Chapter 3

Measurements of Canal Flow with Communication System

3. 1 Measurements of Canal Flow

Flow measurements at all the control structures are critical in Canal Monitoring and Control system. Without Repeatability, Reliability and Accuracy of flow measurements, canal monitoring & control may prove disaster. Wrong measurements, even at one location on the main canal may make the complete canal control system unstable, losing the whole purpose. Open canal flow measurements are quite difficult and we have to adopt proper discharge measurement methods depending upon the criticality of the measurements. Measurement of flow is the key issue, with all adverse site conditions, including social, political and economic aspects, in general and technical in particular.

There are many methods for measurement of canal flow. We will illustrate the same in brief, and decide about the best available system at present.

There are variety of measurement schemes and structures for flow measurements in the open canal. This topic itself is worth of detailed research; however the researcher is some of the methods which are used regularly in the present schemes and can be adapted in new or during modernization.

3.1.1 Stage Discharge by Level Measurement:

In the case of a running canal, with predefined structure, the water level in the canal can be extrapolated to calculate the flow. This method is quite useful with stream line flow and measurement point is quite away from the control structure. This method is the simplest one can be used in remote areas, where all other methods are difficult to implement. The flows are pre calibrated with respect to level. The discharge is calculated with chart in case of manual operation, reading the level with gauge and with the preprogrammed look up table with Remote Terminal units. Though not so accurate it can be used for tentative application, when any other system is not possible to implement.

3.1.2 Current Meters

This is one of the techniques used to measure the flow. Current meter gives the velocity at particular point. A cross sectional canal is sampled for measurements of velocity at 66% of the water depth, which indicates the average velocity at that vertical column. The water height is measured by any other means for this application. It is essential to have this process carried out at least at three different water heights to have accurate results. This method is generally used for calibration of gates.

Since the measurements by this method give instantaneous results, we cannot use the same for Monitoring and Control of canal system. Since better methods are available now, we will not discuss the same in details.

3.1.3 Measurement by Flumes

One of the method to measure flow, so far is by construction of Flumes. Flumes are open-channel flow sections that force flow to accelerate. Acceleration is produced by converging the sidewalls, raising the bottom, or a combination of both. When only the bottom is raised with no side contractions, the flume is commonly called a broad-crested weir. When the downstream depth is shallow and enough convergence exists between the upstream and downstream channels, the flow passes through **critical** depth. Therefore, flumes are sometimes called *critical-depth flumes*. When flow passes through critical depth, a unique water surface profile occurs within the flume or broad-crested weir for each discharge. This condition is known as **free flow**. For this case, upstream heads at one location relative to the control bottom elevation near the region of critical depth can be used to determine a usable head versus discharge relationship for flow measurement.

Flume head loss is less than about one-fourth of that needed to operate a sharp-crested weir having the same control width, and in some long-throated flumes, may be as low as one-tenth. Another advantage compared to most standard weirs is that for a properly designed and installed flume, the velocity of approach is a part of the calibration equations. Velocity of flow can usually be designed to minimize sediment deposition within the structure. Gradual convergence sections at the entrance tend to improve velocity distribution of approach flow and the passage of floating debris.

Some flumes can be more expensive than sharp-crested weirs or submerged orifices in unlined channels.

Construction of Flumes for measurements is acceptable during the construction of the new canal. However it is very difficult to construct the same during modernization, as the canal is already ready and running for quite some time, which is the case in most of the places in India. Construction is quite difficult, as one needs shut down for quite some time. In the case of canals running 24x7, it may not be possible to have shut off.

Level measurements in canal can be measured with Gauge Patti, Float with Encoder, and Ultrasonic level sensor in a stilling well.

In the developing countries, where, the distribution of water has not reached to its optimum standards, Water Users Associations are not, either formed or defined, water is charged on Crop- Acer basis. Farmer is not really sure of the availability of water at proper time, tries to collect water as and when available, and tendency of creating blockage in the canal, to get advantage of increased water level. Some of the crud methods adapted are indicated Fig.3.1 and 3.2.

One of the problems with this type of measurements is the heading up of water just above the measuring structure. Even though there is no discharge, the level is up, indicating very high discharge. Some of the photos indicate the actual position at sites in remote parts of India. We should not use this method with SCADA system unless we cannot use any other method.

Since there are many better and accurate methods flow measurements available now, adaptable any time, we will not discuss the same in details.

Fig. 3.1

Fig. 3.2

3.1.4 Upstream, Downstream Levels with Gate Openings (Energy Equation)

Measurement flow is generally required at the control structures, during the monitoring and canal control operation. This method is quite reliable, accurate and most suitable for this application.

Gates are provided at each control structure or cross regulators. We use RTU at each control point to measure various parameters like Upstream Level, Downstream Level, Gate Openings, and Position of Escape Gate etc. on Real Time Basis. An ultrasonic level sensor installed in a stilling well, on both upstream and downstream, at proper location measures the water level at that point quite accurately, reliably, and consistently all the time.

Discharge is calculated with standard energy equation, proven and tested imperially at various laboratories.

The RTU calculates discharge, suitable up to two decimal digits for small canals and up to four decimal digits for larger canals with the following equation.

The discharge coefficient is site specific and may vary from site to site depending upon the site conditions, but once confirmed, will fairly remain constant. This value is generally derived by calibrating the same. The calibration of the same once every year or every five years is advisable for proper operation of the system.

In the case of Head Regulator, at Dam site, the canal flow is of Free Flow type, with downstream (H_2) height as zero. Free Flow means there is no water head on the downstream side of the gate. Generally water fails substantially at lower level, from where the canal starts.

Even if banking (heading of water in the canal) is done at any place, as mentioned earlier and shown in figures, the calculated discharge is still accurate, as downstream level will rise, considered in the equation. However, it is not possible to measure discharge at any other location in the running canal with this type of arrangement, unless control structure is constructed.

The Flow rate is calculated flows:

$$Q = Cd\,(H_1^{\,2/3} - H_2^{\,3/2}) \times W \times H.$$

Where

Q = Discharge Rate in Cmsec. (Cubic meter /Second)

Cd = Coefficient of Discharge.

H_1 = Upstream Level in Meters.

H_2 = Downstream Level in Meters.

W = Width of the Gate in meters.

H = Vertical Gate Opening. (Height of water column in meters)

3.1.5 Ultrasonic Transit Time Flow Measurements

Ultrasonic canal gauging is based on the continuous measurement of stream velocity at chosen depths by recording the difference in time for sound pulses sent obliquely across the canal in opposite direction. Sound waves travelling downstream propagate at higher velocity than those travelling upstream due to the component of the stream velocity parallel to acoustic path. Since the stream velocity is much lower than the velocity of sound in water, the difference between the upstream and downstream travel time is very small as compared to the individual travel times. This requires that an accurate time measurement is made in order to achieve the required accuracy. Transducers are mounted on the each bank of the canal to transmit and receive these sound pulses. The angle between the transducer line, or flight path, and the direction of canal flow is normally made between 45^0 and 60^0. The stream velocity component across the acoustic path can be measured to within +/- 0.1%. Simultaneously the average depth of flow is measured using any level measuring instrument. The discharge is then calculated by a velocity-area method from the mean velocity component along the flight path, the average depth of flow and the channel width. Velocity measurements are made several times a second and averaged over the several minutes to smooth out fluctuations in the flow.

Single path System:

In a single path system, measurement of velocity is made at one depth only with the pair of transducers normally set at 0.6 of most frequently occurring depth. If the transducers are movable, they are used to calibrate the system by taking line velocity measurements throughout the depth as in the vertical velocity distribution method. Instead of verticals being used, however as in the velocity-area method, horizontal paths are scanned at an infinite number of verticals.

A single path system is normally used when the variation in stage is small for a larger percentage of the time.

Multipath System

The more common multipath system incorporates several pairs of transducers to provide velocity measurements at various depths and is particularly suitable to canals having wide range in level difference or with irregular velocity distribution. The transducer assembly is normally installed on a sloping section, set flush with canal bank.

A Microprocessor based RTU controls the system, selecting which transducer pairs is submerged. Each pair of transducers is energized in turn, starting with the lowest. The sequence is repeated continuously for the prescribed period, and mean velocity for each path is calculated. Weighted summation of these velocities, allowing for the spacing between paths and the length of each provides the discharge. As with the single path system, the velocities, the depth and discharge are calculated.

The multipath system, with fixed transducers, is now favored by the users. The cost of extra transducers is small in proportional to the total cost, including installation. Normally four to six pairs are used, depending upon the site conditions, although even twelve pairs are also used.

As regards to open canal measurements with this type of system, one of the major problems is installation and maintenance. The installation angle is quite critical and must be maintained properly. We need the complete shut-down of the canal for cleaning and maintenance. Cleaning is generally a great problem in most of the developing countries and India in particular.

Reflector system

The installation of typical ultrasonic flow gauge requires a cable to be laid in the canal bed to carry the signals across the canal, as the transducer on the other bank of the canal requires power to activate the same. A reflector system incorporates the transducers only on one bank, with reflector on the other bank installed in the form of a length of angled steel.

In a reflector system, the main and the reflected beams make different angles in the direction of flow and give a first-order cancellation of errors caused by oblique flow, giving better results.

3.1.6 On-Line Acoustic Doppler Current Profiler (OADCP)

This is a relatively a new development in the basic instrumentation in last decade, with the measurement based on Doppler Principal. The reflection of the sound waves from a moving particle or air bubbles in the flow causes an apparent change in frequency. This difference in frequency between the transmitted and the reflected sound waves is a measure of the relative velocity of the flow in both magnitude and direction and is known as Doppler Shift.

Two types of Doppler instruments are available, for continuous Discharge measurements, one is side looking (SL) type and other one is up looking (SW) type. Side looking type unit is mounted on the side of the canal, whereas up looking one is mounted at the bottom the canal. The instrument also measures the water height above the same, one with pressure sensor and another with ultrasonic type.

A side looking Doppler (SL) can be easily installed at sides of the canal, near the bottom end as shown in the Fig.3.3A and 3.3B. The height from the bottom of installation is such as not to affect the reflected wave from the canal bed. Shut-off is not needed for maintenance. The instrument measures the average velocity over the entire canal area, by subdividing in separate segments along the length of the canal. With all the as-built construction parameters like bed width, side slope, along with installation parameters, like height of instrument from bottom, programmed the Doppler calculator calculates the average velocity, of the complete cross-section using well proven one-sixth power law. The instrument also has the ability for storing the total discharge. A built in temperature measurements allows the OADCCP to take care of any changes in the water properties due to temperature.

The side looking Doppler is mounted on a skid attached to the side of the canal, and can be lifted up for cleaning & maintenance if required, without the need of canal shut-down. Lot of dust or plastic bags or many such objects fly along with the water and may cover the Doppler, which is one of the major issues in all developing countries. Doppler gives really accurate results, not requiring any calibration and any empirical constants.

Fig. 3.3 A

Fig. 3.3 B

The researcher made measurements at site near Bikaner on IGNP, to conclude that the Side Looking Doppler having range more than the size of canal, where it is installed, must be used in Developing Countries like India, if more than two gates are used to control the discharge of water in the canal, as proper gate scheduling is generally not possible, or if one of the gates goes faulty, it takes long time to get repaired and maintain.

Similarly Up looking Doppler is quite useful for small canals or distributaries with single gate. This makes sure that the stream flow is maintained throughout. As the canal is small one can get the shut-off for maintenance.

3.1.7 Radar Flow Measurements

In recent years level devices using radar have seen tremendous growth in uses requiring precision measurement, in part because of their ability to overcome such level measurement problems as foaming, temperature changes, vapors, condensates and surface agitation. Unlike acoustic devices, where the accuracy of the device is affected by the temperature effects on the speed of sound, radar devices are virtually immune to such errors. Now, flow-sensors incorporating radar are entering the open channel flow meter are available providing non-contact flow measurement.

A basic principle of radar is its ability to reflect off the surface of materials based on the material's dielectric constant. Any material that has a dielectric constant greater than 2, such as water or ammonia, will easily reflect radar signals. The higher dielectric constant of the material, we get larger signal that is reflected and available for processing. On the other hand, radar signals tend to pass through materials that have a dielectric constant less than 2, such as air, vapor, certain gases, or foam, and therefore these materials have a minimal effect on level and velocity measurements as compared with other measurement technologies.

Radar flow meters determine the velocity of the flow similar to how police radar guns measure the velocity of an automobile. The radar beam is transmitted from the sensor's "horn" at a defined angle to the flow surface. This transmitted beam interacts with the fluid and reflects back a portion of the transmitted signal. The portion of the signal that is reflected back is at a slightly different frequency than that which was transmitted. For instance, the frequency is slightly higher if the flow is coming toward the beam and is slightly lower if the flow is going away from the beam. The reflected signals that return to the radar horn are detected and compared with the transmitted frequency.

The frequency shift is a direct measure of both the velocity and direction of the flow particles from which the signal was reflected. Operating at a relatively high frequency, the radar flow meter can measure velocities with only a minimum amount of surface disturbance.

In all open channels, the flow varies throughout the cross-section. These "velocity profiles" generally terminate along the surface of the flow. In other words, a fingerprint of the flow profile exists on the flow surface itself. By measuring a portion of this fingerprint, the radar flow meter can determine the average velocity of the flow stream.

Because the position of the beam relative to the flow surface is known, the relationship between the sensed velocity and the average velocity of the flow stream is defined and flow can be determined to an accuracy of ± 5 percent or better. Like all flow metering devices, the flow needs to be reasonably uniform in nature to obtain the highest accuracy.

The non-contact nature of the radar open channel flow meter reduces the need for periodic maintenance and helps limit sensor fouling. Also, radar flow meters can operate from above existing channels without the need of flumes or weirs and without any limitation on the minimum or maximum flow range.

Researcher could not have experience on these sensors so far as the instrument was not used in India so far. However, it seems, this type of instrument may not be really useful for canal applications, as it works on the principal of waves, a must in the flow. Generally canal flows are very smooth and steady. It might give errors due to wind flowing in the opposite direction of velocity of water, resulting in surface waves moving in exactly in other direction, indicating negative flow.

3.2 Communication:

Data and Voice communication is one of the crucial system components in the complete canal Monitoring / Automation network. All real time parameters like Upstream & Downstream Water Levels, Discharges, Gate openings of Cross Regulator (CR), condition of Escape Gates (Generally Escape Gates are either Closed or Open), Power Supply Conditions at Local Station along with Alarm Conditions generated if any, are communicated to the Mater Control Canter (MCC) directly or through SCADA Station, depending upon the system configuration. Since all real time data is available at MCC, Decision Support System (DSS) can activate various commands as per the system requirements through the same communication network, thus requiring two way communications.
Reliability of Communication is heart of Canal Monitoring/Control 0peration.

Generally Master Slave arrangement is most suitable for this operation. Polling frequency and priority is decided depending upon the site conditions. Generally 15 minutes to 1 Hour scan time is a good compromise for normal canal operation due to power supply situation. Programmable Station Identification (ID) that is configured at site distinguishes every specific station. Master Controller collects the Field Station or SCADA Station data by broadcasting a command, indicating particular Station ID. All the stations receive this command, decode it, and send the required data if the request belongs to it. All other stations ignore the command. If the master doses not receive the response within predetermined time, it requests once again, and collects the data. This process is repeated 2-3 times, before confirming the problem at that particular station. Alarm is generated to take care of this problem. With new communication systems, it is possible to confirm the failure in the communication link making it possible to ascertain the failure of either communication unit or Remote Terminal Unit (RTU) at site. Generally Cyclic Redundancy Code (CRC) is appended to the request and response string, in order to confirm the Authenticity of the request and received signals, and sometimes used to correct the error during transmitting or receiving. Type of CRC algorithm used may vary from site to site or operator to operator.

If stations are used only for monitoring purposes, economical one way communication is preferred. In this case each station sends data to the master at predefined time. Here the RTC must be quite accurate and the data should be transmitted along with the Time Stamp.

Generally, two different networks for Voice and Data are incorporated. Data network, is continuous to poll the required data; at predetermined time, or anytime if required under emergency, however Voice Network is used, to pass on instruction, to and from various Field or SCADA station to Master Station. In case of Manually Controlled Canal system, voice communication is used to instruct the operator to move the gates manually to desired position. In the case of Semi-Automatic Canal Control, the operation of gates is confirmed by voice signal at cross regulators to operate the gates, to appropriate level, and is confirmed by the next routine data received. This voice network is also used to pass on instructions to operate the gates to desired position, in case of power failure at site, where in the gates must be operated manually. If the gate movement at that location is critical, the data is collected frequently from that particular location.

Voice / Data Communication can be broadly divided in two main categories

3.2.1 Wired or Line Communication

3.2.2 Wireless Communication

3.2.1 Wired or Line Communication:

This type of communication is being used extensively for last few decades, for voice communication. A large distributed network is available almost all over India, but mostly in urban areas. There are some pockets in remote areas, where the line communication is not available. Line communication is also being used for large & fast data communication. However because of various issues, the system is quite uncertain in remote areas, where, the cables (Copper wire or Fiber optic cables) connecting various stations to Telephone Exchanges are quite susceptible for sabotage, theft and other malpractices. Firstly it is difficult to locate the fault, because of long lines and it might take long time to rectify the faults in remote areas, as it is difficult to find out the location of the fault itself. Sometimes it is not possible to reach the faulty site, during night times, making it difficult to depend on the same. Now with new techniques, it is possible to locate the tentative location, but repairing the fault may be still more time consuming. Thus total network becomes most unreliable for Data transfer services, for monitoring or controlling applications, unless it is (Total network) in a small secured confined area. If we do not receive the data, it is very difficult to ascertain the type of fault, in the case of Remote unmanned station. We must have another voice standby system for reliability, with different pair of lines. But fault generally occurs on both the lines simultaneously, and thus, we end up with the same problem. So this type of communication may not be advisable for Real Time Remote Control / Monitoring Applications. The system may be useful for urban operations. Internet Access is also possible with this type of communication. The cost of such system is quite reasonable. There are no constraints on the power resources, as the power for communication is very minimal and comes from nearby exchange, themselves. The network area is quite large. The security of the data may not be ascertained, as the total data may be routed through many telephone exchanges. Crosstalk due to use of multi core cable which is one of the basic problems of this system, may create problem for long term operation. Since the cable is underground, any natural calamity disturbs the communication line. As the communication is through wires, there is no effect of weather conditions, like Rain, Humidity, Temperature, Clouds etc. No government clearance is required; however most of the network is still with government undertakings.

Fiber-optic cable is another line communication system, however researcher concludes not to use it on the remote fields like canal Cross and Head regulators, as it is prone to sabotage and difficult to attend the faulty point along the canal service roads for maintenance during rainy season. It is quite fine for fast inter-office communication

3.2.2 Wireless Communication

3.2.2.1- UHF/VHF Communication

This type of wireless communication is useful for closely held individual secured short distance and medium distance networks. The range of the network can be say up to 70 -100 Km., in radius, (aerial distance). The range can be extended using Repeaters, high power transmitters, high gain antennas or feed-forward method of communication. The initial cost of the system is moderate or bit high, depending upon the height of masts, with long term running cost quite low. The individual network can be designed separately. The system basically works on line of site consideration and may need high masts in hilly terrains. The data is highly secured as the total network is under user control. Proper frequency allotment, from Wireless Planning Commission (CWC), is essential. The speed is limited to 1200 baud (bits per second) in case of Analog Radio and 9600 baud for Digital Radio, though 19.2Kbps and 38.4 Kbps radios are available now. The radios with 19.2 & 38.4 Kbps data transfer rates have power output limits, reducing the area coverage. The advantage with this type of network is that it can be utilized for voice communication under emergency, directly in case of Analog Radio or with special units for digital Radios. Diagnostics is now inbuilt part of these digital radios, making it very easy to maintain the network more efficiently. This facility also helps in confirming the problem about the failure, as communication or RTU. Power requirement for such system is slightly higher. The system once installed works very well, without any additional attendance, and hardly requires any maintenance. Generally Half Duplex type of operation is used for data communication in Master / Slave type of operation. There can be fading effects during high temperatures, less humidity. High sensitivity receivers or proper fade margin is to be provided to avoid loss in communication link, during design stage. Increasing the output power or using high gain antenna can solve this problem. As it is a closely organized communication network, it can be installed at any remote place, making ideally suitable for remote monitoring and control operation of Dams and Canals, and other Agriculture / Water sector applications. Master can initiate the communication, polling critical parameters quite often than noncritical parameters; which aids in appropriate control application. Volume of data transfer should be kept to minimum with proper algorithm to reduce the time of communication and in term of power requirements. As the carrier frequency (143MHz – 173 MHz and 455MHz) is low, the antenna size is slightly big and has to be supported firmly to mitigate the operating wind speed of say 150-175 Km/Hour, in hilly and sea shore applications. The decision of the use of the type (Omni, Yagi, GP, High Gain GP etc.) of Antenna depends upon the type, distance, geographic conditions and direction of communication. Generally High Gain GP antenna is used at Master and SCADA Stations as it has to communicate to all the stations in different directions, whereas Yagi antennas are used for Field Stations, as it has to communicate only Master or SCADA stations, in defined direction. We have to take care of High Voltage Lightning suppressor for these radios, with perfect Grounding system, to avoid accidents. Dry lighting, particularly just before the monsoon is most dangerous.

Advancement in the digital communication technology now, some radios with 19.2 Kbps or 32.0 Kbps communication facilities are also available even with Ethernet facilities. Though the output power (10Watts RF Power) is limited, the Ethernet facility can be utilized to route the communication from one point to another through various in line Ethernet stations. Though the distance between two stations is limited because of power output, the network can be quite large, as the signal can be passed from one station to another. As the signal is limited to small distance, the tower height requirements are also small, even with line of site communication requirements, due to hopping facility. Low power output reduces the power supply requirements and in turn on Solar Power and Batteries. The power supply requirements is one of the very crucial factors, as most of the remote field stations work on solar power, as no electricity is available. As the canal flows through remote areas, bringing electrical power to the cross regulator is quite difficult, expensive, and dangerous.

As the network is under the control of SCADA, and not dependent on a third party vendor, it is possible to understand the failure of Link, RTU or Power source at remote field station, immediately, and proper action can be initiated. There are many reasons like a) Power Failure 2) RTU Failure 3) Link Failure 4) Damaged Antenna, etc. which can cause failure, and can be rectified immediately. The radio adjusts the hopping communication, and the data may be routed through 2-3 different links, and the best one is selected for use. In this case if one radio or RTU or Power Supply fails, the further communication is routed through some other link. It is easy to interface with the Remote Terminal Unit (RTU)

Licensed Band (The License is issued by Wireless Planning Commission, (WPC), Ministry of Communication to use particular frequency depending upon the site)

Frequency Ranges are:

Very High Frequency (VHF) – 134 – 174 MHz
Ultra High Frequency (UHF) – 400- 512 MHz

Researcher feels, this type of communication is a preferred mode of operation for Canal Monitoring and Control.

This type of arrangement is implemented at

1. Mazalgaon Canal Automation
2. Khadkwasala Canal Automation Control
3. Venuguntha Canal Automation, Andhra Pradesh
4. Bhira Dam Control System
5. Nagpur Water Supply Scheme.
6. Mysore Water Supply Scheme

Some of the projects used Repeaters for communication. These projects are:

1. Rajghat Canal Monitoring / Control System
2. Rajghat Rain & River Monitoring system.
3. Upper Wardha Dam Automation system.
4. Surya Canal System

3.2.2.2 Global System for Mobile Communication (GSM) / General Packet Radio Service (GPRS) Communication

In the recent development in communication system particularly in the last decade GSM /GPRS technology is getting quite popular, particularly applied for Mobile Telephones, SMS and MMS applications. It is a wireless technology, suitable for voice, small and medium messaging service (SMS). Since this technology is quite recent, it has not reached the very remote areas in India, applicable to full coverage. The technology is quite suitable in urban areas for non-critical monitoring operations. This technology delivers the message on First Come First Serve (FCFS) or First in First out (FIFO) basis. The time or delivery of a messages (SMS) depends on number of massages in the queue, or congestion in the network, as the same spectrum is being used for both data as well as voice communication, i.e. how many people have sent the message, and capacity of delivering the same, with number of service providers involved in completing the messaging transitions. It is seen that every service provider does not cover all the territories, as on today. Thus the message is completed through multiple service providers. During the days like Diwali /Xmas / New Year /Festival Seasons, large greeting messages are lined up in queue, and it is observed that it takes 4/5 or even more days for delivery. This might also be the case under emergency, when everybody wants to have communication. This phenomenon puts constraints in using this type of communication, where time is an essence of the system. This can be useful during non-critical monitoring applications, where in data collection is to be done for future use.

Initial price and the running cost of this messaging is quite reasonable, with single service provider, generally is our case, because of local communication. Similar to line messaging the security of the message may not be fully guaranteed. The distance of service may not be a problem where there is coverage. The fading and other effects are negligible, but there can be a problem at fringe areas, which is quite dangerous. Since there is no control on the return message timings, it may not be possible to know the failure of the system or the link for immediate rectification. The control at both ends is required to be governed by the user network. Similarly Internet activity can be used for larger data applications. This type of technology is quite useful for data collection and storage purposes and non-critical monitoring applications. As the GSM / GPRS modem requires less power, once it is tuned to network the power problem is quite less. With a Small battery, it is possible to run the system for 3-4 days. Towers are not required, thus avoiding sabotage and other allied problems. This type of communication is quite useful for collecting the data every one or two hours for monitoring purposes. Volume of data will not make any difference in the speed of operations or power constraints. There will be some limitations on volume of data with SMS or MMS, as SMS has 155 characters and MMS has about 600. If volume of data is more, than we may need 2 or 3 messages and add to complexities.

It is not possible to have a priority to the Specific Clients, from any of the service providers so far. If such a facility is made available to the Government or Water Sector Applications, this type of communication may find greater application even in the control applications. As the cost of one unit covering say about 10Km. is not high, it may be possible to install some stations at remote canal, dam sites, by some service provider.

Many people are thinking about it, but the Researcher has not seen any system in operation for some time continuously. This communication is being used for sending details on SMS to particular officer, regarding some critical errors during operation.

3.2.2.3 Satellite Communication:

3.2.2.3.1VSAT (Very Small Aperture Transmission) Communication:

This is one of the latest technologies for communication. The Geostationary (satellite moves at same speed and direction of earth's movement, covering the same area at all the times) satellite installed about 36,000 Km above the earth is used for communication. As large area is covered by one satellite there are no constraints on coverage area, generally required for long canal automation sites. The data is uploaded to the satellite from any place through a Small dish or directive Yagi Antenna, as frequency of transmission & reception is high (Table 3.1 indicates the typical uplink and downlink frequencies). The data is down converted and received to earth station, located at specific place. Now this data can be retrieved by land–line for single hop operation or retransmitted to satellite and then to any other point of operation, with double or multiple hop operation. In this system there is no coverage problem, no typographical problem, or distance problem. High Towers are not required. The only constraint is that the antenna should be able to see the satellite, without any disturbance. Since the Cross Regulators on the canal are open to the sky, there seems to be no problem, except some trees obstructing the clear line of site. Power requirements are also small. However the equipment and systems is bit expensive today with moderate running cost. There may a problem for two-way communication (Field Station to Master Stations and vice versa) as the running cost depends upon the requirement of Bandwidth. The requirement of bandwidth depends on number of stations communicating with each other and the volume of data to be exchanged. Though each field station has limited data, but if we have quite a few SCADA stations requiring the data of all other SCADA stations, we may need bigger bandwidth, as this type of communication works basically on Time Division Multiplexing Application (TDMA) fashion. Data security may pose some problems as in the case of line communication, because all the data is received at ground station, covered under third party control. It is essential to finalize preferably with Indian satellite, as the foreign satellite may stop providing services under some critical emergency, and valuable secret data relating to water may become available to the foreign satellite holder, reducing security involved. Thirdly due to finite life of the particular satellite, one may be required to change the protocol, antenna direction etc. for new available satellite, after some time. The system is most suitable for high bandwidth application like picture transmission etc. This communication may find application in near future, if Equipment and Running Costs go down for Receiving Ground station, and one can have one specific ground station for each project. This will be an ideal method of communication for Integrated Dams and Canals operation, and also useful for Integrated Nationwide River Operation. This type of technology can be put to use to collect the data at central location from all the state or from the entire nation. The system will continue to operate under emergency, as we have a very small antenna, and the satellite is well above in the sky.

The controller works on Ethernet connectivity and has some interfacing problems with normal RTU. As towers are not required, the installation time is quite low.

Table 3.1-Frequency band for Satellite Communication

Frequency Band	DOWN-LINK Frequency (GHz)	UP-LINK Frequency (GHz)
S BAND	2.555 to 2.635	5.855 to 5.935
Extended C Band (Lower)	3.4 to 3.7	5.725 to 5.925
C Band	3.7 to 4.2	5.925 to 6.425
Extended C Band (Upper)	4.5 to 4.8	6.425 to 7.075
Ku Band	10.7 to 13.25	12.75 to 14.25
Ka Band	18.3 to 22.20	18.3 to 22.20

It we get special VSAT controller with power down facility at low cost, duplex communication can be easily achieved, without overloading the power supply. During transmission RTU will wake up the controller, send the data, and go to sleep mode, while during reception, the received signal will wake up the controller collect the data and will go to power down mode.

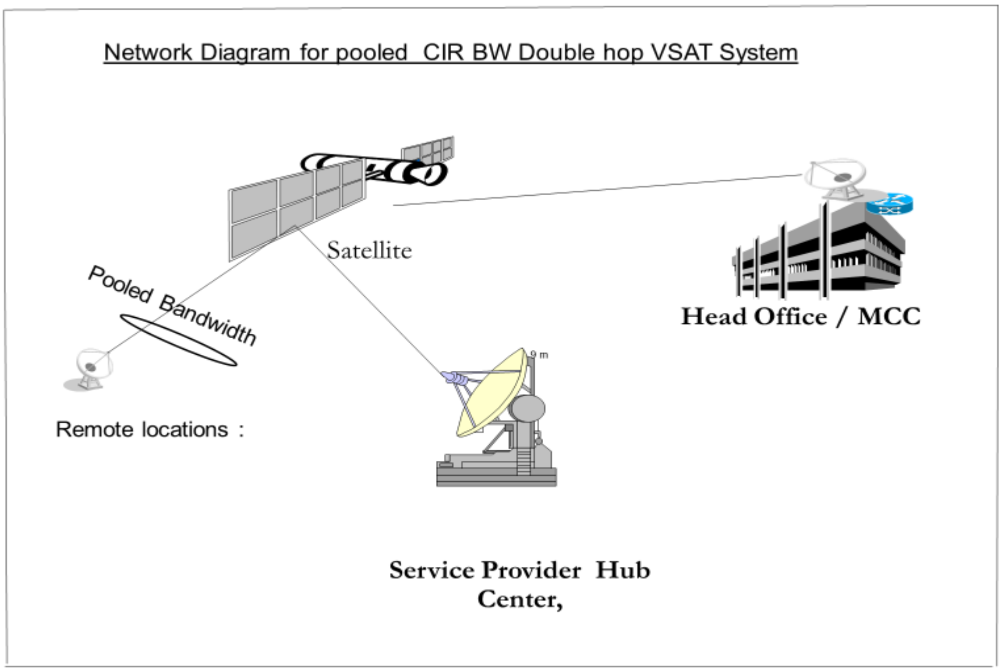

Fig 3.4.1 Typical Double Hop Satellite System

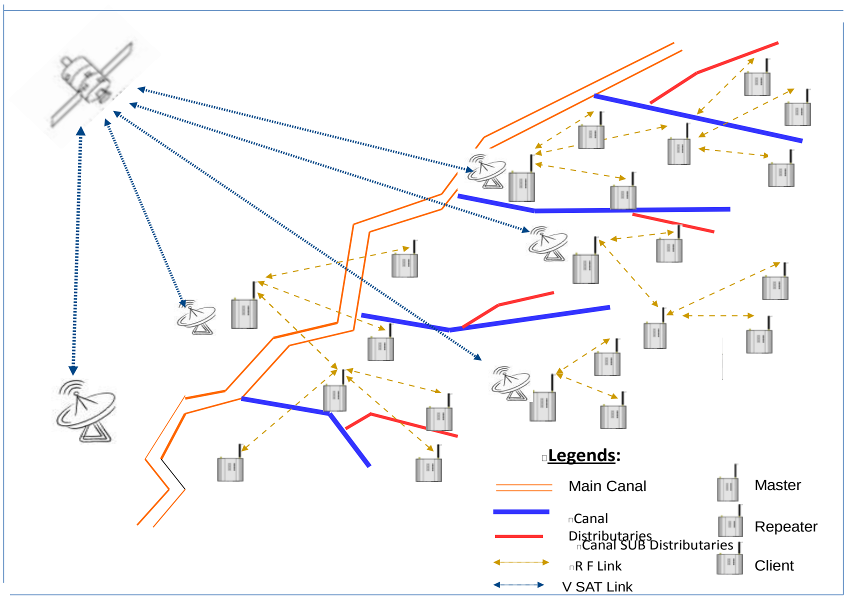

Fig.3.4.2 Typical two way communication system using VSAT

As regards to Bandwidth, two types of Bandwidths are commercially available a) Pooled Bandwidth where in it is shared between many clients and cheaper. Sometimes we may get good speed, if others are not using, but may get very low share if others are extensively using the same. b) Dedicated bandwidth where in the total bandwidth belongs to you, getting same speed of operation all the time. Though this bandwidth is expensive, we should use the same, as we may not get the share of bandwidth during emergency (flooding due to heavy rains) wherein our need is most essential for Flood Control and Dam Safety.

This type of communication is being used at

1. Indira Gandhi Nahar Pariyojana (IGNP) Rajasthan,
2. Real Time Data Acquisition System (RTDAS) by Government of Maharashtra.
3. Canal Monitoring System at Narora, Uttar Pradesh.
4. KBJNL project at Narayanpur - Proposed

3.2.2.3.2 INSAT (Indian National Satellite System) Communication:

This type of communication is with the ISRO satellite, and is mostly being used by Indian Meteorological Department, for weather monitoring system. It works on Time Division Multiplexing Arrangement (TDMA). It is only one way communication system where data is transmitted from field stations is collected at Indian Metrological Department (IMD) hub. We might get some slot for communication, and that can be used for weather data, rain gauges and River Gauges, wherein there is no control and command activity. However we have to depend upon line communication or internet for collecting the data from IMD hub. Since it is TDMA, all the RTUs must be time synchronized with GPS clock, as we get only one second to transmit data, and must be absolutely accurate, otherwise data conflict might take place making the data from two stations useless. It is also learnt that the recurring charges for each station per year are quite high making it unviable, unless it is made free to the Government, which controls the complete water sector.

3.2.4 Microwave Communication

This type of communication though available may not be useful for normal data transfers, as it is totally governed by independent government agencies, and is not covered in this topic. It may be possible to use this technology in case it becomes free to use in other sectors.

Selection of Communication System:

Table 3.4.3 shows typical comparison of communication systems used in the Water Resources / Canal automation units.

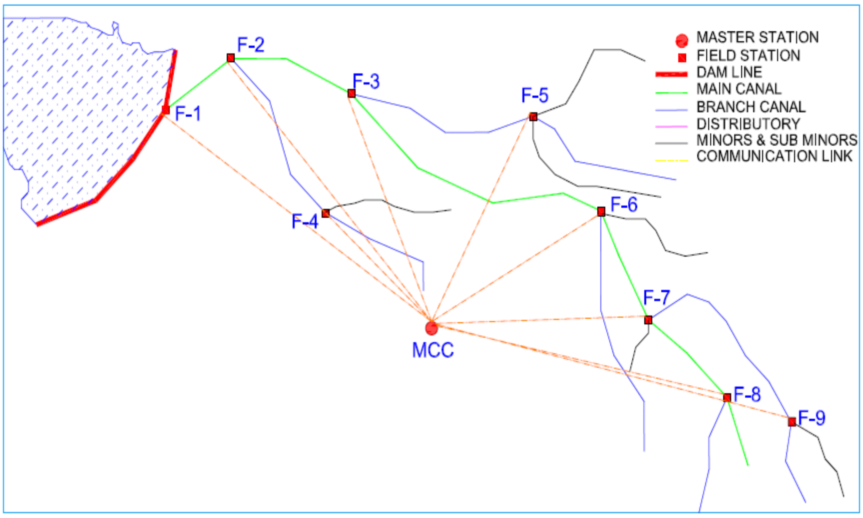

Fig.3.4.3 Direct Communication from MCC to Field Stations

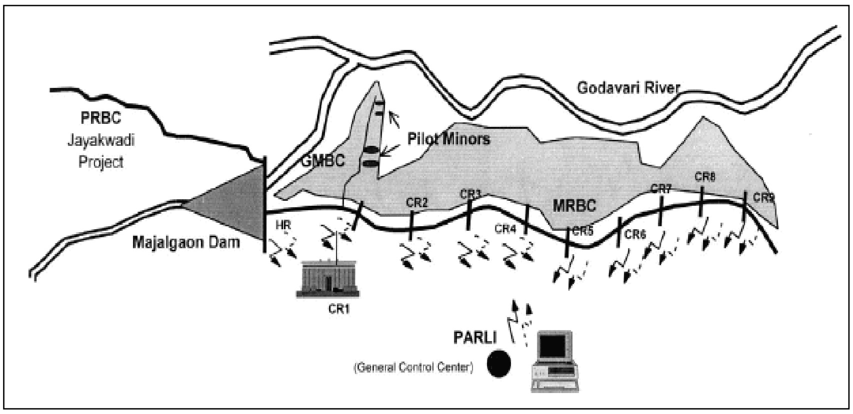

Fig.3.4.4 Typical scheme at Mazalgaon

It is observed that only one type of communication may not be suitable for the particular application. We have to select the system so as to work reliably, with controlled initial cost, and reasonable long term running cost, taking due care of site conditions, considering social constraints.

Direct communication from remote site to MCC is always not possible. However the system can be implemented using few repeaters. These repeaters can be stand alone or one of the field or SCADA station (Distributed type). Similar system is being implemented at Rajghat canal system with Repeater stations at Zanshi and Akhavada. Fig.3.4.5 shows the details of the system.

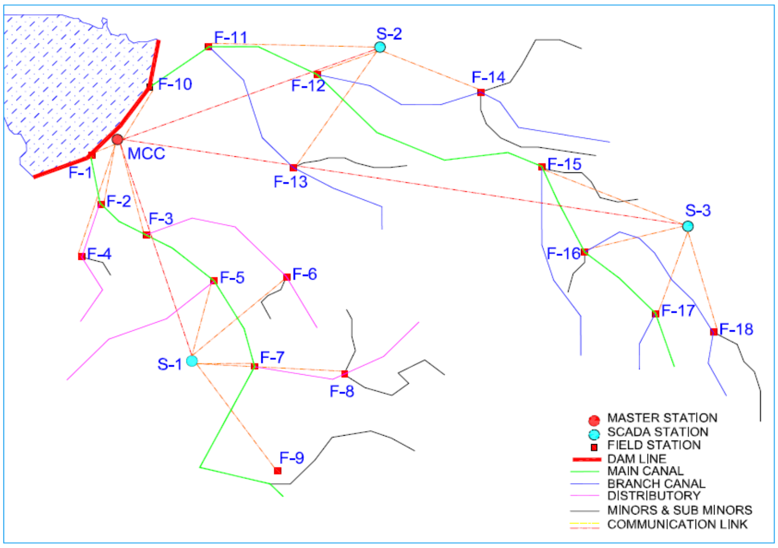

Fig.3.4.5 Distributed Communication with Repeater Stations

Total Hybrid Communication system as shown in Fig.3.4.6 is also implemented at Real Time Data Acquisition System (RTDAS) at Krishna-Bhīma valley project at Sinchan Bhavan at Pune Maharashtra, wherein all Dams, some critical River Gauging Stations and few remote field stations are covered by VST. Remaining stations are communicating with GPRS type of communication.

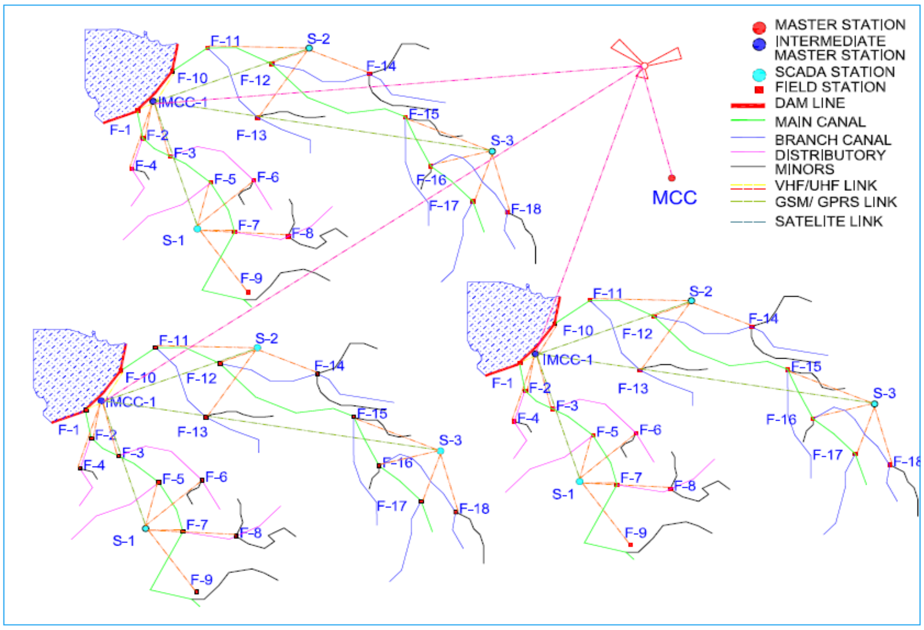

Fig 3.4.6 Hybrid communication system

A much complex communication system is proposed at Krishna Bhagya Jal Nigam (KBJN) at Narayanpur Canal Automation Scheme. All the main Canal uses VSAT, communication, with distributaries are communicating with nearby HR with Radio, and Kiosks through Internet or GPRS system.

Thus the design of communication network is completely site dependent, and must be studied carefully before the start of the project. It may be needed to complete the site survey, before finalizing the scheme.

Table 3.2 Typical Selection of Communication System

Type of Communication	Wire / Line	UHF–VHF	GSM-GPRS	Satellite	Microwave
Range	Very large	Limited to 70-90 Km.	Covered Network Area	No Limit	Limited By Towers
Power	Quite low	High	Quite Low	Quite Low	Quite Low
Speed	Very high	Low	Medium	Very High	Very High
Data Security	Very low	Very High	Low	Low	High
Reliability	Poor	Quite High	Good	Good	Good
Maintenance	Quite High	Moderate	Moderate	Unpredictable	Unpredictable
Sabotage Malpractices	Most Susceptible	Very Low	Quite Low	Quite Low	Not Known
Price	Moderate	Moderate	Low	Very High	Not Known
Running Cost	Moderate	Quite Low	Low	Very High	Knot Known
Clearances from WPC	Not Required.	WPC Frequency/Site Clearance Required	Not Required	ISRO/Service Provider.	Not Known
Error Detection	Good	Very Good	Not possible	Good	Not Known
Semi-Duplex/ Full-Duplex Capacity	Full Duplex	Half Duplex	Full Duplex,	Not Known	Not Known
Installation Time of Equip.	Low	High	Low	Low	Not Known

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