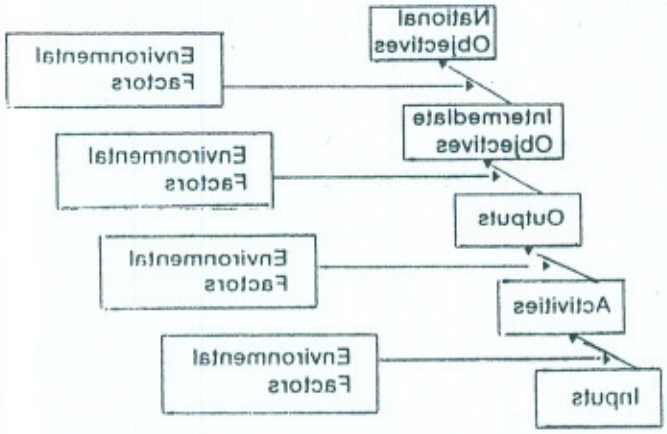

Fig 1. The Levels Between Input and Ultimate Objectives

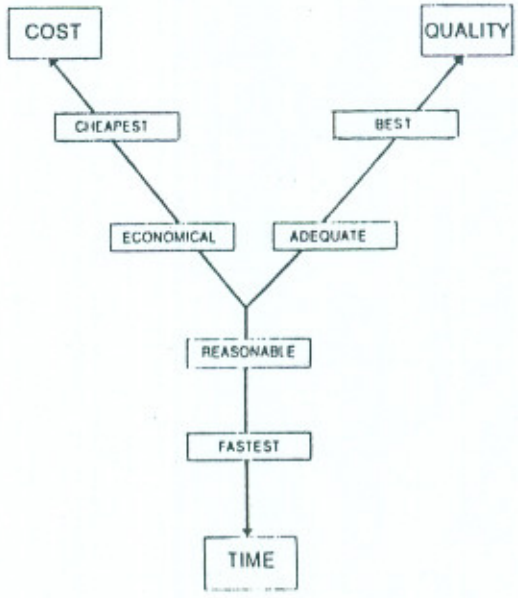

Figure 2. The Tug-of War

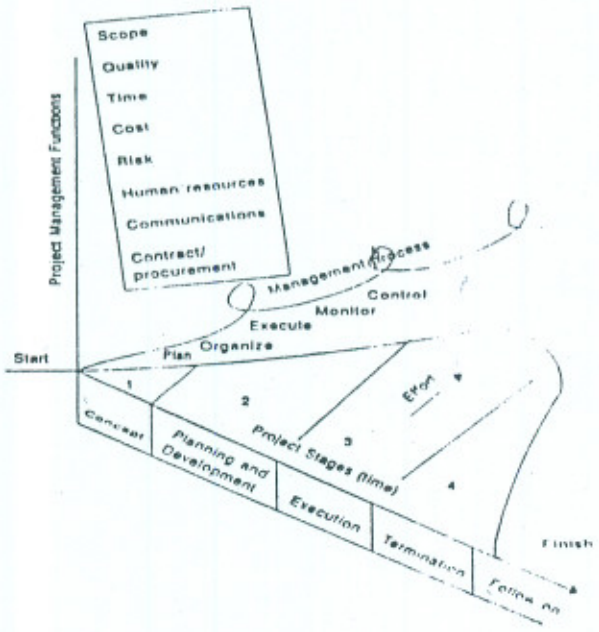

Figure 3. Project Life-Cycle Phases.

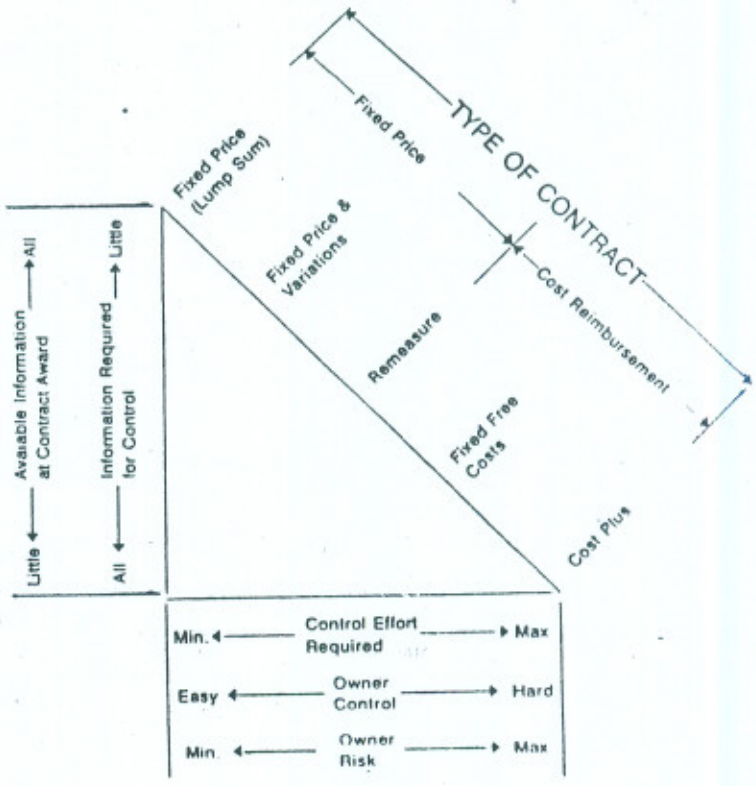

Fig 4. Type of Contract

COMPUTER AND TELECOMMUNICATION TECHNOLOGY

LATEST TRENDS IN TELECOMMUNICATIONS

(This valuable article highlights the challenges posed by new strides in information technologies globally.

** Engr. Saleem Akhtar*

INTRODUCTION

The rapid pace of development of the telecommunication services has resulted world wide in a situation in which scientists and Engineers, to an unprecedented extent, are facing up to the problem of the impact of telecommunication technology and its human benefits. Telecommunication technology and the new Telecommunication services which it is making possible is virtually immeasurable. The course followed towards a future telecommunication technologies will reinforce this trend even further. In connection with the introduction of new telecommunications technology, scientific affairs in general, have turned their attention to the economic and social benefits of telecommunication. The interest focuses on now to boost performance in telecommunications at lowest costs, for example versatile multifunction equipment's and systems better adopted to the wide variety of user requirements. Throughout the world, many countries are modernizing their telecom infrastructures in response to pressures from government, customers, competition, and the financial community. Some have replaced older technology with digital fiber or fiber/coax networks capable of delivering enhanced, broadband services. What is required is the management of the new communications network and services by computer-based systems that perform behind-the-scenes tasks necessary to deliver high-quality service to customers. This paper will look at the direction, we are heading in the evolution of technologies that under lie the telecommunication industry.

It is abundantly clear that the telecommunications environment of the future will be driven by the partnership of technology and marketing. In the near term, marketer will specify those features to be included in products based on available existing technologies. In the long term, the technologists will establish a menu of technological possibilities and marketing people will select from that menu to determine the specific capabilities that best meet customer needs.

Attempting to make technological predictions is always risky. Over the past two decades, few would dispute the statement that electronics and photonics have been driving technological forces behind the explosion in the range and scope of telecommunications services offerings. Today, telecommunications switches are large, interconnected processors using software control to deliver a wide variety of switching and related vertical services.

Photonics is becoming the key transmission technology and is determining the rate at which telecommunications advances into the provisioning of broadband-based services. Through photonics, specifically the wide deployment of fiber optic cable and accompanying terminating equipment, we are able to achieve economies of scale and increases in the quantity of information that can be transmitted over a facility.

The next two decades will see a continuation of the trend of electronics and photonics doubling their performance capabilities every twelve to eighteen months. However,

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these two disciplines will no longer be the primary driving forces in bringing applications to reality. Instead we can expect the progress in informatics and ergonomics to become the major controlling forces.

The term informatics is from a French word used to describe information processing. We use it here to address the ability to produce computer software in an economic and timely fashion so that advances in other technologies, namely electronics and photonics, can be fully exploited. Without progress in informatics, and the ability to produce large quantities of complex software, we will be able to make use of only a fraction of the capabilities provided by the advances in solid state technology. The ability of the public network to provide the flexible customized services required by the modern day telecommunications user will depend on the rate of progress that can be made in informatics, and the ability of network planners and implementers to transfer these capabilities to the public network through the introduction of flexible, customized intelligent network services.

Ergonomics is the design of human machine interfaces that allow people to communicate with machines easily, using the natural ability to hear, speak, touch and read. Success in informatics alone may permit the offering of information services the mass market may want and need, but cannot utilize because they are not willing or able to learn a new computer language or spend numerous hours at a terminal learning or relearning a complex inflexible set of interface protocols. What is required are user interfaces which allow humans to communicate with machines and networks using the natural human senses and language. The phenomenon that we are observing today, whereby a large body of the potential users of a service or capability find it too difficult to either learn in the first place or remember now to use a new service will become even more acute without major break through and advances in ergonomics. Ultimately, the level of sophistication available to the user in the year 2000 will depend largely on the success that has been realized in meeting this ergonomics challenge.

Now we will look at some of the major network latest trends that illustrate how the application of these underlying technologies is providing a wide variety of new capabilities for businesses and consumers of both developed and developing nations. These are intelligent Network, GSM, PCN, Iridium Mobile System. Satellite Communications, Internet, Broadband communication(SDH), Frame Relay, ATM, ISDN & some brief about Network Evolution.

INTELLIGENT NETWORK

The intelligent network architecture give flexibility of using information processing for the creation of customized services, either for individual large customers or for a group of small subscribers software and the ability to create new software becomes more crucial to the introduction of there services. Informatics becomes the key to capitalize on the electronics technology capability available in the network.

This architecture may be implemented in a number of ways in its full implementation, a processor called service control point or SCP, is established that works in concert with central office switching. The SCP is a general purpose computer with access to large data base. The switch performs its usual function of setting up and Completing phone calls while the SCP can be programmed relatively easily to provide a vide range of services, that can the customized for individual customer. Then, as central office switches evolve, some of the features can be incorporated into hardware designs to the extent that it makes sense to do so.

This service concept illustrates the possibility of using intelligence in the network to provide a vide range of creative services for customers. Data bases can become the vehicle for allowing network to store

information that can be used in many ways while processors will manipulate the data as needed. Information services, and transaction services and voice messaging are services that will build naturally from these concepts

WORLD OF GSM (Mobile Telephone System).

GSM has established itself as one of the largest smart card applications around the world with interoperability. The number of subscribers world wide is projected to grow to more than 50 million by the years end. Initially developed Europe as an alternative to analog cellular and to allow roaming among countries. The united states and china are the newest countries to join GSM infrastructure. However three digital system compete in the united states, GSM, CDMA (Code Division Multiple Access) and TDMA (Time Division Multiple Access). Although TDMA and GSM have a similar interface between base stations and mobile, CDMA uses a different transmission method.

GSM already proven as one of the most mature digital technologies, is in its third generation and gives operators a vendor list of equipment necessary to have systems running within months, Because of GSM's advanced features with its smart card technology, this digital system has set the world standard for digital communications.

WORLD OF IRIDIUM MOBILE SYSTEM

Communication satellites do not respect national boundaries. consequently they have a vital part to play international communications. Motorola and a number of the other leading telecommunication companies have planned networks of satellites in low earth orbit (LEO) that would enable subscribers to use small hand held telephones when even in the remotest part of the Globe. This technology will complement existing terrestrial cellular and wired systems and could meet the need of remote areas where it is too expensive to provide communications. However, even in the long term it will not be a low-cost option. Because the cost will run into billions of dollars, a limited experimental system will be launched initially. In the longer term, the potential market is huge, expected to be 2 million customer by 2002.

The name iridium was chosen for Motorola's global, digital, wireless communication network because the original concept required 77 satellites to span the globe and 77 is the atomic number of the element of iridium, have been reduced to 66 by further development of the original concept. The iridium system intends to offer high quality, global voice, paging, facsimile, data and radio determination satellites services to its subscribers.

The iridium system includes a constellation of low earth orbit satellites located approximately 420 nautical miles above the earth. The satellites will be small, light weight and interconnected to provide continuous line of sight coverage between all points on the globe. Each satellites will project beam patterns on to the earth's surface and the entire constellation will provide ubiquitous coverage. The iridium telephone will communicate directly with satellites overhead and will interface with public switched telephone networks (PSTN's) through terrestrial gateways. These gateways will store customer billing information, keep track of user locations and interconnect with terrestrial carriers. Service will be available on a country by country switched basis as negotiated with individual governments, telecommunication authorities and services providers.

PCN (PERSONAL COMMUNICATION NETWORK)

The personal Communications Network (PCN) is undoubtedly an exciting and challenging development in mobile communications of the late twentieth century. The concept of low-cost, high quality mobile communications for the mass market has created a tremendous surge in interest, not only within the industry, but also amongst the general public. One of the most interesting aspects of

PCN is its rapid gestation. The most suitable technology was determined to be the digital European Cellular Specification known as Groupe Special Mobile (GSM). A great deal of work had already gone into developing this specification, and minimal variations are required for PCN. This leads into the question of what changes are needed to adopt the GSM specification to make it suitable for a mass market. It is spectrum allocation, GSM is specified for operation at 900 MHz - an already overcrowded area and not suitable for a high density system such as PCN. To achieve this, it was proposed to simplify the GSM specification by selecting relatively low power mobile approach. By going for a hand-portable system, roughly equivalent to a cellular Class V set, PCN can gain a number of major benefits. Because cell sizes are small, handset power can be reduced and reducing size. PCN will be a GSM based network but configured around a hand portable. The PCN service is targeted to provide a high quality of service and this will require a massive investment in infrastructure. The selection of the GSM approach eases the engineering problems but increases the investment cost. Lower- power handsets mean more base stations, and PCN will require more than five times the number of base stations currently in use by each of the present cellular operators. A long term benefit from the much larger system is its much greater capacity. A total of 5 million users can easily be accommodated and perhaps up to 10 million in the longer term. This means small cells- typically less than 1-km radius in city centers and 6km in the country compared with up to 15km for current cellular systems. Fortunately, the equipment now being developed and validated for the forthcoming GSM system can be utilized for PCN with very little modification. Only at the RF end are there major differences; the signaling protocols and other elements of the network interfaces remain unchanged. In fact, in some areas, the standard GSM equipment can be simplified and improved. The lower power requirements mean that high power amplifiers are not needed. The network architecture will be same as for GSM with distributed network intelligence to locate and charge the customer.

A general architecture for the up-and -coming PCNs will use technology based on the findings and recommendations of the GSM Committee, which is a constituent of the European Telecommunications Standards Institute (ETSI). Mobile telephone communicate with base stations at a frequency of about 1.8 GHz. In some cases, very large quantities of traffic may be local to a very small area, for example, a major travel port or tourist attraction. In this case, the area may be subdivided into a number of smaller cells, termed "microcells" or "picocells", which serve to relieve the loading on the parent cell. Each cell has as its core a base transceiver station (BTS), which communicates directly with the users handsets. Groups of between 5 and 20 cells are linked to a base station controller (BSC). Finally, the BSCs are connected to (master) switching center (MSC). MSCs will communicate with each other and also with the public switched telephone network(PSTN).

FWA (Fixed Wireless ACCESS)

Fixed wireless access (FWA) technologies offer the promise of high-quality telephone service for many people deprived of basic access and competitive costs. FWA technologies also help fulfill several core policy objectives, such as a rapid increase in teledensity, universal service objectives, and preserving radio spectrum efficiency and value. Essentially two imperatives are driving FWA deployment, one is unsatisfied demand for "plain old telephone service" (POTS). and the other is emerging legislation fostering competitive local access provision. From the user's perspective, achieving core policy objectives translates into affordable service prices and increased service quality and functionality, independent from the kind of technology used to deliver voice signals. A radio access system should

cover the same service as a copper pair network to conventional customer premises equipment (e.g. telephones, fax machines and modems). The search for economic growth is producing trend toward a more liberal business climate that favors deploying wireless technologies in the local loop. FWA technologies greatly enhance local exchanges competition due to their flat cost structure, which depends less on economies of scale than copper and fiber in the loop solutions. Besides capitalization, fast deployment of access networks is one of the major challenges facing telecommunication operators attempting to increase telephone penetration. The International Telecommunications Union (ITU) recommended in 1992 a desirable POTS penetration target of at least 20 main lines per 100 inhabitants to meet the minimum requirements for economic development. That may be challenging to achieve by the end of 2000, given the actual teledensity reaches an average of 9 percent. Nevertheless, it is fairly desirable given that in some North American and European countries, the teledensity figures surpass 50 percent. In Latin America, expenditures for FWA systems have reached US $59.7 million, still behind the US$77.6 million spent in Western Europe, but surpassing Eastern Europe's investment level of US$14.9 million and Asia Pacific's of US$39.8 million.

Numerous technical and economic advantages differentiate FWA from wireline systems.

Operational costs

Wireless access means less copper wire to install, as well as less right-of-way and civil engineering works. Without large amounts of under ground plant, maintenance cost can also be reduced. Radio can serve a large subscriber base at a lower cost per customer covered (assuming appropriate range and capacity).

Deployment velocity and flexibility

The main business disadvantages of wireline networks include long lead times and stranded investment. Wireless systems can be deployed in months rather than the years required for wireline infrastructure and civil engineering works. FWA allows an operator to build network to meet customers service needs where little or no telecommunications infrastructure exists, without delays and with minimum cumulative capital investment. Wireline networks require intensive planning and forecasting, but if demand increases in unexpected areas, the resulting deployment becomes inefficient. Wireless systems enable operators to expand infrastructure along with the increase in subscriber numbers and match investment with service revenues.

Competitive access provision

In FWA networks, a large portion of total costs is variable. Radio technology makes access networks traffic sensitive, allowing traffic channels to be shared among several subscribers over a common-air interface. Wireless network can break even at an earlier point than wireline networks, which require extensive planning and sustain the revenue flow for longer time.

SATELLITE COMMUNICATIONS

We have witnessed a real revolution fostered by the use of telecommunications satellites. The satellites have advantageously replaced terrestrial system in many situations since they made possible the provision of reliable and high quality communications at lowest cost, both for international and domestic applications.

In the field of international communications, satellite systems became fully stable and sound when they replaced short-wave links and old submarine cables. The use of satellites to provide mobile stations installed at ships and boats with communications has come true, thus allowing there interconnection with public networks showing quality and reliability levels never achieved by systems

that used HF bands for such a purpose.

Nevertheless, it happens that, with the advances in telecommunications technology, new means and techniques available to terrestrial systems, such as optical fibers and network digitalization, appears to pose strong competition to satellite uses.

As present, the great challenge imposed upon satellites communication concerns the availability of small size and low cost earth-stations, which may contribute to overcome the serious difficulties, developing countries usually face, when attending remote and scattered inhabited regions of their territories.

Also, earth-station costs and portability will be a decisive factor for their use in vehicles, thus allowing satellite communications with those areas not covered by mobile cellular telephony.

Unlimited possibilities for satellites utilization may be also foreseen with the perspective of direct connection between satellites and with transponders switching techniques, which will decisively influence the future of telecommunications. Thus, communications satellites show wide perspectives, either as a complementary means for the terrestrial network or in applications for which their features are better adapted, or even as an alternative means, improving the reliability of services and allowing the attendance of more immediate requirements of users.

INTERNET

Internet is something simultaneously more than and less than a network, but rather as a huge number of different computer applications trying to talk to each other. If we think of the Internet as equivalent to the Global street numbering scheme, we may be getting close. Using this addressing I can send a letter, or I can spend 100 times more on an overnight courier service. In either case the address will remain exactly the same, except that my package will use a different infra structure from the letter and will get there on time.

The Internet from the providers point of view, is fast beginning to look like a fluid arrangement of under connection agreement. The drift of regulatory change in allowing global providers, or alliances of providers, to build end-to-end owner ship of the underlying facilities across the core network. This allows them to increasingly offer service quality as a competitive differentiator.

Confidence is high that Internet traffic will overtake telephony traffic on the world's switched digital networks by the end of the decade. However, while the Internet is daily becoming more and more of an opportunity for telecom. It also poses some distinct threats. It is important to note that the Internet is not expanding at an equal rate, everywhere, simultaneously. Growth varies by region, and at present, the Asia Pacific is the area of fastest development. In fact, the point when Internet traffic will actually exceed telephony is expected to be reached first in Australia. By the end of the year there will be more bandwidth from Australia to the US for Internet connections than for all telecomms combined. The growth in the Asia Pacific Internet market has been phenomenal evident, which estimated a 239% increase in host computers and a corresponding increase in PC sales well over the international average of 28%. Japan, Taiwan and Australia are the front runners, while growth in some other countries has been shifted as a result of the political economic and regulatory barriers placed on Internet access by national regimes. The year 1996 to 1998 will show a three fold growth in users up from 2 million to 6 million. One of the main reasons for such dramatic growth is Asian demographics. Some 50% of the regional population is under the age of 25, the dominant age group of Internet users.

However, the existing infrastructure is inadequate and national & international networks have struggled to keep pace with the huge growths in Internet usage. The scarcity in back bone capacity across the Pacific is slowing access speeds, causing delays in connections and

resulting in traffic congestion. Local access in many of the less advanced. Asian networks is similarly problematic, being slow and unreliable. Pricing regimes also put the Internet beyond the reach of the mass of the populations in developing countries.

The Asian Pacific Internet community started working towards an Asia Pacific Internet infrastructure through various ventures which initially provided local language support over the past five years, there has been a remarkable degree of cooperation between different Internet players. For example three Singapore ISP's got together to form the Singapore Transport Internet exchange. Hongkong ISP's creating AP Mesh. Today the region has two Internet hubs, one in Japan, the Asian Internet holding(AIH) and Singapore based STIX. In addition a major commercial initiative, the AP Mesh, is in place, to whereby telecom are developing a backbone through bi-lateral peering. There are also many other Internet exchange points T&T, Global one, UUNET, IBM & Concert have set up a global Internet backbones.

SDH

Telecomms networks today integrate digital technology, fiber-optic transmission and micro processor components. Together these technologies are forging a network infrastructure that will support telecom needs well into next century. These same technologies actually international versions are building blocks of Global intelligent networks. One particular network transmission standard, known as the synchronous optical network (SONET) in the USA and Synchronous Digital Hierarchy (SDH) in Europe, offers particular promise for the future.

Sonet was developed by Bell Communications Research (Bellcore), a "Central Services Organization" funded by the seven regional Bell Companies. It will be used to boost the speed and efficiency of fiber-optic transmission and to open the door for intelligent network services. Optical Cable ranging form 51.8 Mbit/s to more than 2.4 Gbit/s.

The use of Sonet eliminates the need for de-multiplexing and re-multiplexing synchronous data traffic. SDH will bring great cost and efficiency benefits to telecom and eventually to large users, but the impact on vendors is less certain. The huge research and development costs required to stay in the SDH market look likely to continue at least until the current shake-out in the telecomms equipment market reaches its logical conclusion. This will mean there will be only a handful of global players in the main stream market for SDH transmission equipment.

SDH is designed to provide considerable flexibility in the way tributaries can be concentrated into single high-speed bit streams. This flexibility is necessary to support migration from a number of different transmissions system towards a common worldwide frame work which provides vendors with a Global market.

FRAME RELAY

Because it offers significant advantages over high speed data transmission techniques, frame relay technology is expected to enjoy dramatic world wide growth over the next few years. Compelled by increase competition in both Europe & Abroad, businesses are turning to this fast, efficient method of transmitting packetized data in an effort to cut their communications cost while improving network performance. One of the earliest adopters of frame relay in Europe is the Union Bank of Switzerland, the country's largest bank. The bank began using a new network to provide voice & data services to its 250 offices throughout Switzerland. The network is managed by four computers, and initially consists of 112 nodes, supporting more than 1000 terminals and automatic teller machines.

The basic nature of frame relay is ideal for variable bandwidth uses because it is a more efficient user of

bandwidth than TDM protocols. These speed improvements and cost savings can be significant when compared to the private line networks now offered by European PTO's. As a result, PTO's are gearing up to meet the expected demand for frame relay. The roots of frame relay are to be found in the protocols designed for use with the Integrated Services Digital Networks (ISDN) now being deployed in Europe & the U.S. Like ISDN, frame relay is a standard based solution for public and private data networks. Frame relay strips down the protocols information needed for transporting packetized data. Packets can be of variable size and the focus is on moving the packets, or frames, from one end of the network to the other as quickly as possible with the greatest utilization of bandwidth. Frame relay has the ability to detect transmission errors at the mode level. However, unlike protocols such as X.25, frame relay leaves data recovery to the applications. A frame that has an error simply discarded. Frames are individually addressed and sent serially in bursts so that no sequencing information is required. Only routing and congestion control information is included.

Frame relay is ideal for applications such as financial trading transactions, order entry, transaction processing, and point of sale inquiries. A common usage is for large order -entry systems. in this case, LANs or terminals are connected to a frame relay node, which is then linked to an inventory center and immediately decide whether to fill the order from inventory or route the order to manufacturing. Frame relay gives the company the flexibility to use higher bandwidth only when it is required giving the user bandwidth on demand.

Implementing an international frame relay network is not a simple task. As one can imagine, planning and implementing such a network usually requires outside expertise and a significant commitment of internal resources. Planning must continue even after the new network is installed. While frame relay will be an important issue over the next three to five years, it is only a first step towards Asynchronous Transfer Mode (ATM) using cell relay techniques. Between now and the end of the decade, user of frame relay will enjoy greater network efficiency, faster response time, and reduced maintenance and telecom cost. With many vendors predicting that frame relay will be superseded by B-ISDN, it will almost certainly start to become redundant. At the recent Telecom 91 exhibition in Geneva, while the US companies focused on frame relay, European and Japanese vendors were pushing ATM. These venders see frame relay simply as a faster version of X.25, suitable for data applications running on private networks.

ATM NETWORK

There are predictions that ATM will be the most important networking technology of the next two decades. Though ATM is described as the technology to provide integration of voice, data and multimedia applications on the same communication infrastructure, the initial applications, possibly for several years, will be data applications. Asynchronous transfer mode (ATM) technology combines the characteristics of channel-oriented synchronous network (wide bandwidth, low delay) with the advantages of packet switched data networks (flexible bandwidth). This is particularly true in the areas of quality of service (QoS), network performance and transmission quality. Interoperability between ATM and conventional networks is growing in importance since ATM will be used initially within a heterogeneous network structure to provide flexible links between existing networks. Since ATM is a statistical multiplexing technique, there is no fixed assignment of a time slot to reach source. Each source occupies only as many ATM cells as are needed at a particular instant. As a result, statistical (random) delay variations and even buffer overflows can occur when multiplexing different sources. However, the biggest advantage of ATM, flexible allocation of bandwidth, entails additional outlays in the area of network management. In the

future broadband ISDN (B-ISDN), ATM will integrate a variety of services, including:

- Data services (LAN backbones, LAN interconnects, LAN-VAN);
- Video services (video distribution services, image data servers, video conferencing); multimedia (voice, data and video combined);
- Voice telecommunications services.

There are at least three possible causes for a cell loss which go back to the specific characteristics of the ATM network. Firstly, error checking for the ATM cell header, however, if two or more bit errors occur in the header, the cell is discarded by the network and thus lost. Secondly, asynchronous multiplexing of ATM cells offers the significant advantage of flexible bandwidth allocation for individual users. If more cells are switched to a port than the port can handle in terms of bandwidth, then a buffer overflow occurs and cells are lost. Thirdly, before establishing the connection, the management functions of the network negotiate a traffic contract between the end user and the network access. The usage parameter control (UPC) function must verify and ensure compliance with the maximum allowable bandwidth and other traffic parameters of an end user. The queuing delay for the cells in the buffers of ATM exchanges have a statistical nature and vary along with the loading of the exchanges. An increasing cell delay can be seen as an early indicator of possible cell loss due to buffer overflow when the network is overloaded. Absolute delay impairs the QoS; when making a phone call, for example, it can be extremely disruptive.

Business strategies and the applications needing broadband transmission and switching capacity could not be developed owing to the lack of standards, transmission and switching equipment. Therefore, no demand was built up. ATM as a basic technology enables a new generation of products for use in the business as well as for the residential user. In the health industry, which relies especially during diagnosis more and more on picture archiving systems. These pictures are processed and stored electronically. The pictures have to be transmittable on demand and be available to other medical doctors or specialists in critical situations. ATM based networks is the technology that can achieve this. Another area is access to super-computing resources. True super-computers are and will continue to be very costly items of equipment. The sources of super-computer centers can be made available to a greater market by offering these as a service over a network. ATM based networks will, therefore, play the role of an information highway to users of such a super-computer service.

Numerous high-speed networking approaches that can meet at least most of the identified criteria, of these approaches , asynchronous transfer mode (ATM) has been selected by international standards bodies as the basis for future broadband ISDN facilities. ATM is a high speed, virtual circuit oriented cell-switching technology. ATM carry different kinds of services such as voice, data, image, video and multimedia, including real-time information, over a single network rather than several overlay networks, one for each service. So ATM presents a single integrated switching mechanism capable of supporting a comprehensive range of multimedia and data services. Switched services like ISDN offer a logical migration path to follow as the industry moves towards ATM technology of tomorrow which is likely to be based on broadband ISDN technology, but they provide the starting point for improved internetworking today.

ISDN

Further growing complexities of every body's tasks in the developing societies around the globe cause a continuing rise in terms of expansions of the

various existing networks and in demand of integrated services enabling subscribers to use any possible combinations of speech, text. Data, image and video communication services. At the same time there is strong pressure from the users and operators alike for the evolution of public communication networks into one universal network providing internationally compatible multimedia communication in one network in an integrated services digital network (ISDN). The digitalization of the telephone network based on the advances in microelectronics is a prerequisite to fulfill the users requirement.

The most vital stage in the evaluation at to days Telecommunication networks is without doubt the digitalization of the telephone network with considerable technical and economical advantages for users and operators. On the based of this network it is possible to transport all communication services over one network, the ISDN, using the existing subscriber line network of copper cables with internationally standardized, so interface 2B+D (64+64+16 K bits) will offer voice, text, the data and image communications at much higher performance levels and more economically than previous networks. This evolution has already been started and it is in different countries around the globe in different steps of realization. In this 2B+D configuration, the signaling information is carried on D channel and the B channels are used exclusively for subscriber data connections.

ISDN-based technology can also offer advantages in terms of ease of installation and maintenance. There is no need for complex routing tables since the user simply connects the protocol transparency to an Ethernet or Token Ring LAN to the access switch unit and makes the connections to the telephone service company. The system is then configured by identifying the telephone numbers for the network sites and establishing a connection is similar to making a telephone call. Another important maintenance and budgetary consideration is that line upkeep costs are the responsibility of the PTTs. Consequently there is the need for high speed information transport and wide area connectivity. Public telecommunications providers have proposed the Broadband Integrated Services Digital Network (B-ISDN), which has the potential to restructure the network technology used by both users and network operators, and which can bring forth a remarkable new era of communications capabilities. Sonet/SDH and ATM are the core transport and switching technologies for B-ISDN, and lead to many issues in technology, network architecture and service deployment strategy.

NETWORK EVOLUTION

What causes network evolution? Evolution of the communication network is influenced by two key factors: increased end-user needs and advancements in technology. In order to ensure a graceful evolution, the combination of both needs and advancements is very important. As technology in the field of information communication advance, communication previously dominated by telephone is changing into one that consists of a large share of non-vice services. This trend is most prominent in the area of business. In the business field today, a large number of office automation equipment such as personal computers, mini computers, and word processors are being used as network components. To this end, various network have been constructed to enable communication between each type of equipment. These network are expanding from office to office, and even from country to country. Another current trend, caused by the declining prices of office automation equipment, is the increased use of world processors, facsimiles, and

personal computers for home use. This trend indicates that the home has also become a base for producing and storing information. As a result of this trend, users are demanding single access multimedia services. To meet these demands, information communication services are gradually being extended to end users.

ADVANCED TECHNOLOGY

In order to achieve a network which satisfies both the needs of end users as well as network providers, advancement in the following three technologies is essential: computer technology, communication technology, and component technology. Progress in such areas as network intelligence, optical transmission technology, broadband ISDN, and LSI device technology will greatly contribute to our rapid entrance into the age of modern communications.

NETWORK EVOLUTION REQUIREMENTS

In order to satisfy the diversified, ever increasing needs of end user and to construct a network that is receptive to technology advancements, an evolution in networks is required. However, this evolution must have continuity with existing network services. That is, network evolution must utilize, to the fullest extent possible, existing telecommunication systems as they have been developed over a long period of time. In other words, while a network must function as a single system, although seemingly contradictory, each element in the network must evolve on its own. Therefore, standardizing the interfaces between network elements is an important issue.

Unless the requirement just described are met, an economical solution to network providers is highly improbable. In addition, networks must also have the flexibility to promptly meet requests for new services and changes in demands from end users.

CONCLUSION

We are about to enter a new world: of modern communication. The optimal infrastructure to support such modern communications is the universal and intelligent information network.

In leading us to modern communications, ISDN and intelligent information networks, supported by computers and advanced communications technology, are likely play an important role. Conventional networks were developed mainly by network providers and equipment suppliers; however, future network development work must now include the active participation of end users so that we can understand the full impact of Modern Communications on both society and business.

In order to successfully develop a large number of service features in a timely fashion, we must take full advantage of the advancements in such high-level technologies as digital technology, optical technology, LSI technology, and software technology. Cooperative "steering" must take place to ensure that this movement is aimed in the direction of enriching people's lives. So far, CCITT has provided excellent control from a technical standpoint and I am sure that they will continue to do so. However, the same quality of participation from a "non-technical stand-point" must take place for Modern Communications to make a truly positive contribution to society.

BALLOKI-SULEIMANKI LINK CANAL

A MEMORABLE ENGINEERING FEAT

Late Engr Mian Muzaffar Ahmed

1. INTRODUCTION

In the chrono-political scenario of fifties Lord Mount Betton came to India in 1947 to announce and implement the decision of the British Parliament for granting freedom to India. The sub-continent was to be divided into two sovereign states viz Pakistan and India. Pakistan was to comprise predominantly Muslim areas of East and West. Thus in the East, Bengal was partitioned into East and West Bengals, East Bengal being named as East Pakistan. In the West, Punjab was to be divided into East and West Punjab, the former constituting predominantly non-Muslim community to go to India and the later was merged with Sindh, N.W.F.P. and Balochistan and named as West Pakistan.

The task of the division of Punjab was entrusted to Sir Cyril assisted by Chief Justice Mr. Din Muhammad representing Pakistan and Justice Jogindar Singh Majitha to represent India.

By the 12th of August, 1947 they had jointly decided that West Pakistan would include Ferozepur District (Muslim majority) containing Ferozepur Headworks and Gurdaspur District. (Muslim Majority area) in which Madhopur Headworks was located. This information, however, leaked out and Mr. Saroop Singh, Chief Engineers, East Punjab rushed to the Maharaja of Bikaner and told him that Ferozepur Headworks and Madhopur Headworks were going to Pakistan and that his state would be deprived of water for irrigation purposes. The news upset him to such an extent that he rushed to Lord Mount Betton and Nehru and told them that he would opt for Pakistan under those circumstances. Lord Mount Betton asked Sir Cyril to withhold the division line. Pakistan was made independent on the night between 14th and 15th August, 1947 without any indications of the division line which was subsequently announced on the 17th August, 1947 and whole of Ferozepur District with Ferozepur Headworks and entire Grudaspur District., with Madhopur Headworks, were handed over arbitrarily to India.

THE PREDICAMENT

Soon after the announcement of this demarcation, India stopped supply of water to Pakistan from Madhopur and Ferozepur Headworks with the result that Lahore District., Multan District., and much of the Bahawalpur areas were deprived of water from these sources despite the legal riparian rights of Pakistan on the Ravi and the Sutlej from which its Canals had been taking water in the past. Pakistan's hue and cry fell on deaf ears for 5 years and India contended the Pakistan should pay seigniorage changes for the water she wanted from the Indian Headworks. The amount claimed was beyond the reach of Pakistan and it continued to brave the suffering. In one of his

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speeches Liaqat Ali Khan, Prime Minister of Pakistan had to raise his fist and forewarn that he would send his army to Ferozepur and Madhopur for opening the canals. The news went around the world and it was apprehended that India and Pakistan may go to war on the supply of water to the canals issue.

THE VIABLE PROPOSALS

In the wake of this unsavoury situation many people from abroad came to Pakistan to help sort out this problem. A meeting was held at Balloki Headworks in which Ministers were also present. It was decided that 60 mile long, 300 ft. wide and 15 feet deep canal should be constructed from Balloki to Suleimanki for diverting 15,000 cusecs of water from Ravi River to the Sutlej. The foreigners present in the meeting worked out the size and number of machinery required for the construction of the canal and concluded that such a large number of Machines would not readily be available anywhere. The required machinery, they opined, would have to be manufactured and would take 6 to 8 months to reach the sites before any work could be started. One of the foreigners pointed out to the author and said "what do you think". At the author's reply that we could hardly brook any delay what to say of six months to wait for the machines he was pertinent to enquire about the availability of machinery in Pakistan. He was told that our machinery was waiting outside ready for the signal to go. To his bewilderment, the officer on coming to the window instead of machinery found only a few donkeys and remarked that he could see only donkeys outside and no machinery of the sort. The author invited laughter from the foreigners at the remarks that we would start construction with these machines that very day.. Remarking that construction of such a big canal could not be undertaken without machinery they convinced the Ministers to place and order for machinery abroad who all agreed spontaneously and left for Lahore.

DELIBERATED DECISION

Burning with the patriotic zeal to do something practical to overcome the devastating situation of non-supply of water to canals, the author collected the staff and told them to celebrate the brick laying ceremony and start construction of the canal. Thereafter, the orders were flashed on the canal signaling network that construction of Balloki Suleimanki Link Canal had started and every contractor with donkey labour must reach Balloki without any delay. The message was repeated to each Headwork office every day and information was sought about the number of donkeys and labour that reached Balloki daily. The author stationed himself at Montgomery to do the planning of the Project. Daily information was fed from Balloki by the Executive Engineer, Sardar Allah Bukhsh deputed to supervise the works.

ACQUISITION OF LAND AND IMPLEMENTATION PLAN

As the time progressed the number of donkeys started increasing unbelievably, 20,000 donkeys reached Balloki in 2 months time. Alignment drawings of the canal were completed and segments of work sites were allotted to the Contractors according to their capacity, to do the work during the next eight (8) months keeping in view the number of donkeys and labour available with them.

Deputy Collector and Ziladars were despatched to the villages to give tidings to Zimindars that construction of Balloki Suleimanki Link Canal to feed their canals, which were closed due to high handiness of India, had been started. They were told

that their land would be measured and compensation paid for the land which would be acquired from them. Every landowner happily gave his land though already planted in this area, so that the donkey labour could enter vacant lands and start work. Thus when the work of digging the canal was started and went on smoothly and it was realised that work was proceeding in a well organised manner and would go on unabated without any let or hindrance, the author took the opportunity to announce on the Radio Pakistan that construction of 60 mile long Balloki Sulemanki Link from Balloki Head on Ravi River to Suleimanki on the Sutlej had been started and that all kind of labour was invited to come to construct this national water way as quickly as possible in ordered to feed these canals, supply to which had been cut off by India for 5 years. Chief Engineer M. Allah Ditta Ashraf, Minister of Irrigation, Mr. Muhammad Hussain Chattha and Minister for Revenue Mr. Muhammad Khan Leghari, all came to Balloki to stop the construction of the canal by donkey labour emphasizing that since order for machinery costing millions of dollars had been placed for this project which was in the manufacturing process and would be arriving in Pakistan in due time, all that money would go waste. They reprimanded that donkey labour would never be able to build that canal. At this they were invited for themselves to see the donkey labour working from Balloki to Suleimanki all those 60 miles. They were informed that 20,000 donkeys working at site were well poised to dig the canal before the machinery would arrive. They drove from Balloki to Suleimanki and all along found donkey labour digging the canal much both to their astonishment and satisfaction. Hailed by the labour working on site, they realised that the nation had risen to the occasion and started building canal with their own hands for the welfare of its future. Fully satisfied they were pleased to finish the contract to build this canal without machinery. The machinery ordered was sent to Taunsa Barrage. The press photographers who accompanied the Ministers took photographs of various activities which were published in the various papers.

At that time the author was of incharge Lower Bari Doab Canal Circle with Head-quarters at Montgomery (100 miles away from Balloki). The construction of the canal was an extra work which was supervised by Executive Engineers (Construction) Sardar Allah Bux and Executive Engineer Headworks. Sub Divisional Officers and Overseers were also posted under these Executive Engineers to supervise the worked. Thus canal construction was an additional work of the circle and the Irrigation Department later posted an additional Senior Executive Engineer to assist the author in routine jobs of the circle.

Sardar Allah Bux, Executive Engineer had a good control over the works and kept running from Balloki to Lahore Design office to get designing of the structures prepared in the Design Office. He also went frequented the Mechanical Division at Mughalpura to get the gates & gearing built there. In order to facilitate the transport of material Railway line was extended from Changa Manga to Balloki Headworks. This helped to bring cement bags from Wah Factory straight to this Headwork alongwith the gates and gearing which were being manufactured at Lahore.

At many places when the digging reached about 7 feet deep water was encountered and the donkey labour found difficulty in digging the canal resulting in slowing down of the work. Four drag lines and Bulldozers had, therefore, to be sent for from various Headworks to Balloki. Upon their arrival digging a cunnete in the centre

drag lines went on digging deeper and deeper and donkey labour went on digging the canal till designed bed was reached. While the canal was being dug brick kilns were setup for making bricks and brick tiles for the bridges and lining of the canal. Arrangement for the coal was made from Quetta mines and coal continued reaching Balloki regularly without any interruption for making of the bricks. Railway Department was also approached to build the bridges on the new canal on Lahore-Karachi and Kasur-Lodhran Railway lines. Railway promptly started building the bridges by laying diversion for passage of rail traffic and they too were completed simultaneously with the completion of canal works. The two Ministers and the Chief Engineer followed a routine to regularly visit the work almost every week which boosted the labour morale and they continued to work harder.

For the sake of economy, some of the canal plantations were felled to provide planks and struts for the bridges and other works. Thus enormous works were completed within record two years time in 1954. Malik Feroz Khan Noon, Chief Minister of the Punjab also visited the works in progress a number of times and made it convenient to perform the opening ceremony, by turning the gates and gearing of the Balloki Head Regulator when Ravi Waters mercifully started flowing to embrace the Sutlej upstream of Suleimanki Headworks and quench the thirst of parched lands. For the illustration of a large number of Engineers and general public, a model of the canal was built with details of works involved in the construction of these works at the occasion.

The work was completed with 20% saving in the estimated cost. Some of the big contractors like Hastam Khan complained that the land being excavated was hard /wet and the Superintending Engineer was not sanctioning the hardness or wetness allowance within his competence. To do justice to such claims Mr. Farrant, the only British Engineer still in Pakistan working as Director of Irrigation Research Institute of Lahore was appointed, as an Arbitrator who allowed Rs. 1,000,000 as compensation for the hardness & wetness of the land dug out by big contractors like Hastam Khan at their representation. The accomplishment of this marvelous feat was so hilarious that the Governor General Ghulam Muhammad and Federal ministers opted to make it convenient to visit this canal. With them also came King Saud Bin Abdul Aziz of Saudi Arabia, who was so flabbergasted to see that such a huge canal was running in Pakistan whereas in his own Kingdom there was none. He made a request to the Government of Pakistan that some Engineers from Pakistan be sent to Saudi Arabia to examine and suggest possible water resources development projects in his country.

CONCLUSION

A few days after the visit of the Governor General the Ministry of Natural Resources in consideration of the practical and fruitful services of the author in helping construction of a canal of huge magnitude in record time with primitive indigenous labour, and in defence to King Saud's desire invited the author to attend a meeting in the office of the Secretary of Natural Resources, where a commission was to be setup for Saudi Arabia. Representative gathering of various departments including Mr. Mohsin Ali, Chief Engineering Advisor, Mr. Saleem-Uzzaman Siddiqui, renowned Scientist, Raja Sher Jang, Deputy Governor of State Bank of Pakistan and few other high officials of the Government of Pakistan present in the meeting were pleased to direct the author to accompany that mission and do the appraisal of the water resources of Saudi Arabia and its utilization which was duly attended.

Thus goes the story of the construction of one of the biggest canal conveying 15,000 cusecs which was constructed in record time of two years with primitive donkey labour and altogether domestic resources. No foreign exchange was involved, no expatriate professional inputs were needed and 20% saving in the overall budgetary provision was accomplished.

The enviable achievement was possible only with the spirit of service to nation, sincerity of purpose, hard work and belief in Almighty.

RELIABILITY ANALYSIS IN SUPPORT OF RISK ASSESSMENT FOR HYDROELECTRIC GENERATING STATIONS

by

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ABSTRACT: In work sponsored by the U.S. Army Corps of Engineers (USACE), Pacific Northwest Laboratory (PNL), Richland, Wash., has performed a frequency analysis regarding the nonroutine closure of water flow through the turbines of powerhouses along the Columbia and Snake Rivers. The analysis involved developing a frequency analysis model capable of producing frequency profiles of overspeed and flooding events as a function of time and the associated component importance rankings. Data regarding hydropower equipment failures from a previous study were used to estimate component failure rates within the model. The present paper summarizes the model development and quantification, and calculation of component importance measures. The results of this analysis can be used as input to further analyses to evaluate economic consequences of overspeed and flooding events and to provide policy recommendations for operations of hydroelectric generating stations.

INTRODUCTION

The Pacific Northwest Laboratory (PNL) was requested by U.S. Army Corps of Engineers (USACE) to provide a frequency analysis that evaluates the nonroutine closure of water flow through the turbines of powerhouses along the Columbia and Snake Rivers. The purpose of the analysis is to evaluate the risks associated with events that would require a nonroutine shutdown at hydroelectric stations and could involve an inability to close the intake gates within the time normally allotted.

Current USACE guidance for rapid closure of the intake gate is the 10-minute closure rule, which requires intake gates to be capable of providing closure within 10 minutes of an overspeed of flooding event. The ability to meet the 10 minutes closure rule is questionable for hydroelectric stations that have their intake gates removed or raised from the original design position. The intake gates at some hydroelectric stations on the Columbia and Snake rivers have been removed or raised to improve fish guidance.

Alternate methods of providing emergency gate closure are being considered that would reduce the cost of providing the raised gate operation. However, closure time will exceed the 10 minute rule. Currently, there is no statistical information to determine the frequency of events requiring closure. Likewise, the equipment damage and economic impacts associated with failure to stop

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the water flow within 10 minutes for these events have not been determined. The risk analysis will provide the frequencies of significant failures and estimate associated damages. The results from the risk analysis will provide input for assessing option and making decisions regarding intake gate closure capabilities.

This paper summarizes the frequency analysis of significant

events requiring emergency intake gate closure, the component importance measures, and results of the analysis. Results of this analysis will be used in future analyses, which will estimate the damages incurred by significant failures, estimate of the cost of these damages, and estimate the risk caused by failure to close intake gates during an emergency condition. Finally, these estimations will be used to provide input to policy recommendations. Detailed results of the analysis are provided in Vo et al. (1995).

METHODOLOGY

The analysis was broken down into seven major activities (1) developing system descriptions; (2) developing the basis frequency analysis model; (3) modifying the basic model to account for time-based actions; (4) quantifying the model to produce time-based frequency profiles; (5) calculating component importance rankings; (6) performing sensitivity analysis; and (7) preparing a report summarizing these activities. Fig. 1 show the tasks associated with each of these activities and presents the relationships among the activities.

DEVELOPING SYSTEM DESCRIPTIONS

To ensure that an adequate understanding of system design and operation existed, system descriptions were developed for each of the major systems prior to developing the frequency analysis model. This was accomplished by obtaining and reviewing various publications regarding hydroelectric station design and operation.

DEVELOPING THE BASIC MODEL

The initial frequency analysis model (basic model) for this study was developed and evaluated using the Integrated Reliability and Risk Analysis System (IRRAS) software developed for the Nuclear Regulatory Commission (Russell et al. 1992). The basic model consists of event trees and fault trees constructed to describe system and component interactions. It is capable of analyzing 48 different plant designs. These various designs represent differences among plants in intake closure device fish screen type, wicket gate emergency closure, and governor type. Tables 1&2 show a "design features matrix" for the basic model. The numbers across the top of the matrices identify the 48 unique plant designs to be potentially considered by the analysis. The X's indicate which design features are implemented for each design. For example, plant design 3 represents a plant with hydraulically operated intake gates, traveling mesh fish screens, no wicket gate emergency closure system installed, and an electrical governor.

It would not be practical to analyze all 48 designs possible in the basic model, so six designs were chosen that were most representative of plants on the Columbia and Snake Rivers. Additionally, the intake gate systems at columbia and Snake River plants are in various conditions ranging from ready to operate in 10 minutes to completely removed and incapable of operation for at least six hours. Because of

the various intake gate readiness conditions, three different intake gate "cases" were defined for each of the six designs.

Finally, three initiating events were considered: (1) turbine overspeed resulting from a loss of load; (2) flooding originating from a location upstream of the wicket gates; and (3) flooding originating from a location downstream of the wicket gates. Flooding from tailwater was not analyzed because it is not dependent on intake gate operation. Three initiating events, six designs, and three cases resulted in quantification of the model 54 times.

Input to the basic model consists of component failure rates and event probabilities. The failure rate data and event probabilities were obtained from an earlier phase of this project (Blackburn et al. 1995).

DEVELOPING THE TIME-BASED MODEL

Output from the basic model is analyzed to incorporate operator recovery actions and other time-based information. The basic model's failure sequences are used as input and are altered to account for the minimum time that a component can fail, and time-based operator recovery actions. This time-based information was elicited during the expert workshop conducted in this study.

QUANTIFYING THE TIME-BASED MODEL

A simple computer program was developed to quantify the time-based model. The program calculates the event frequency (occurrences/unit-yr) over time and performs the component importance calculations. This program was developed for the improvement of data manipulation and storage capabilities to IRAS to be checked for consistency.

DEVELOPING COMPONENT IMPORTANCE MEASURES

In addition to developing frequency profiles, the computer program also calculated component importance values for each initiating event/design/case combination at each time step analyzed. The importance results are presented using three quantitative importance measures (Vesely et al. 1983). These are the Fussell-Vesely (FV) importance, the risk-reduction worth (RRW) ratio, and the risk achievement worth (RAW) ratio. In this analysis the importance results are estimated based on the event frequency, so they provide an indication of component importance based on event frequency, not risk.

The FV importance indicates the percent change in the total event frequency produced by a change in the probability of a basic event that contributes to the event. It can be booked on as a type of sensitivity coefficient. Components with higher values of FV importance contribute to a larger percentage of the total event frequency than do components of lesser FV importance.

The RRW ratio is defined as the ratio of the original even frequency to the event frequency with the failure probability of the basic event in question set to zero. The RRW ratio gives an indication of how much the event frequency would be reduced if the component were totally reliable (failure probability equal to zero). The component with the largest risk-reduction ratio would give the largest reduction in even frequency for a corresponding reduction in the component failure probability. If one is interested in getting as large a reduction in frequency as possible by increasing the reliability of a single component, then efforts should be focused on the component with the largest RRW ratio.

The RAW ratio is an indicator of how much the event frequency would

increase if a specific event were totally unreliable (failure probability equal to one). If one is interested in preventing event frequency from increasing, then efforts should be focused on preventing increases in the failure rates of the component that has the highest RAW ratio.

PERFORMING SENSITIVITY ANALYSIS

In this analysis the time delay in operator action to perform recovery actions or to close intake gates when the wicket gates fail to close after the initiating event was considered using sensitivity analysis. This time delay represents the condition in which the only readily available station operator is unable to immediately respond to an event (e.g., overspeed or flooding events). For this sensitivity analysis three conditions are analyzed. The first is the base case in which no time delay exists and the operator is immediately available to perform necessary actions. This is the same condition assumed in all of the previous analyses and is used in this sensitivity analysis for comparison purposes. The second condition has a 30-minute time delay and reflects the case in which the operator is delayed in providing response due to involvement with another activity such as being at the lock. The third time delay condition is similar to the second except that it represents a longer delay in operator action that lasts for four hours.

The model was altered by changing the minimum time to success for various components that must be operated manually and by changing the operator recovery action times to account for the associated operator time delay. The altered model was then quantified and frequency profiles were generated.

RESULTS

Quantification of the model produced 54 frequency profiles (one for each initiating event/design/case combination) that consist of the estimated frequency values calculated at 17 different times steps. The upstream and downstream flooding profiles are then combined to produce 18 combined flooding frequency profiles. An example of an overspeed frequency profile is contained in Fig. 2: an example of an upstream flooding frequency profile is contained in Fig. 3; an example of a downstream flooding frequency profile is contained in Fig. 4; and an example of a combined flooding frequency profile is contained in fig. 5.

These figures show the frequency profiles for design 3, case 1. This design/case combination (also called a filed condition) represents a plant with hydraulically operated intake gates, traveling mesh fish screen, no emergency closure system, and having an electrical governor (see Tables 1 and 2). The intake gates are capable of meeting the 10-minute closure rule (case 1).

The figures contained event frequency versus the chosen time steps of concern. The time step range is 0-420 minutes. Note that the time axis is not linear; it begins in five-minute intervals, progresses to 10-minute intervals, next to 30-minute interval and finally to 60 minute intervals. The time intervals are chosen to be smaller at the beginning because more actions occur soon after the initiating event so more detail is necessary soon after the initiating event. The frequency profile represents the time dependent, best estimate of overspeed and flooding frequency. All frequency estimates are in units of occurrences/unit yr. For example, an event frequency of 1E-03 at 60 minutes indicates that a given unit can be expected to suffer an event lasting at least 60

minutes one time in 1,000 years.

FREQUENCY PROFILE RESULTS

In general, the frequency profiles exhibit several common characteristics. The frequency profiles start at zero minutes with the initiating event frequency. By five minutes the overspeed, downstream flooding, and combined frequency profiles have dropped significantly because the wicket gates have had the opportunity to close. The upstream flooding profile are not affected because wicket gate closure does not stop water flow to flooding originating from upstream of the wicket gates. A second significant drop in overspeed frequency occurs at a later time depending on the design and case being considered. This drop is due to intake gate operation.

The frequency profiles are compared among various field conditions that are representative of hydroelectric stations located on the Columbia and Snake Rivers. These visual comparisons are made by plotting the frequency profiles for the various field conditions on the same axes. The overspeed frequency profiles for design 3, case 1; case 2; and case 3 are compared in Fig. 6. The combined flooding frequency profiles for design 3, case 1; case 2; and case 3 are compared in Fig 7. This comparison illustrates the differences in the frequency profiles for the various conditions of hydraulically operated intake gates (case 1-ready to operate in 10 minutes; case 2 dogged off or latched-operate in 30 minutes; Case 3 gates or cylinders removed-operate in six hours).

The major difference among the frequency profiles for these three cases is due to the time required to operate the intake gates. In case 1 the attempt to lower the intake gates occurs at 10 minutes; in case 2 it takes 30 minutes; and in case 3 it takes six hours. This comparison shows that having the capability to meet the 10-minute rule significantly improves the frequency profile. The overspeed frequency profile at 10-minutes is reduced by a factor of 8 from the cases that do not meet the 10-minute rule. The combined flooding frequency profile at 10-minutes is reduced by a factor of 26 from the cases that do not meet the 10-minute rule.

A case comparison among crane-operated intake gate systems (design 4) yields frequency profiles similar to those of design 3 previously; therefore, no figures are presented. For crane-operated systems case 1 represents the best case time (30 minutes) in which crane-operated intake gates could be lowered. The crane is located above the unit that must be shutdown; the gates are suspended on the crane and ready to be lowered to stop water flow. Case 2 represents the best estimated time
(60 minutes) in which crane-operated intake gates could be lowered. The crane is located in the middle of the dam; the gates are suspended on the crane; and the operator must start the crane, position it above the appropriate unit intake, and lower the gates to stop water flow. Case 3 represents the worst case time (six hours) to lower the intake gates with the crane. In this scenario the gates have been taken off the crane. The operator must retrieve the gates, position the crane over the intake, and lower the gates.

The overspeed and combined flooding frequency profiles for design 3, case 1 are compared to design 4, case 2 in Figs 8&9. This comparison illustrates the differences in the frequency profiles between hydraulically operated intake gates and crane-operated intake gates. Design 3 represents hydraulically operated intake

gates, and design 4 represents crane operated intake gates.

The differences in these two profiles are mostly due to the time it takes to operate the intake gates. For hydraulically operated intake gates, the gates operate in the first 10 minutes so the overspeed frequency is rapidly reduced. Crane-operated intake gates operate at 60 minutes so the frequency does not significantly drop until then. This comparison shows that hydraulically operated intake systems have better frequency profiles than crane-operated systems. The overspeed frequency profile for hydraulically operated intake gates at 10 minutes is reduced by a factor of 8 from crane-operated intake gates. The combined flooding frequency profile at 10 minutes is reduced by a factor of 26 from crane-operated intake gates. These factors are the same factors found in the design 3 case comparison Fig. 7. This indicates that hydraulically operated and crane operated intake gates have about the same reliability.

The frequency profiles for design 3, case 1 are compared to design 7, case 1 and to design 11, case 1 in Fig 10. This comparison illustrates the differences in the overspeed frequency profiles among traveling mesh fish screens, fixed bar fish screens, and no fish screens installed for hydraulically operated intake gates in a case 1 configuration. Design 3 represents hydraulically operated intake gates with traveling mesh fish screens; design 7 represents hydraulically operated intake; gates with fixed bar fish screens installed; and design 11 represents hydraulically operated intake gates with no fish screens installed.

The three curves are identical until an attempt to lower the intake gates is made at 10 minutes. The overspeed frequency profiles significantly diverge at this point. This is because there is a probability that the fish screens may fail due to high flow conditions. Because they are located just upstream of the intake gates, fish screen failure may result in the intake gates being jammed, preventing closure of water flow to the turbine. Fixed bar fish screens protrude further into the water stream and are more likely to fail under high flow conditions; therefore, they reduce the chance of intake gates closure the most. The comparison shows that fish screens have a significant adverse effect on overspeed frequency profiles. Having no fish screens installed reduced the frequency at 10 minutes by a factor of 4 over having traveling mesh fish screens installed and 16 over having feed bar fish screens installed. Having traveling mesh fish screens reduces the frequency at 10 minutes by a factor of 4 over having fixed bar fish screens.

Fish screens have almost no effect on the flooding frequency profiles. This is because the model assumes there is no significant increase in flow during a flooding condition, so there is no associated chance of fish screen failure resulting in the jamming of the intake gate.

The overspeed frequency profile for design 3, case 1 is compared to design 15, case 1 in Fig 11. This comparison illustrates the differences in the frequency profiles between powerhouses with and without emergency closure systems. Design 3 represents hydraulically operated intake gates without an emergency wicket gate closure system installed, and design 15 represents hydraulically operated intake gates with an emergency wicket gate closure system installed.

The two frequency profiles diverge at 10 minutes because it is expected that the operator will actuate the emergency closure system

with five to 10 minutes of initiation of the overspeed event. The emergency closure system is very effective at overcoming many wicket gate failures, resulting in a reduced overspeed frequency. It does not affect intake gate operation or recovery in any way. Overall, actuation of the emergency closure system is not as effective as closure of the intake gates but it does have an impact in reducing overspeed frequency. Having an emergency wicket gate closure system installed reduces the overspeed frequency at 10 minutes by a factor of 2 over not having a system installed.

A wicket gate emergency closure system has almost no effect on the flooding frequency profiles. Actuation of the wicket gate emergency closure system cannot help stop flooding originating upstream of the wicket gates because upstream flooding is not isolated by the wicket gates. Additionally, the emergency closure system only overcomes selected governor and wicket gate failures. These failures were dominant in the overspeed scenario, but are negligible in the downstream flooding scenario.

COMPONENT IMPORTANCE ANALYSIS RESULTS

In addition to developing frequency profiles and comparing these profiles, this analysis also calculated component importance values for each component. The importance results are presented using the FV importance, the RRW ration, and the RAW ratio. In this analysis the importance results are estimated based on the event frequency, so they provide an indication of component importance based on event frequency, not risk.

When the FV importances are viewed across all initiating events (overspeed, upstream flooding, and downstream flooding) designs, cases, and times, several key components tend to dominate. These components are listed in Table 3. Before 10 mihutes the list contains only wicket gate components because the wicket gate system is the only system that can operate before 10 minutes. At 10 minutes hydraulically operated intake gates can close so the list contains both wicket gate and hydraulically operated intake gate components. At some time after 10 minutes (15-420 minutes), crane-operated intake gates can be lowered so the list contains wicket gate, hydraulically operated intake gate, and crane-operated intake gate components. For most components there is very little importance variation with time. Components that begin important to stay important, Next, the component importance values were plotted across field conditions at a given time to explore how component importances change with field conditions. This revealed that field condition. For example, the FV importance values for design 3, case 1 are compared against design 3, case 2. At 120 minutes, the FV importances for the wicket gate servomotor increase slightly. At the same time, the FV importance for the governor mechanical connection decreases.

Using the RAW ratios, the component importance analysis revealed that overspeed frequency could be significantly improved by improving the reliability of fish screens under high flow conditions. This analysis also showed that downstream flooding frequency could be improved by reducing the likelihood of basic events resulting in the jamming of the wicket gates and intake gates. Upstream flooding frequency could be improved by reducing the likelihood of basic events resulting in the jamming of the intake gates.

Using the RRW ratios, the component importance

analysis revealed that if governor components such as the gate distributing valve and actuator pilot valve, and governor mechanical connections, wicket gate servomotor, or wicket gate shift ring components were less reliable, the overspeed frequency would be significantly worsened. Therefore, it is important to maintain the reliability level of these components.

SENSITIVITY ANALYSIS RESULTS

In this analysis, the time delay in operator action to perform recovery action or to close intake gates when the wicket gates fail to close after the initiating event is treated using sensitivity analysis. This time delay represents the condition in which the only readily available station operator is unable to immediately respond to an event. For this sensitivity analysis three conditions are treated. The first is the base case in which no time delay exists and the operator is immediately available to perform necessary actions. The second condition has a 30-minute time delay, and the third time delay condition last for four hours.

The overspeed and combined flooding frequency profiles for the various operator time delays analyzed are shown in Figs 12 & 13. The frequency profiles start at time zero with the initiating event frequency. The shape of the overspeed and combined flooding frequency profiles both show the reduction in frequency attributed to potential closure of the wicket gates. After this reduction the curves show no further reduction in the frequency until the operator responds at the times indicated previously. At these times the frequency profiles a reduction that reflects the potential for the operator to recover the wicket gates, and if unsuccessful, to take action to close the intake gates. The overspeed frequency profile at 10 minutes is reduced by a factor of 8 from the case when the operator is unavailable. The combined flooding frequency profile at 10 minutes is reduced by a factor of 26 from the cases when the operator is unavailable.

These comparisons show that operator response time is very critical in reducing the event frequency for both overspeed and flooding scenarios. Thus, if any operator is not available to respond to an event, the benefits of a hydraulically operated intake gate system capable of meeting the 10-minute rule can be quickly negated.

As described previously, hydraulically operated intake gate systems have better frequency profiles than craneoperated intake systems, and meeting the 10-minute rule significantly improves the frequency profile. Fish screens adversely impact the frequency profile; wicket gate emergency closure systems improve the frequency profile; and an operator time delay in responding to an event adversely impacts the frequency profile. Any improvement in a frequency profile will reduce the associated risk. However, the magnitude of risk improvement for a given frequency decrease can vary greatly. The next phase of this project will quantify the differences in risk amount the field conditions analyzed by applying the damage incurred over time.

Additional sensitivity analyses were performed to address the changes in event probabilities by using their uncertainty estimated values (5 and 95 percentiles) as reported in calculations in Blackburn et al. (1995). As expected the frequency profiles change accordingly. A comprehensive sensitivity and uncertainty analyses will be performed at a later date to address uncertainties in the

overall risk estimates. The estimated event probabilities were also reviewed against historical occurrences of such events at hydropower facilities. In addition, the event probabilities and industry related literature were reviewed, and discussions were held with USACE personnel to validate the results.

CONCLUSIONS

In summary, the following insights were obtained from this analysis.

The overspeed initiating event frequency is 5E-01 occurrences/unit. yr. By five minutes after the initiating event, the wicket gates had attempted to operate, resulting in a frequency reduction to 1E-02 occurrences/unit. Yr. At various times after five minutes, the intake gates attempt to operate. This further reduces the overspeed frequency to between 3E-03 and 1E-04 occurrences/unit. yr. (depending on the design and case).

The combined flooding initiating event frequency is 1E-02 occurrences/unit. yr. By five minutes after the initiating event, the wicket gates had attempted to operate, resulting in a frequency reduction to 6E-03 occurrences/unit. yr. At various times after five minutes, the intake gates attempt to operate. This further reduces the combined flooding frequency to between 4E-04 and 1E-04 occurrences/unit . yr (depending on the design and case).

Having the capability of meeting the 10-minute rule (hydraulically operated intake gates, cylinders installed, ready to operate using emergency intake gate closure system) is the best intake condition for reducing event frequency. Hydraulically operated intake gates with cylinders installed are more effective at quickly reducing the event frequency than are crane-operated intake gate systems. If a station has hydraulically operated intake gates capable of meeting the 10-minute rule, the overspeed frequency at 10 minutes can be reduced by a factor of 8, and the flooding frequency can be reduced by a factor of 26 over systems that cannot meet the 10-minute rule.

In addition to reducing the event frequency soon after the initiating event, it is also important to reduce the frequency by as large an amount as possible. Having fish screens installed reduces the amount of frequency reduction attained by operation of the intake gates for the overspeed event. The increased flow and vibration associated with an overspeed event increases the chance that a fish screen could fail and jam an intake gate open. Because fixed bar fish screens protrude further into the flow, they are more likely to fail and have the largest adverse affect of the frequency profile.

In addition to the intake gates reducing the event frequency, having a wicket gate emergency closure system installed also reduces overspeed event frequency. The reduction is not as significant as that attained by the intake gates, but it is significant. A wicket gate emergency closure system has very little effect on flooding originating downstream of the wicket gates because it does not effect the dominant failure mechanisms for downstream flooding. Additionally, it has no effect on flooding originating from upstream the wicket gates because wicket gates cannot isolate flooding from a location upstream of them.

The component importance analysis revealed that overspeed frequency could be significantly improved by improving the reliability of fish screens under high flow conditions. Downstream flooding frequency could also be improved by reducing the likelihood of failures or events that result in the jamming of the

wicket gates or intake gates. Upstream flooding frequency could be improved by reducing the likelihood of failures or events that result in the jamming of the intake gates. Finally, if governor components such as the gate distributing valve and actuator pilot valve, and governor mechanical connections, wicket gate servomotor, or wicket gate shift ring components were less reliable, the overspeed frequency would be significantly worsened. Therefore, it is important to maintain the reliability level of these components.

The sensitivity analysis showed that the ability of the operator to respond to an overspeed or flooding event is critical. If the operator is alone (e.g., night shift) and is away from the powerhouse (e.g., at the lock), and does not know that an event has occurred, the operator cannot perform any recovery actions. Additionally, for any field condition intake gate operation requires that the operator perform some action. Consequently, the only event frequency reduction possible until the operator becomes available comes from operation of the wicket gates. Operator unavailability can defeat the benefits of being able to meet the 10-minute rule and having a wicket gate emergency closure system installed.

Results of this analysis will be used to estimate damage incurred by significant failures, estimate the cost of these damages, and estimate the risk caused by failure to close intake gates driving an emergency condition. These estimations will be used to provide input to policy recommendations for design and operation of hydroelectric generating stations. Due to the complexities of the analysis, a comprehensive uncertainty analysis will be performed at a later date to address uncertainties in the overall risk estimates associated with emergency shutdown/closure at hydroelectric generating stations. The analysis incorporate plant generic component failure rates, plant specific information from the Columbia and Snake River hydroelectric stations, and information gathered from expert workshops. The results are approximate and should be interpreted with caution.

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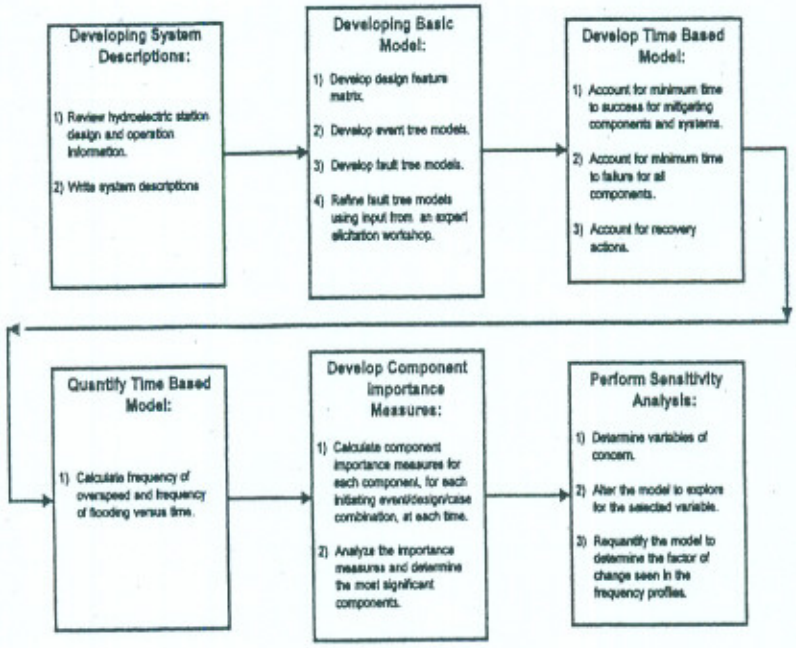

FIG. 1. Frequency Analysis of Major Activities

TABLE 1. Design Feature Matrix—Plant Design 1–24

Design features (1)	Plant Design 1 (2)	2 (3)	3 (4)	4 (5)	5 (6)	6 (7)	7 (8)	8 (9)	9 (10)	10 (11)	11 (12)	12 (13)	13 (14)	14 (15)	15 (16)	16 (17)	17 (18)	18 (19)	19 (20)	20 (21)	21 (22)	22 (23)	23 (24)	24 (25
Intake gate:																								
Intake valve	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—
Hoist	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—
Hydraulic	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—
Crane	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X
Fish screen:																								
Traveling mesh	X	X	X	X	—	—	—	—	—	—	—	—	X	X	X	X	—	—	—	—	—	—	—	—
Fixed bar	—	—	—	—	X	X	X	X	—	—	—	—	—	—	—	—	X	X	X	X	—	—	—	—
Emergency closure:																								
Not installed	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—
Installed	—	—	—	—	—	—	—	—	—	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X
Governor:																								
Electrical	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mechanical	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 2. Design Feature Matrix—Plant Design 25–48

Design features (1)	Plant Design 25 (2)	26 (3)	27 (4)	28 (5)	29 (6)	30 (7)	31 (8)	32 (9)	33 (10)	34 (11)	35 (12)	36 (13)	37 (14)	38 (15)	39 (16)	40 (17)	41 (18)	42 (19)	43. (20)	44 (21)	45 (22)	46 (23)	47 (24)	48 (25
Intake gate:																								
Intake valve	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—
Hoist	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—
Hydraulic	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—
Crane	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X	—	—	—	X
Fish screen:																								
Traveling mesh	X	X	X	X	—	—	—	—	—	—	—	—	X	X	X	X	—	—	—	—	—	—	—	—
Fixed bar	—	—	—	—	X	X	X	X	—	—	—	—	—	—	—	—	X	X	X	X	—	—	—	—
Emergency closure:																								
Not installed	X	X	X	X	X	X	X	X	X	X	X	X	—	—	—	—	—	—	—	—	—	—	—	—
Installed	—	—	—	—	—	—	—	—	—	—	—	—	X	X	X	X	X	X	X	X	X	X	X	X
Governor:																								
Electrical	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Mechanical	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

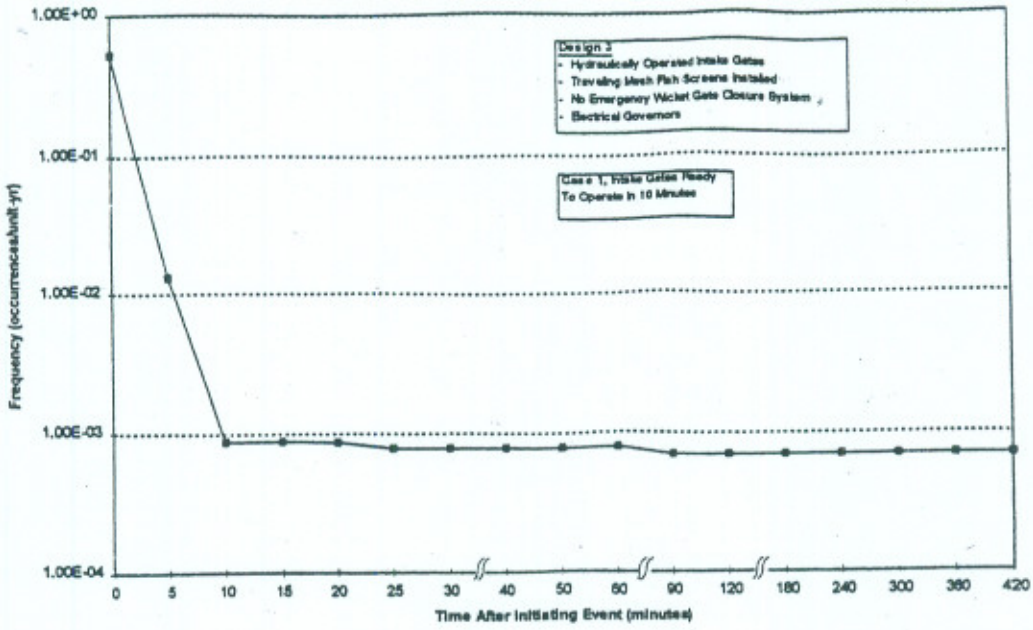

FIG. 2. Example of Overspeed Frequency Profile

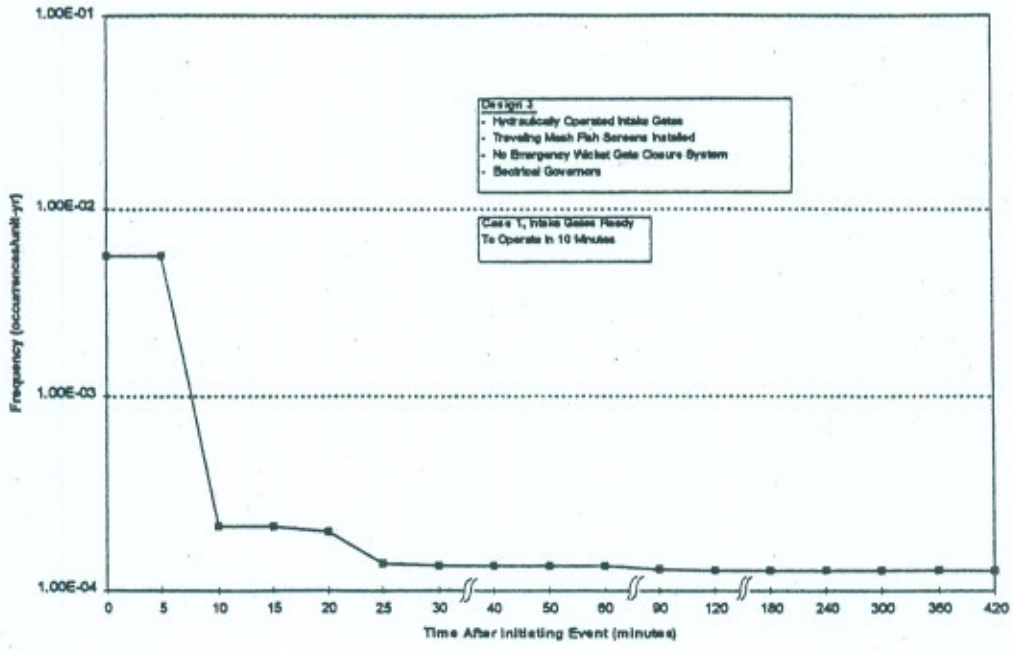

FIG. 3. Example of Upstream Flooding Frequency Profile

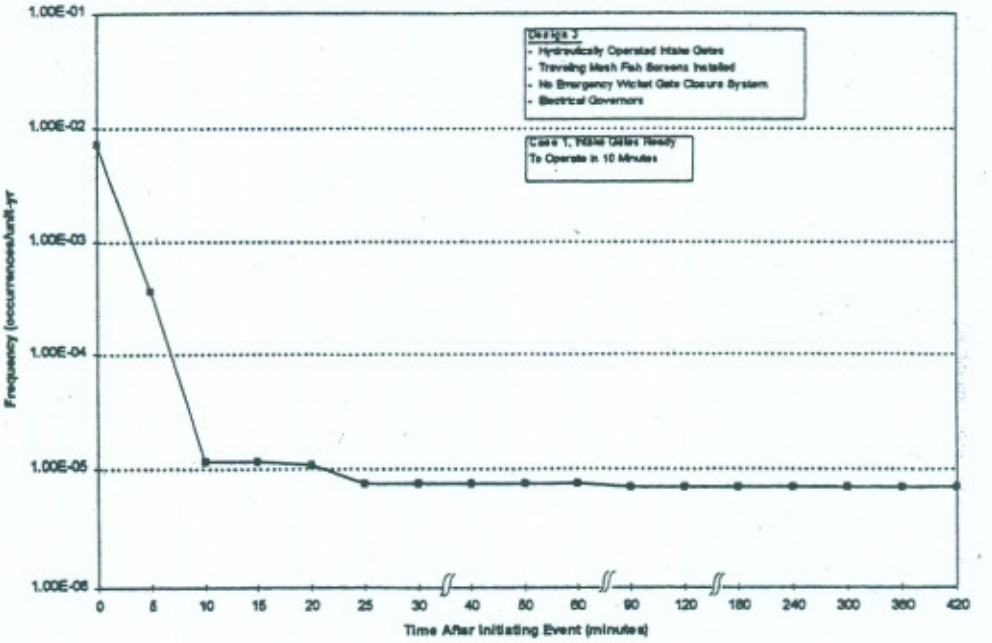

FIG. 4. Example of Downstream Flooding Frequency Profile

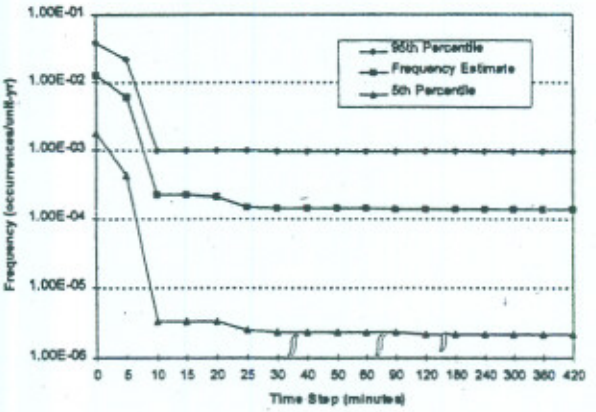

FIG. 5. Example of Combined Flooding Frequency Profile

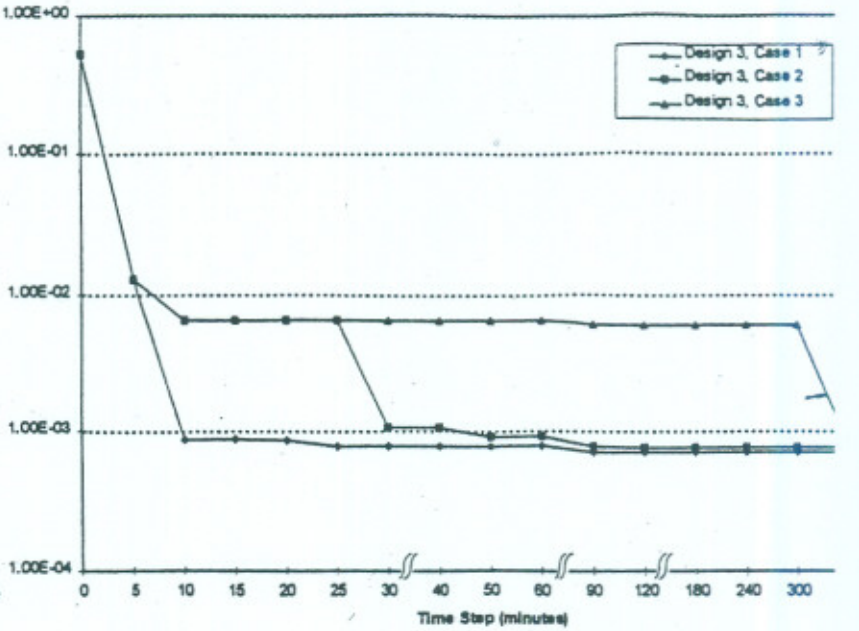

FIG. 6. Design 3 of Overspeed Case Comparisons

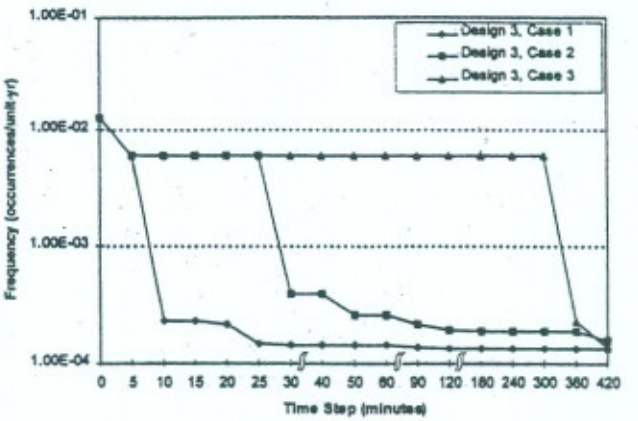

FIG. 7. Design 3 of Combined Flooding Case Comparisons

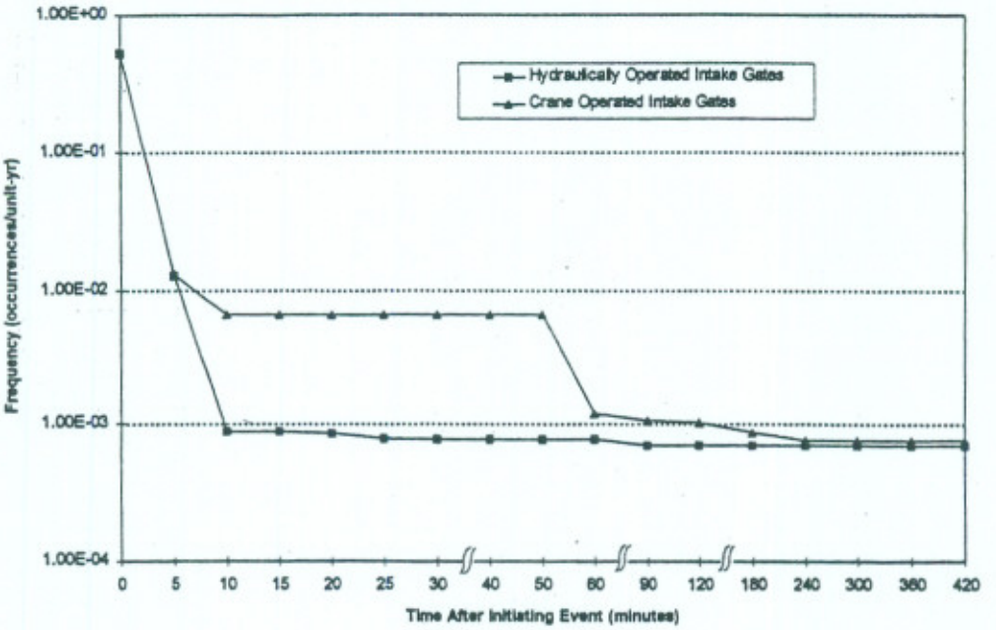

FIG. 8. Hydraulically Operated (Design 3, Case 1) and Crane-Operated Intake Gate (Design 4, Case 2) Overspeed Frequency Profile Comparison

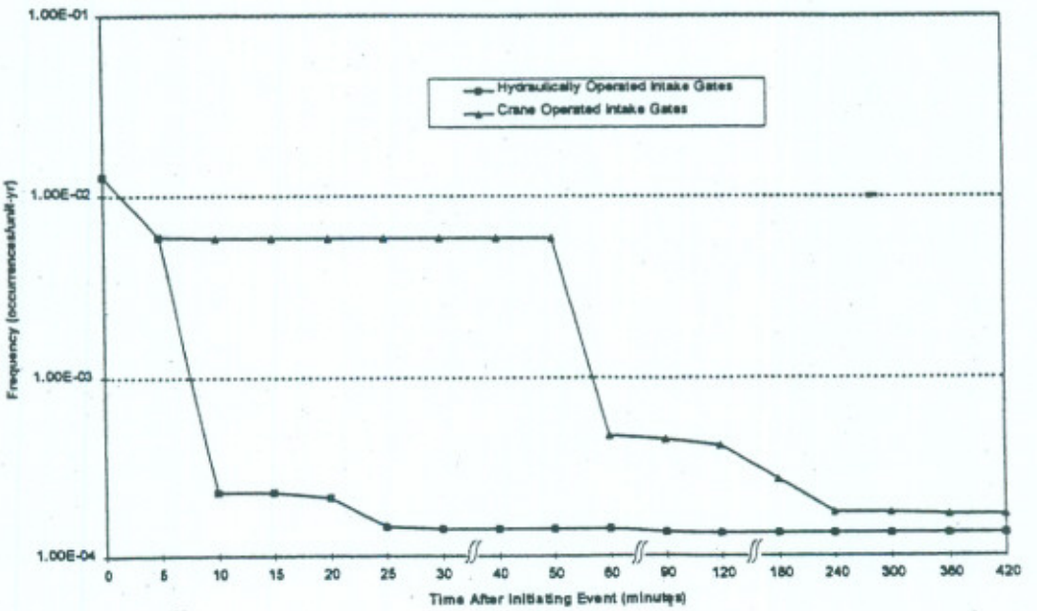

FIG. 9. Hydraulically Operated and Crane-Operated Intake Gate Combined Flooding Frequency Profile Comparison

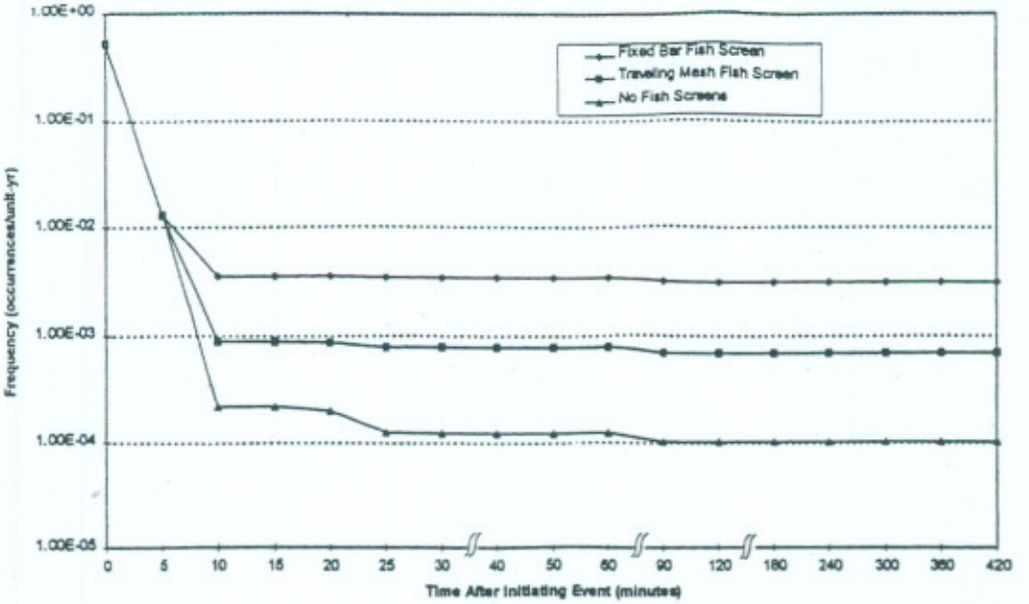

FIG. 10. Hydraulically Operated Intake Gates with Fixed Bar, Traveling Mesh, and No Fish Screen Overspeed Frequency Profiles

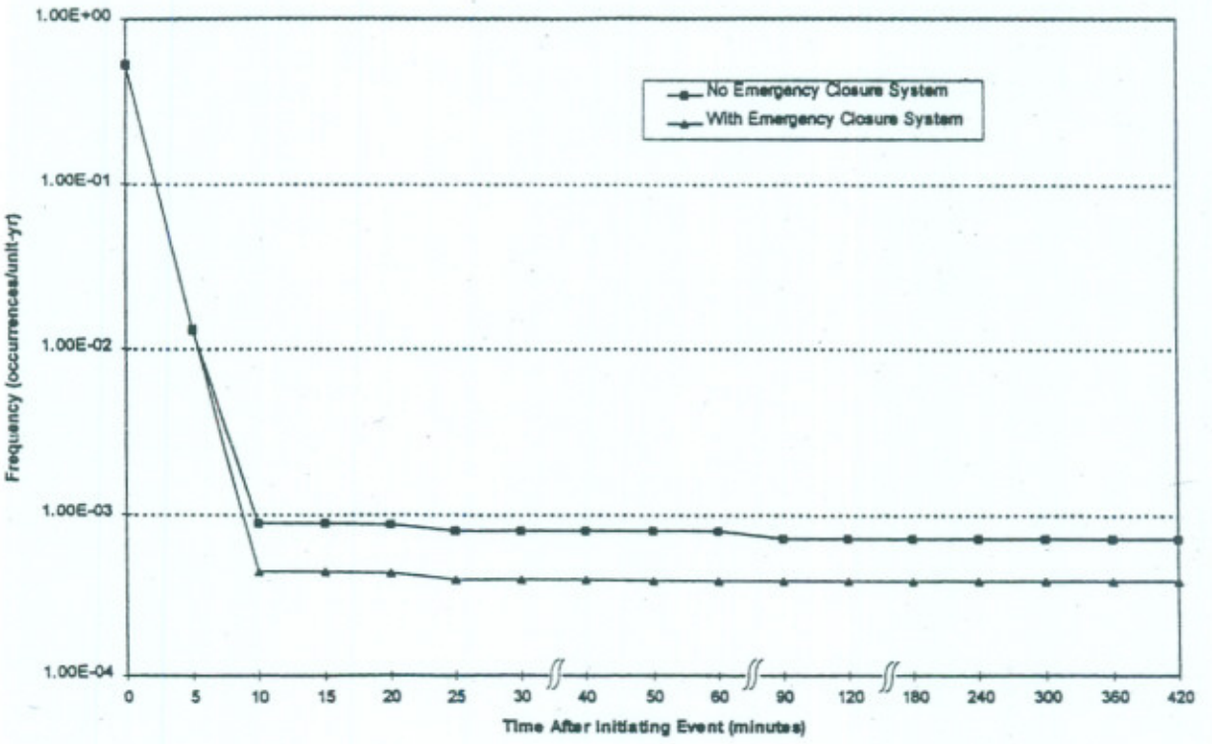

FIG. 11. Hydraulically Operated Intake Gate with and without Emergency Wicket Gate Closure System

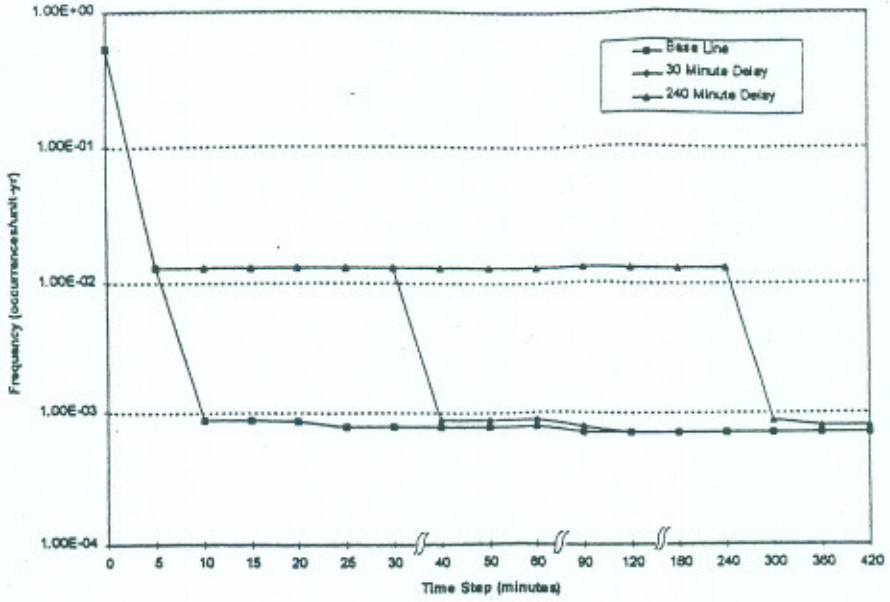

FIG. 12. Operator Time Delay Overspeed Frequency Profile Comparison

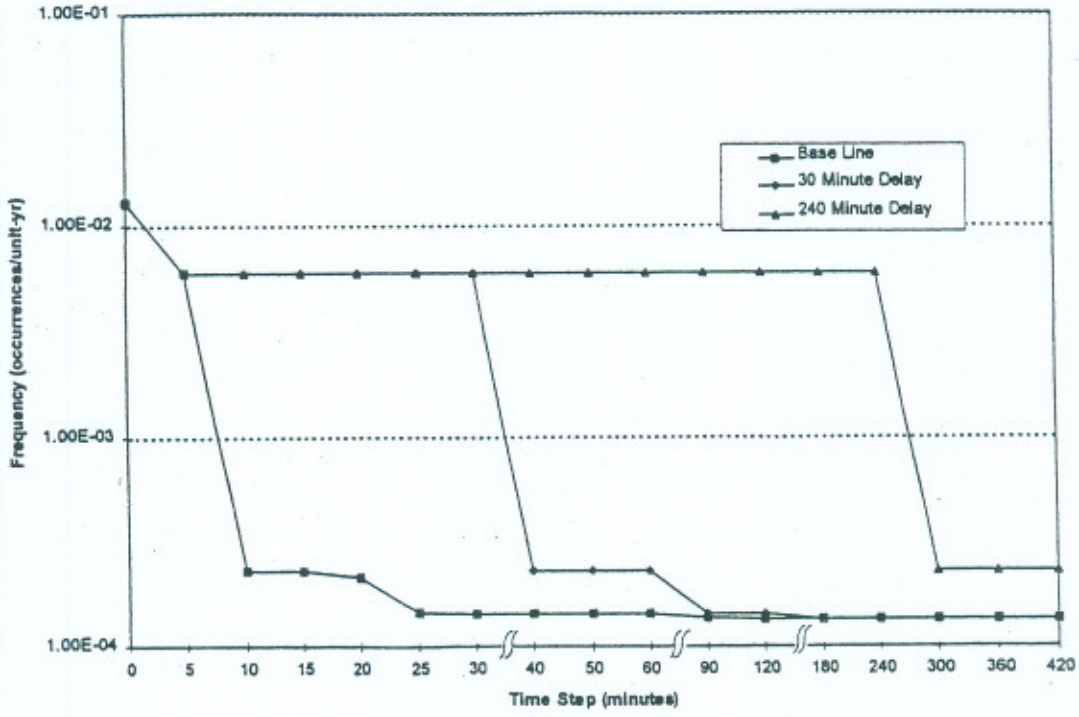

FIG. 13. Operator Time Delay Combined Flooding Frequency Profile Comparison

DESERTIFICATION AND SOIL EROSION

Prof Dr. Javed A. Aziz.

INTRODUCTION

The term desertification refers to the expansion of desert or desert like conditions into adjacent areas. In desertification, masses of dust and sand move to smother fringe settlements. Desertification is the result of a combined impact of adverse climatic conditions, such as persistent drought in arid areas, and stresses created by human activities such as agriculture, energy demand and urbanization. In the present days, desertification has become most serious environmental problem in some of the countries of the world's arid zones. Desertification ruins valuable land, forces out wildlife and threatens endangered species.

UNEP defines desertification as land degradation in arid areas resulting mainly from adverse human impact. UNEP estimates suggest that at least 35% of the earth's land surface is threatened by desertification and this area is inhabited by 20% of the world population (Middleton, 1995). Due to desertification, around 200,000 km^2 is lost to economically productive agriculture every year (Botkin and Keller, 1995). The areas directly threatened are those adjacent to the deserts on all continents. In Africa, the Southern Sahara desert is extending at a rate of 6 Km per year (Money, 1994).

CAUSE OF DESERTIFICATION

Desertification may be caused by natural processes. Prolonged drought, for example, kills the plants and the wind erosion removes the most fertile top soil leaving a barren landscape.

Human activities may initiate desertification in the absence of increased aridity. Such activities include overgrazing, over-cultivation, deforestation and over irrigation.

The overuse of pastures caused by allowing too many animals to graze has been the major cause of desertification on the global scale. Grasses in the rangelands have fibrous roots which hold the soil in place. With overgrazing, the grasses cannot recover and die resulting in desert like conditions. UNEP, 1992 estimates show that 72% desertification is caused by overgrazing (Middleton, 1994). The problem is very common is Senegal, Niger and Kenya.

Humus and nutrients bind the soil particles together into aggregate. The removal of the two through over-cultivation makes the soils susceptible to erosion. the introduction of arable agriculture into areas more suited to grazing may also result in desertification. Agricultural techniques which allow the soild to lie exposed and unprotected by vegetation for a large part of the growing season also contribute to the problem. When water and wind erode the top soil, it becomes impossible to cultivate the land and ultimately desert like conditions prevail.

In northern China' areas that were once grasslands were overgrazed, then some of these rangelands were converted to croplands. Both practices led the conversion of the land to desert (Botkin and Keller, 1995).

Clearance of forested land for cultivation or fuelwood production reduces the protection offered to soil by tree cover. Poor forestry practices including cutting all the trees in an area marginal for the growth ultimately result in barren lands and thus promote desertification.

Increase in salt contact of the top soil, i.e. salinization, can be

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induced through over irrigation. Salinization stunts crop growth, lowers yield and eventually kills crop plants and ruins the land. The ultimate impact of salinization is therefore desertification.

The problem of salinization is found in dryland irrigation schemes throughout the world. In Pakistan where irrigation is used on 80% of all cropland, about 35% of irrigated area suffers from the problems of salinization and more than 40,000 ha of irrigated lands are lost each year to water logging and salinity. (Middleton, 1995).

PREVENTION OF DESERTIFICATION

Desertification can be prevented by good land use planning which includes best use of land keeping in view its carrying capacity. It would involve restriction on grazing and cultivation in many regions to prevent desertification. The destruction of woodlands will have to be stopped. Trees and shrubs protect the land against erosion, yet they are being cleared at an alarming rate. Ethiopia which had 40% of its area as woodlands in 1900 has now only 3% as that (Kemp, 1994). In fact, the destruction of woodlands to get fuel wood is the major cause of desertification in most of sub saharan Africa.

Soil conversation techniques may effectively help prevent and revert desertification. These are being discussed in the later sections of the paper. Overpopulation has also been traditionally regarded as an integral part of desertification. Population densities must therefore be examined to assess human pressure on the land in the form of over cultivation. The fight against desertification has been marked by a distinctive lack of success and effective solutions are unlikely to be widely available in the foreseeable future. (Kemp, 1994)

The foregoing discussion, however, clearly indicates that to prevent desertification the loss of fertile topsoil must be stopped. Soil erosion in itself is an important environmental issue of the present day and as such is being discussed in detail in the following section.

SOIL EROSION

The thin layer of the earth known as topsoil is essential to land fertility. Typically only some 15 cm deep, topsoil is a rich medium containing organic matter, minerals, nutrients, insects, microbes and worms.

Erosion of soil is a natural process which occurs on most of the earth's land surface. Since soil is a vital part of the life support system, its loss is an important environmental issue. Infact the rate of soil formulation, i.e. around 2.5 cm of topsoil in 200 to 1000 years, is so slow that the resource is essentially nonrenewable in human life span (Brown et al, 1995).

The term soil erosion refers to the movement of soil from one place to another. The two main natural agents of soil erosion are flowing water and wind. Water erosion occurs when rain detaches soil particles on impact and run off transports material. Wind moves soil particles from one place to another. The resulting sediments clog irrigation ditches, reservoir and lakes and damages hydroelectric plants.

Most of the human activities that affect soil erosion do so by altering the erodibility of the soil surface. Soil erosion is thus caused timber cutting, overgrazing, mining and urban development. Several aspects of more intensive farming also contribute to the enhanced soil erosion. These include expansion of arable crops onto steeper slopes, creation of large fields by removal of walls and hedges and breaking of soil into fine tilth using powered horrows to aid seed germination (Middleton, 1995). In rangeland areas, concentrated livestock population weakens the vegetation cover and exposes soil to wind and water erosion. It is estimated that overgrazing, deforestation and agricultural mismanagement accounts for 70% of damage done to the world's soils.

Soil erosion results in loss of fertile top soil and of nutrients and makes the remaining land less able to hold water. The phenomenon results in the reduced crop yields. It is estimated that 30 percent of the world's cropland has lost

productivity from soil erosion. Soil erosion also gives rise to air pollution and may result in sand blasting of crops and buildings. Sediments deposited downstream cause damage to water supplies, irrigation systems and hydroelectric plant.

It is estimated that 24 billion matric tonnes of topsoil is being lost every year world wide (Miller, 1994) and around 6 million ha of productive dryland are converted into worthless deserts (GOP-IUCN, 1992). Due to soil erosion, China loses around 390 million cubic meters of water storage capacity each year (Brown et al, 1995). The costs of failing to check soil losses can be seen in Ethiopia and Haiti that have lost so much soil they can no longer feed themselves.

Monitoring the sediment load of major rivers indicates the amount of soil lost in a watershed. In Pakistan, the River Indus carries a sediment load of 750 million tonnes per year, being fourth in the world in magnitude (Brown et al, 1995). Around 11 million ha of Pakistan land suffers from water erosion whereas about 2 million ha experiences wind erosion. (GOP-IUCN, 1992). Water erosion thus accounts for the loss of over 47 million tones of soil per year whereas 13.5 million tones are being lost every year due to wind erosion. The major causes of soil erosion in Pakistan include overgrazing, forest removal, cultivation on marginal lands and the lack of soil conservation measures. In irrigated areas, water logging, salinity and sodicity have degraded the land whereas the range lands overgrazing is the primary cause of land degradation.

The National Conservation Strategy of Pakistan (1992) puts emphasis on soil conservation through maintaining permanent vegetation cover in high risk erosion areas, agriculture and biological soil conservation practices and water logging and salinity control. To achieve sustainable use of rangelands, the NCS recommends their periodic closure and granting the licences to the whole community and not to individuals.

SOLUTIONS OF SOIL EROSION

Top soil loss must be minimized to sustain the food production system to meet the needs of increasing population. To protect cultivated soils from erosion many techniques may be employed. Maintaining a vegetation cover on fields during fallow periods and rotating grasses and legumes such as alfalfa or clover with grain crops are the most important defence mechanisms against erosion. Similarly 'mulching' in which some residual crop material is left in the soil can be employed to reduce erosion. However, it gives rise to insects and weeds and thus more pesticides and herbicides are required. In addition, the following techniques can be helpful to reduce soil erosion.

i) Conservation Tillage farming

In this method, special tilling and planting machines are used to disturb the soil as little as possible while planting crops.

ii) Terracing

In this practice, steep slopes are converted into nearly level terraces. Terracing retains water for crops on each terrace and reduces soil erosion by controlling run off.

iii) Contour Farming

Soil erosion can be significantly reduced on sloping lands by plowing and planting crops in rows across, rather than up and down, the sloped contour of the land. Each row planted horizontally, along the contour of the land acts as a small dam to help hold soil and slow the run off of water. In Ethiopia, contour plowing is being used successfully to conserve water and prevent erosion (Kemp, 1994).

iv) Strip Cropping

In this practice, a row crop like corn is alternated in strips with a soil saving cover crop such as grass or legume that completely cover the soil and thus reduces erosion.

v) Wind Breaks

Wind erosion can be reduced by planting long rows of trees so that they partially block the wind.

To prevent soil erosion, erodable lands should neither be planted in crops nor cleared for vegetation. In addition, where possible, reforestation should be employed. In Mali and other parts of West Africa, reforestation is being attempted to stem the southward creep of the desert. Soils that have been badly eroded can be reclaimed by providing plant cover and through restricted land use to restore soil fertility.

SUMMARY

1. Desertification, the expansion of deserts, is a serious environmental problem which is caused by adverse climatic conditions, poor farming practices as well as the conversion of marginal grazing land to croplands. At least 35% of the earth's land surface is threatened by desertification and this area is inhabited by 20% of the world population.

2. Overgrazing, over-cultivation, deforestation and over irrigation are the main human activities responsible for desertification.

3. Desertification can be avoided by good land use planning, improved farming practices and planting trees as wind breaks.

4. Soil erosion, the removal of soil from the land by the action of water and wind is a natural process that is often accelerated by human activities such as farming on arid lands and deforestation,. It reduces the land productivity, clogs reservoirs and damages hydroelectric plants.

5. Conservation tillage, crop rotation, contour plowing, strip cropping and terracing can be used to help control erosion and mineral depletion. Soil that has been badly eroded can be reclaimed by providing plant cover and through restricted landuse to restore soil fertility.

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DRAINAGE OPTIONS FOR PUNJAB

ENGR. MIAN HAFIZ ULLAH

The twin menace of water logging and salinity plagued the irrigated agriculture since early 1960's as a consequence of seepage from canal system and irrigated fields. It had devastated vast areas (20% of C.C.A) in the beginning. Therefore Salinity Control and Reclamation Projects were taken up under a master plan formulated by consultants from United States. As these projects are still going on in a phased programme evaluation of their working have raised further environmental issue and problems due to flat slopes and lack of disposal facilities for Drainage affluent specially in saline ground water areas. Scarp-V in the Rahimyar Khan is a typical example. Therefore it is necessary to have a second look at our strategy for drainage of water logged areas in Punjab. Unlike Sindh, Punjab's 68% area is underlain with fresh ground water and another 16% of area has marginal quality (useable) ground water and only 14% of C.C.A lies in saline ground water zone for which drainage facilities are required.

Drainable surplus in FGW areas is being dealt by public and private tubewells. Recently Government is successfully transitioning the public tubewells by private tubewells in Scarp areas. In non-scarp areas public tubewells have multiplied at almost the same rate. The pumped water is being used to supplement canal supplies keeping S.S.W.L below the critical level. Some studies have suggested over mining of sub soil reservoir in about seven canal commands.

There are difficulties in Saline Ground Water Areas (SGW) where it the S.S.W.L has a rising trend.

The problems are;

a) high energy expenditures of pumping saline ground water.

b) Lack of disposal facilities for saline affluent.

c) Limited life of Tubewells.

d) High O & M costs both for horizontal and vertical drainage.

e) Saline water intrusion in FGW areas.

Sub soil water level used to be 70 ft. below the ground level prior to inception of Irrigation system. The rise in sub soil water level is attributed to seepage from Irrigation system and fields etc. Therefore the viable option left for saline groundwater area is checking of seepage from the

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source through lining of canal branches and distributary etc.

It is estimated that 4.12 MAF of water is being lost to saline ground water areas. And we can reserve a substantial part of this through lining of canal system is Saline ground water areas. A proposal has been framed by consultants for lining of canals estimated cost 25 billion rupees. This cost has been under estimated as it provide for concrete lining with bitumen as joint sealant. If concrete is under lain by Geo-membrane;. The cost ill be 100% higher. Moreover lining of all the channels in the Saline Ground Water Areas, had not been taken up in this proposal and if all the channels are lined in SGW zone, the cost is going to be Rs: 150 Billion approx. for Punjab.

Lining of secondary canal (less than 100 CS capacity) is already being provided in various water sector projects e.g. Fordwah Eastern Sadiquia South, D.G. Khan Scarp, Punjab Private Sector Ground water Development Project NDP etc.

SUGGESTIONS/OPTIONS

Small days (less than 100 Cs.) are included in Foreign Aided Projects referred above. It has been determined that there is nominal seepage through small channels and investments could be made cost effective if relatively larger canals (more than 300 Cs) are lined. Therefore government may decide to line channels under all projects which are more than 300 Cs upto 3000 Cs. in saline canal water areas i.e. FESS, D.G. Khan Scarp, Punjab Private Sector Ground water Development Project, NDP, Accelerated Salinity Control and Reclamation Programme. The work could be phased as per resource availability. This option will have definite advantages over the conventional Scarps as under:

I. It will not require any disposal facility.

II. It is environmental friendly.

III. No foreign exchange is required.

IV. Less O & M requirements to ensure sustainability.

V. Longer Life.

VI. It conserves water this can be used in development of new areas. It is estimated that about 3 MAF will be available as a consequence of this project.

VII. Reclamation of water lodged area.

VIII. Increased yield/Acre and increase in agriculture production with increase in farmer Income.

IX Settlement of the jobless through development of new area.

Cost Recovery

The water so saved can be used in irrigating new areas and lining cost could be recovered from farmers of those areas for to satisfy donor agencies for cost recovery and beneficiary participation. These new areas may be made beneficiary managed so far as O & M and water distribution in tertiary system is concerned.

WATERLOGGED SOILS, THEIR CHARACTERISTICS AND DISTRIBUTION IN THE PUNJAB PROVINCE

** CH. KARAMAT ALI,*
*** MUHAMMAD AZHAR JAVAID*
**** MUHAMMAD FEROZE & TASHKIL-UR-RAZA KHAN*

ABSTRACT

This paper reviews the extensive informations on waterlogged soils to develop an easy understanding into the phenomena of initiation of this hydra headed hazard. The redox potential (Eh), pH changes, general chemistry of waterlogged growth performance of arable soil flora are also envisaged in the text. Canal division wise statistics and suggestive measures are given to grapple with the cancer of waterlogging. It accentuates that the water cycle, weather cycle, controlled water release system and the discharge capacity should be researched and studies evolved.

INTRODUCTION

Waterlogging and soil salinity have since long plagued the fertile basin of Indus river rendering large tracts of land unproductive. Despite concerted efforts of the Government the problem seems to be gradually but constantly increasing. The injudicious and indiscriminate use of water together with seepage from the unlined canals proved to be the main source for spread of salinity and waterlogging which by the passage of time acquired status of the foremost environmental threat to the agriculture industry of Pakistan.

On the other hand it may be noted that all the major crops have shown a decline or nears stragnation. The rice and cotton crop, for example, have considerably fallen down in respect of total area under cultivation or the average yield per acre. The rise and fall in water table depth directly or indirectly affects the agricultural crops. According to a WAPDA report about 1.5 million hectares have watertable depth within about 5 feet during April/June and October. Areas with a watertable depth between 5-10 feet during April and October were estimated to be 6.36 and 4.25 million hectares, respectively. These statistics show the spread of this cancer in the country.

This situation makes it imperative to devise an appropriate course of action for adopting to the waterlogged environment and this is possible if the existence of the problem is recognised and identified. Therefore, inhand study besides envisaging the valuable suggestions to grapple with the cancer of the waterlogging, includes its nature, distribution and characteristics in depth.

WATERLOGGING

Waterlogging is a condition of the soil where watertable rises high and reaches within one meter from ground surface and thus affects crop roots. In extreme cases, the watertable rises even higher than groundwater. Waterlogging is very extensive problem in irrigated areas. It is caused by addition of huge amounts of percolation and seepage water from canals, distributaries and water channels as well as by in-efficient irrigation practices of the farmers. The problem gets intensified because of absence of any effective drainage system.. The intensity of waterlogging is variable and depends on season, general slope and soil porosity etc.

On the other hand, presence of gravitational water in the root zone excludes the soil air. Plants are, therefore, unable to respire properly. Oxygen dissolved in soil water gets exhausted. In some cases, the groundwater may pick up excessive amounts of salts and intensify problem. The increased concentration of CO_2 in the

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groundwater further complicates the situation.

SYMPTOMS ON PLANTS

Since respiration is one of the most basic physiological process of plants, therefore, any disturbance in respiration of roots has an overall depressing effect on all the life processes. Such plants loose vigour and are unable to withstand any adverse change in their vicinity. Anyhow, some symptoms of waterlogging include: dropping leaves, decreased stem growth rate, leaf abscission, leaf chlorosis (pale colouring), adventitious root formation, decreased root growth, death of micro-roots, absence of fruits and reduced yields. The overriding effect of soil flooding is the limited diffusion of oxygen to the roots.

THE CHEMISTRY OF WATERLOGGED SOILS

Waterlogging a soil containing decomposable organic matter causes the onset of anaerobic or partially anaerobic conditions because the soil micro-organisms, in decomposing the organic matter, will use up any free oxygen dissolved in the soil water much faster than atmospheric oxygen can diffuse into the wet soil. This shortage of oxygen will cause some species of bacteria to carry out a number of chemical reductions which may effect plant growth very considerably.

In order to obtain energy for their vital processes they bring about certain biochemical changes in the soil system by the transport of electrons from one substance to the other. Under the anaerobic soil conditions, other species can accept electrons and take part in a reduction reaction. Some oxygen containing compounds e.g. NO_3, SO_4, can accept electrons to loose their oxygen as exampled below:-

$NO_3 + 2H + 2e = NO_2 + H_2O$

$2NO_2 + 8H + 6e = N_2 + 4H_2O$

High valence cations such as Fe^{3+} and Mn^{4+} accept electrons and are reduced to divalent ferrous and magnous ions, and finally, H^+ ions also accept electrons to become hydrogen gas [4],

$2H+ + 2e = H_2$

Ponnemperuma [5] reported that a second consequence of bacterial activity under anaerobic conditions is that the organic nutrients are no longer fully oxidized to CO_2 and H_2O, but instead intermediate products are excreted, such as simple fatty acids, alcohols, ketones, hydroxycarboxylic and poly carboxylic acids, some of which are conducive to the reduction of ferric oxides. These organic compounds may further decompose with the production of CO_2, CH_4 (methane) and other hydrocarbons and sometimes H gas.

The principal inorganic reductions that poise a soil as it becomes more anaerobic are: NO_3 (Nitrate) to NO_2 (Nitrite), ferric hydroxide to ferrous ions, hydrogen ions to H gas, SO_4 (Sulphate) to sulphite and mangnic plus manganese (Mn) dioxide to mangnous ions. The chemical reactions are explained.

$NO_3 + 2H + 2e = NO_2 + H_2O$

$Fe(OH)_3 + 3H + e = Fe_2^+ + 3H_2O$

$2H^+ + 2e = H_2$

$SO_4 + 10H^+ = H_2s + 4H_2O$

$MnO_2 + 4H + 2e = Mn_2 + 2H_2O$

$CO_2 + 8H + 8e = CH_4 + 2H_2O$

Soils also contain CO_2 dissolved in the soil solution and if the conditions are suitable, either ferrous carbonate will be precipitated, or the CO_2 in the solution, through its effect on pH will alter the concentration of ferrous ions in the equilibrium with, $F_3(OH)_8$, if this is present [4].

EFFECT OF REDUCTION AND ORGANIC PRODUCTS ON PLANTS

The principal organic acids produced as a consequence of reduction of organic compounds added to or already present in a waterlogged soil are acetic acid (CH_3COOH), with smaller quantities of proprionic, butyric, lactic, valeric, fumeric and succinic acid. A concentration of 10^{-2}M of acetic acid is toxic to the roots of many plants. If such soils are to be used for rice, either these acids must be washed out of the soil by flooding and leaching, or the land must be left wet long enough for their

concentration to fall to a low level before the crop is planted .

Among the various reduction products under anaerobic conditions, ethylene is the only one of the hydrocarbons that have detrimental effect on root development of many crops. The seminal roots of tobacco and tomato will have their rate of elongation reduced by 75% if the solution contains 1 ppm of ethylene and this concentration will reduce the rate of elongation of barley roots by 60%, rye roots by 25% but will not effect the elongation of the several varieties of rice, wheat and oat come intermediate between rye and barley..

REDOX POTENTIAL

Redox potential (Eh) varies with the condition of the soils. Its measurement on Redox Potentiometer is a useful index to the oxidation reduction status of the soil. Patric and reddy reported that wet land soils have low or negative redox potential (Eh-value). Aeroted soils have Eh varying from + 400 to + 700 mv, waterlogged soils show Eh valued as low as + 250 to - 300mv on the instrument.

pH CHANGES IN SOIL

Jones has reported that upon submergence the pH of the most soils changes toward neutral i.e. acid soil (Not common in Pakistan), pH increases and alkaline soil pH decreasing to an equilibrium pH of about 6.5 to 7.5. The pH buffering action of wet land soils is due largely to the Fe and Mn redox system and carbonic acid, the former increasing pH of acidic soils and the latter decreasing pH of alkaline soils.

A decrease in pH of alkaline soils following submergence is the result of several chemical and biological changes. Microbial decomposition of O.M (organic matter) produces CO_2, which reacts with water to form H_2CO_3 (Carbonic acid) which then decomposes to H+ and HCO_3 ions. The decreased pH of alkali and calcareous soils upon flooding can be attributed to Na_2CO_3-H_2O-CO_2 and $CaCO_3$-H_2O-CO_2 systems, respectively.

ADAPTATION OF PLANTS TO WATERLOGGED SOILS

Plants adopted to conditions of poor soils aeration develop a system of interconnected internal air spaces (aerenchyma) through which oxygen from the atmosphere can diffuse down into the roots and out of the root into the soil immediately outside the root, thus allowing the actual uptake of ions by the root to take place as an aerobic process. A consequence of oxygen diffusing out of plant roots growing in waterlogged soils is that they are often surrounded by a sheath of soil having a dark brown colour, due to the conditions being sufficiently oxydizing for the formation of ferric hydroxide and manganese dioxide.

DISTRIBUTION OF WATERLOGGED AND SALT AFFECTED SOILS IN PUNJAB

Thur and Sem Statistics Division (T&SS) of the Directorate of Land Reclamation, Punjab conducts an annual survey to apprise of the people about the extent of the cancer of waterlogging and salinity. The data given in Table 1 reveal that the cancer of waterlogging and salinity has become so chronic a disease for our agricultural economy that it has neutralized our efforts to change the fate of our farming community. The fertile agricultural lands are turning into ruins. The canal divisions affected to a greater extent in the Punjab are, Hakra, Balloki along Lower Bari Doab, Fordwah and Sargodha. The perusal of the data in Table 1 shows that out of the surveyed area about 1.60% in Hakra, 1.32% in Balloki, 0.96 in Fordwah is waterlogged. Similarly out of the total surveyed area in the canal division of Sargodha about 0.92% is waterlogged. So today the need is to identify and recognize the existence of the problem. It is also surveyed that salinity/alkalinity prevails to a greater extent in the tails of water distributaries as compared to head or middle of a distributary. This can be attributed to aridity at

the site due to shortage of irrigation water at the tail.

PREVENTIVE STEPS

One of the hinderance in attaining the mitigation of this hydra headed hazard is of monetary origin, the country being a developing one has got limited resources to grapple with the cancer of waterlogging and salinity. This situation makes it imperative to devise an appropriate course of action for adopting to the saline and waterlogged environment while continuing to seek economically as well as otherwise acceptable ways of reducing salt concentration in the future. Anyhow some suggestive and preventive measure against the problem propounded by different technical experts are enumerated here.

Excavation of canals distributaries and water channels water courses along the natural land slope and then their brick lining especially at the profusely seeping points may mitigate the hazard to a greater extent. Similarly the role of installed tubewells to pump out groundwater (seepage) may be identified and recognized. In SCARP areas, watertable has been lowered down to a safe limit by this vertical drainage technology. Agricultural endeavours like increasing the area under forestation, and growing up the plants with high evapotranspiration potential and well adopted to waterlogged conditions may lower the watertable. The planned and proper irrigation may also help to reduce the menace. The practice of digging small drains or installation of a suitable drainage system has performed well under waterlogging field conditions. Hussain, S.M. has suggested that the regulator gates at the iuncture of high and low lands should be installed to contain the rainwater of the high lands on the spot on the upper reaches to avoid the pressure on the banks of the system and to prevent its collapse. Open pipe inlets should be replaced by temper proof steel frames on the pattern of irrigation system in accordance with the capacity of the drainage system. He also reported that the weather cycle, controlled water release system and the discharge capacity should be researched/studied and evolved. Further, the periodic desilting and cleaning of the system be meticulously and regularly planned and carried out.

Similarly, the adherence to the old practice of cultivation of 40% of "Khatedars" lands for Kharif and 30% for Rabi should be strictly followed. It will not only provide water to the tail enders but will also check waterlogging.

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TABLE-1

CANAL DIVISION WISE THUR AND SEM STATISTICS OF THE PUNJAB PROVINCE FOR THE YEAR 1993-94.

S. No.	Name of Canal Divisions	Area Surveyed (Acres)	Thur (Acres)	Sem. (Acres)
1.	Gujrat	572846	17113	1941
2.	Sargodha	511690	137151	4722
3.	Kirana	589250	100475	1171
4.	Rasool	238149	29778	1901
5.	Shahpur	235351	8055	426
6.	Sheikhupura	571450	156408	408
7.	Marala	295627	23662	_
8.	Gujranwala	804361	31830	_
9.	Upper Gogera	701133	55158	_
10.	Lower Gogera	566512	132068	2653
11.	Burala	588923	88552	199
12.	Khanki	296181	49914	_
13.	Hafizabad	412606	56061	108
14.	Faisalabad	387735	39715	4134
15.	Jhang	692270	46721	2542
16.	Lahore	703013	36072	998
17.	Sahiwal	842011	92514	26
18.	Balloki	355679	46229	4697
19.	Khanewal	535616	29487	_
20.	Multan	675849	172009	_
21.	Shujabad	293134	43745	_
22.	Kot Addu	418574	72854	2880
23.	Muzaffargarh	557024	145442	_
24.	Trimmu	396843	134322	1772

25.	Rajanpur	477784	50613	–
26.	D.G. Khan	476097	72610	267
27.	Layyah	690650	10468	97
28.	Bhakkar	694336	3840	–
29.	Khushab	788684	2067	2520
30.	Kala Bagh	201129	–	–
31.	Esa Khel	13599	–	–
32.	S.D. Islamabad	21043	–	–
33.	S.D. Jhelum	1773	–	–
34.	S.D. Chakwal	9401	–	–
35.	R.Y. Khan	581706	111957	–
36.	Dalas	448520	75284	–
37.	Khanpur	477699	71601	–
38.	Sadiqia	608884	132407	4957
39.	Fordwah	464554	148851	4450
40.	Hakra	619843	39499	9921
41.	Bahawalpur	588947	17811	–
42.	Ahmadpur	658412	48175	–
43.	Sulemanki	181092	12675	–
44.	Eastern Bar	464990	34146	–
45.	Western Bar	764981	62779	–
46.	Khanwah	651406	31584	–
47.	Kasur	356717	101635	–
48.	Lodhran	616711	79505	–
49.	Islam	134266	3209	
	Total	23235051	2856051	52790

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- **Pehur High Level Canal Project , 2nd Floor Commercial Complex Block-II, Phase V , Hayatabad, Peshawar, Phones : (0521) 812049, FAX (0521) 812164.**
- **Fordwah Eastern Sadiqia (South) Phase-I Irrigation and Drainage Project Drainage Component , 146-A-1 Township, Lahore, Phones : (042) 5112882, 5116634**
  FAX (042) 5116635
- **Post Flood Rehabilitation and Protection Project , House No.271, St. No.8 Cavalry Ground (Extension), Lahore Cantt. Phones : (042) 6667264, 6669012, FAX (042) 6669013.**
- **Study for Development of Irrigation Uses in Punjab due to Water Accord, 147-M Gulberg-III, Lahore, Phones: (042) 856288, FAX (042) 5862033**
- **Zaibi Dam Project, Mitha Khel, District Karak (NWFP), Phone: (05244) 210520 Ext.58.**
- **Punjab Private Sector Groundwater Development Project, 89/A-1 Township.**

CLIENTS

Some of the major Clients are listed below ;

- **Ministry of Water and Power , Government of Pakistan, Islamabad.**
- **Ministry of Defence , Government of Pakistan, Islamabad.**
- **Pakistan Water and Power Development Authority, Lahore.**
- **Federal Flood Commission, Government of Pakistan, Islamabad.**
- **Government of Punjab, Irrigation and Power Department, Lahore.**
- **Government of NWFP, Irrigation Department, Peshawar.**
- **Government of Balochistan , Irrigation and Power Department, Quetta.**
- **Government of Sindh, Irrigation and Power Department, Karachi.**