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Technical Assistance
HYDROLOGY PROJECT

DHV CONSULTANTS & DELFT HYDRAULICS with HALCROW, TAHAL, CES, ORG & JPS

REPORT

ON

DWLR PERFORMANCE

January 2001

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1 Introduction

Form 20 November to 07 December the Consultant visited the Groundwater Departments of six of the Hydrology Project participating States. Madhya Pradesh was not visited but required information was received through other channels. Gujarat could not be visited due non-availability of staff of the GWRDC Ltd. neither was relevant data received. Hence, it could not be ascertained to which extend these DWLRs are collecting useful data. The mission focussed on the performance of the DWLRs and related aspects. Visits to CGWB Regional offices were not scheduled in the mission due to non-availability of related CGWB officers.

This report is primarily based on information given during discussions with the related officers. Further, several State Agencies prepared timeseries plots of the collected data, which was very useful for assessment of the collected data. The report lays down the general findings and gives suggestions for operational adjustments.

The Chapter Summary summarises the collected information, whereas the Chapter Conclusions and Recommendations indicates findings and recommendations. The Chapter Statistics gives an overview of numbers involved, in particular of Procurement, Deployment, Defective numbers and Repaired/replaced numbers. Other Chapters include Implementation, Operational and Data aspects. Last Chapter Experiences and improvements focuses on encountered difficulties with the instruments and suggestions for improvement. Where appropriate, State specific details are discussed.

2 Summary

The first part of the Summary addresses the general aspects, whereas the second part summarises the recommended actions.

2.1 Summary of general aspects

During the visits to the States, statistical data on the procurement and the implementation of DWLRs was collected; the figures are presented State wise in the Chapter Statistics. The statistics can be summarised as follows:

Table 1: Details of DWLR under HP

status	number
procured	3931
under procurement	2536
operational	1977
non-functional	532

The number of operational units is increasing rapidly as many DWLRs are in the installation stage. The number of non-functioning units is indicative only because not all required information was available during the mission, and units are being repaired/replaced and other units are either damaged or failed. The performance between the Vendors differs largely.

- Greenspan: most of the units fail after some time, initial performance was adequate
- In-Situ : most of the units are operational and perform properly
- Iris : all DWLRs have failed
- MSquared : most units cease functioning prematurely due to excessive power consumption, in Orissa a replacement program is under execution by MSquared.

Initially some of the Agencies hesitated to implement an Acceptance Protocol; presently virtually all deliveries are subject to an Acceptance protocol. Mainly to avoid warrantee issues, the DWLRs are usually installed with cooperation of the Vendor. The Vendor also gives the operational training, in most cases partly classroom training and partly training in practice (hands-on during field installation). Experienced staff of the Agency usually trains incumbent staff. Most of the DWLRs have been connected to MSL by dumpy level (some single run, the major part in double run); also Total Station has been successfully used.

The Agencies take care of the operation of the DWLRs. In case of difficulties, the Vendors are approached for assistance and to remedy DWLR failures. Starting from delivery, DWLRs are under warrantee for one year, subsequent years are covered by an AMC. The percentage of failures, which are due to operator error or misunderstanding, is reducing. As expected, with gaining experience, the performance of the Agencies increases. A considerable number of DWLRs failed due to moisture ingress and to a lesser extent due to a variety of other causes. The performance of the Vendors is reasonable to virtually non-existent.

During data retrieval reference measurements are taken by tape. The regular replacement of desiccator is not fully implemented.

The quality of the data and the increased detail of water level data are much appreciated by the scientists of the Agencies.

Experienced operators develop more and more confidence in the DWLRs and come with suggestions for operational and design improvements.

2.2 Summary of recommended actions

Actions related to technical aspects

- Duly maintain the moisture ingress protection of the DWLRs.
- Implement a electrical level tape with each DRS to augment the quality of the data.
- Maintain for each piezometer well a comprehensive station log to store all the particulars, findings, observations and actions related to the well.
- Test a small number of absolute type DWLR to gain experience and to decide under which conditions absolute type DWLR could be a feasible alternative.
- Discuss with the Vendors the cessation of MS-DOS palmtop PCs and the future replacements thereof.
- Make spare cables available for each DRS.
- Assess the feasibility of IrDA communication to replace the cables between the wellhead DWLR connector and the DRS.
- Improve readability of DRS.
- The graphical visualisation of water level timeseries on the DRS should be made more user friendly, both in operation and in scaling.
- Data selection between dates should be implemented on the DRS.
- The data formats as generated by the DWLR software in PC must be compliant with the DWLR standard specifications.

Vendor related recommendations

- The Vendors should promptly take their responsibility when instruments fail. Further larger stocks of spare instruments, adequate to cope with the experienced failure rate, should be maintained.
- It should be made beneficial and worthwhile for Vendors to deliver good performance both in service and quality of instruments in such a way that bad performance generates a significant loss and good performance results in a fair profit.

- **Where large quantities of instruments fail, further procurement of that product should be suspended until the failures have been effectively and completely remedied.**
- Achieved data return is a good performance indicator for field instruments.
- All delivered DWLRs, both new and repaired / serviced, should be submitted to an Acceptance Protocol.
- The Vendors should deliver comprehensive repair / service reports.

Agency related recommendations

- The Agencies should establish an in-house Instrumentation Cell to render DWLR (or generic instrument) related support.
- The Agencies should maintain a stock of spares and consumables.
- The Agencies should make annual budgetary provisions to cover the costs of the Instrumentation Cell, including operational, repair and servicing costs as well as the purchase of spares and consumables.
- The Agencies should intensify their cooperation and establish a DWLR User Group as a platform for information exchange and development of new operational methods, instrument improvements etc.
- Implement rigorous data back-up procedures.

3 Conclusions and Recommendations

Conclusions and recommendations with respect to the instruments, the Vendors and the Agency's internal organisation are described in this chapter.

3.1 Instruments

Virtually all procured DWLRs are of the vented gauge pressure sensor type, i.e. pressure sensors that measure relative to atmospheric pressure. To convey the atmospheric pressure to the pressure sensor, a vent tube, which is in contact with the atmosphere, is required. This method potentially offers the best accuracy but also may affect the reliability of the DWLR, in particular when the moisture ingress protection system is not properly designed / implemented or not properly maintained. Of the reported defects, a considerable number was due to moisture ingress.

Especially in cases where a slightly reduced accuracy is acceptable, the absolute type DWLRs may also be considered, in particular of a version that is fully encapsulated without a power / communication cable. For suspension of the absolute type DWLR a wire of stainless steel or Kevlar would be adequate. Such an instrument is much less susceptible to moisture ingress. It should be noted that for data retrieval and functional checks the DWLR has to be retrieved from the piezometer. Further, to compensate for atmospheric pressure fluctuations, barometric pressure data is to be collected in the deployment area of the DWLR. A similar absolute type DWLR, with a smaller measuring range though, which is kept above the water in one of the piezometer wells, could deliver the barometric pressure data. A single barometer DWLR could service a number of other DWLRs in the same area / District.

Initially the HP 200LX palmtop PC (MS DOS based) was used as a Data Retrieval System. Although the display is difficult to read because of the small character size and low contrast ratio, most observers have no difficulties in handling the palmtop PC. The qualifications of the user interface software pertaining to various DWLR makes varies from 'cumbersome' to 'easy to use'.

The cable connection between DWLR and DRS is vulnerable; it is one of the major points of difficulties during data retrieval. For the business user, the MS DOS based palmtop PCs are obsolete, various types of handheld PCs and PDAs have replaced them. Because of software incompatibility,

the latter have not penetrated the DWLR market. Presently the DRS functions are being implemented on handheld PCs based on the Windows CE 3 environment. In this case, one practical difficulty is the turbulent market for handheld PCs. As the commercial lifetime of most of the handheld PCs is less than a year, it is difficult for Vendors to develop and continuously support each particular DRS implementation. Alternatively some Agencies implement handheld terminals (HHT). Main advantages of HHT are the low power consumption and the robustness. A disadvantage is the dependency on a single manufacturer / product. Also the limited graphical capabilities of HHT were regarded as a limitation, however, state of the art HHTs offer acceptable graphics.

As an alternative for the vulnerable cables, especially at the DRS end, the use of IrDA (infra red communication) may be considered. In that case no cable connection between DRS and wellhead DWLR connector is required. To achieve this with existing equipment a small IrDA adapter has to be attached to the wellhead cable terminal. The adapter may need a battery for power supply. Virtually all handheld PCs feature an IrDA interface, which is to be aimed (much like with the TV remote control) at the IrDA wellhead terminal adapter from a short distance. Some manufacturers, like Ott and vanEssen, offer infra red communication as standard on their DWLRs. The power consumption of handheld PCs is fairly high.

The DRS software, in particular on handheld PCs and HHTs with the much larger screens, should support easy visualisation of the data in graphical format, like timeseries plots. Scaling should be efficient and intuitive.

Many DWLR operators request for data selection between dates, hence, this should also be supported. Some DWLRs deliver an entirely incompatible data format, which deviates largely from the standard HP specifications. The related Vendors should be ordered to remedy this deficiency.

On several occasions during the execution of the Hydrology Project, the specifications for DWLR have been adapted to reflect the experiences as gained during procurement and implementation of DWLRs. It is recommended to apply the latest version of these specifications (September 1999).

3.2 Vendors

The Vendors play an important role in the successful implementation of DWLR; they should render adequate support to the Agencies. Also for the Vendors the DWLR technology is new, most of the engineers are inexperienced, and in many cases this is their first occupation.

Apparently there is a major communication problem between Vendors and Agencies. The response to the requests by the Agencies is often minimal or virtually non-existent. Obviously, after the purchase is made, some Vendors hesitate to deliver the contractual service.

This could be understood in the following context.

The DWLR technology is very new to the Agencies and as a result the Vendor's support may be requested for trivial matters, e.g. misunderstanding of the use of DWLR or palmtop PC / DRS. A thorough training of the Agency's staff would largely avoid this problem. How can Vendors expect that the Agency's staff grasp the new technology without even making handouts or manuals available as occasionally occurred? Further, it was also observed that some Vendors send engineers who themselves do not have a working knowledge of the details of the DWLR. Another difficulty is the remoteness of the piezometer wells. Consequently, travel times are long, which adds to the after sales costs.

Some Vendors are faced with many non-performing DWLRs, which require repair / replacement. The time it takes before the Vendors / manufacturers take their responsibility is unacceptably long.

There is little incentive for the Vendors to perform well, and it seems that there is no penalty in case of non-performance since Agencies keep on purchasing DWLRs of poorly performing brands. This may be caused by the fact that the communication between Vendor and Agency is mainly at administrative level where the complaints by the users of the DWLRs may not reach. The disbursement to the Vendor may be made related to the performance of the instrument and the Vendor in such a way that poor performance results in a significant loss and good performance in a fair profit. Performance indicators are data return, operational time, time from failure detection to re-implementations and similar. Data return is the annual percentage of authenticated data, i.e. data that comply with the validation criteria.

Considerable numbers of DWLRs have failed due to manufacturing error or other causes not related to the Agencies. This is most surprising because all Vendors stated that they meet the qualification criteria for the offered product as formulated in the Bid document and gave references for that. So how can the DWLRs fail in considerable quantities when the manufacturers have so much experience with the offered model?

In particular, large quantities of the products of Iris and Greenspan suffered from moisture ingress. The product of MSquared also showed poor performance, in this case mainly due to poorly performing electronics, which resulted in high power consumption. **It is recommended to suspend purchase of such poorly performing products at least until the Vendor remedies the failures and proves that the cause of the failure has been understood and solved, including the delivered / deployed units.** Also the In-Situ products suffer from failure, however, the rate of failure is not excessive.

It is recommended to execute an Acceptance Protocol on every delivery or repair. In particular the zero stability test should be executed on all numbers. For MSquared instruments the ice test should be executed, for the other DWLR brands a combination of both ice and in-air-tests should be considered. The tests should run for at least 72 hours.

In case of repairs, some Vendors are reluctant to report the failure cause and the remedial action taken. The Agencies should demand detailed diagnosis and repair reports from the Vendors. This to learn out of it, e.g. to identify general failure causes, which can possibly be detected at an early stage or avoided by modification of the operational procedures.

3.3 Agencies

After some initial problems related to the new technology, most Agencies got over the initial difficulties with the operational use of DWLRs. Major difficulties relate to the support of the Vendors and to failing instruments.

During field operations all activities and observations should be annotated in a station / instrument log. In other words, any details / information required for data validation and instrument performance monitoring should be annotated. For each piezometer well such a log should be maintained. In most states the maintaining of the log and the standing operations need improvement.

Also the method to take reference measurements needs careful attention. It is recommended to introduce high quality (electrical) tape to take the reference measurements. The reference point on the piezometer well should be clearly marked.

Presently the Agencies depend very much on the technical support of the Vendors. Gradually the Agencies should become more self-reliant. For this, the Agencies may consider to set-up an in-house Instrumentation Cell. Such a Cell would comprise a few instrument specialists with a technical background of an adequate level to understand the intricacies of DWLR. Troubleshooting, maintenance, training, small repairs on cables, battery replacement, test and calibration could be some of the Cell's tasks. The Cell may maintain a stock with a number of spare DWLRs, DRSs and

related accessories. The Cell may also be given the responsibility for the pre-installation testing, in field servicing / trouble shooting. Whenever a DWLR fails, the Cell could assess the problem, remedy it or install a spare instrument and have the failing one repaired by the Vendor. The Cell would need some supporting instruments like multi-meters, electrical dipper tape and a pressure calibrator.

Further, the Cell could be given the responsibility for the initial data validation, i.e. at instrumental level (not at hydro-geological level). During purchase of new instruments, the Cell may render its services for the technical aspects like preparing specifications, evaluation of the bids, execution of test measurements, etc.

An annual budget should be allocated for operation of the DWLRs, to run the Instrumentation Cell, for consumables like batteries and desiccator, for spare units / parts and for repair / replacements.

Unavoidably, instruments may fail or get damaged, then the support of the Vendor is required. With the depicted approach, the Agency is less dependant of the Vendor and develops in-house technical knowledge. There is also an advantage for the Vendor because travel to the Piezometre wells will largely decrease.

The Agencies may consider the exchange of performance information amongst each other's, e.g. in a DWLR User Group, which may be established for this purpose. This DWLR User Group may take up the development of new operational methods, initiate the design of improved instruments and co-ordinate tests of new products before they are procured in large quantities.

4 Statistics

The Tables in this chapter refer to numbers of groundwater DWLRs and their status in each of the participating states. To identify the states, the following abbreviations are applied:

AP	Andhra Pradesh
GU	Gujarat
KE	Kerala
KA	Karnataka
MH	Maharastra
MP	Madhya Pradesh
OR	Orissa
TN	Tamil Nadu
CGWB	Central Ground Water Board

Table 2: Procurement overview for groundwater

State	Iris	In-situ	Green span	M2	under procurement	totals per Agency
AP		50+316			522	888
GU			230+156		280	666
KA		1+349		150		500
KE				54	250+100	404
MH		60	640		436	1136
MP		55		350	160	565
OR				60+160	165	385
TN	48	50	200+195		102+120	8+715
CGWB		600	200		400	1200
Totals	48	1481	1621	774	2535	6467

Remarks:

AP, no remarks

MH, no remarks

KA

SGW, of the In-situ instruments, 164 have been delivered, the balance will be delivered in 2 consignments, December 2000 and January 2001. The batteries, which had to be dispatched in a separate consignment due to safety requirements, got astray in the USA and arrived one month late.

The MSquared instruments had to be retrieved from the airport by the SGWD. A box with the cables, manuals and software arrived after two months of intensive exchange of correspondence. The manufacturer offered no explanation for the delay. The box will only be opened under supervision of the Vendor.

SSW is in the process of deploying two series of DWLRs, 29 units pressure type by IRA / Logtronic and 20 units shaft-encoder type by Wheatertronics. Of these 2 respectively 4 were already installed.

OR

In March 98 the installation of the first batch of 60 MSquared DWLRs started. After 6/8 months they started to fail, in January 99 all sites were visited by MSquared and batteries were replaced by alkaline versions. At about 5 sites defective DWLRs were replaced. After about 3 months the DWLRs started to fail again, mainly due to high power consumption. A replacement series of 53 units was received and installed without testing, presently, 25 units are working. Under a new procurement, 160 DWLRs were received and tested, 15 units passed the tests. It was decided by the manufacturer to replace 195 units (in total). Out of that replacement, 53 units have been received and tested, only few failed the tests. A 3rd order (165 units) is held up awaiting the performance of the 195 replacements. In the meantime, MSquared Technology Ltd joined Rochester Instruments Systems Ltd and is now part of Dynamic Logic Ltd.

TN

Iris: initially 150 DWLRs were procured and delivered, some developed problems right from installation, eventually all failed due to water ingress, 102 units were cancelled and returned (May 2000), the other 48 were replaced (returned Jan 2000, replacements received Feb 2000), failed again, to be replaced before end of 2000. The 102 cancelled units have been re-tendered.

In-situ: one unit in store for demonstration purposes, all other units are operational.

Greenspan: 116 units of SW type DWLR are installed in tanks, 4 units are in store. Most of the tanks hold water for a few moths only. These SW DWLRs do not feature in Table 2 Procurement overview.

Ott: 3 DWLRs of Ott make were procured and deployed, no problems were reported.

JAKS: 5 units of JAKS made were procured for testing purposes at the start of the Hydrology Project. The Ott and Jaks units are not represented as individual entities in Table 2.

Table 3: Non-functional DWLRs

State	Iris	In-situ	Green span	M2	Totals Per state
AP					no data
GU					no data
KA					under installation
KE				14	14
MH		2	89		91
MP					no data
OR				195	195
TN	48		4		52
CGWB			180		180
Totals	48	2	273	209	532

Remarks:

The data in Table 3 is indicative only.

CGWB: no comprehensive information available, but apparently most of the Greenspan DWLRs developed failures.

Table 4: Repaired / replaced DWLRs

State	Iris	In-situ	Green Span	M2	Totals per state
AP		32			32
GU					no data
KA					under installation
KE				4	4
MH					0
MP					no data
OR				57	57
TN		2			2
CGWB					no data
Totals	0	34	0	61	95

Remarks:

The table above does not represent the reality; in particular during installation DWLRs were replaced without being reported. Presently, only a few States keep an up-to-date administration of repair / replacement statistics.

Table 5: Deployed DWLRs

State	Iris	In-situ	Green Span	M2	totals per state
AP		366			366
GU			386		386
KA		100			100
KE				54	54
MH		57	551		608
MP					no data
OR				25	25
TN		47	391		438
CGWB					no data
Totals	0	570	1328	79	1977

Remarks:

The above data is indicative only.

KE

Reporting on DWLR performance by the districts to the main office is not fully developed yet.

TN

It appears that there is a large lag between actual status in the districts and the reporting of the same to the main office.

5 Implementation aspects

The implementation comprises Acceptance, Deployment and Training. These aspects are addressed separately.

5.1 Acceptance

AP, the standard HP Acceptance protocol was executed.

GU, no information

KE, no acceptance tests were implemented.

KA

SGW: acceptance protocols are implemented.

In-situ, 6 units could not be opened for battery installation, 4 units were not responding, the remaining 154 units passed the tests.

MSquared, 15 units have been subject to the ice test and another 15 units were subject to the zero stability tests in air. The tests were executed during 24 hours only, instead of the 72 hours as stipulated in the Acceptance Protocol. The remaining 120 units still have to be tested, the Vendor is not willing to cooperate though.

SSW executed Acceptance Protocols on all units in compliance with the stipulations of the bid document.

MH, acceptance testes were executed

MP, no information available

OR

It is the policy of Orissa SGWD to execute an Acceptance Protocol on all DWLRs. In the first batch of MSquared DWLRs, only a few of the instruments passed the tests, according to the manufacturer due to an erroneous factory setting in the DWLRs, which could be rectified. Of the next batch of 160 only 15 units passed the tests resulting in the manufacturer's offer to replace 195 failing units. Five units of the third replacement batch (55 units) failed the acceptance tests.

TN

Acceptance tests (zero stability tests in air) were executed on the In-situ and Greenspan DWLRs, neither the test reports nor the test data are available with PWD Chennai. The Iris DWLRs were not tested.

CGWB

On the 200 Greenspan DWLRs in-factory tests were executed on a subset of the instruments. Upon delivery no acceptance tests were executed.

The 600 In-Situ DWLRs have been submitted to the zero stability tests, both in air and in ice. An overview of the results is not available with the Consultant, however, from CGWB Hyderabad, it was learned that 37 out of 49 units passed the tests. Remedial action, i.e. repair or replacement by the Vendor is awaited.

5.2 Deployment

AP, the DWLRs were installed by the SGWD, under supervision of the Vendors.

GU, no details available

KE

The Vendor, witnessed by SGWD staff, installed the DWLRs. Reference measurements were executed with electrical tape. The level tapes, which were part of the delivery, are very effective. A private company executed the levelling.

KA

SGWD has witnessed the installation of about 100 In-situ DWLRs, the installation of the remaining DWLRs may take till the end of December 2000. Most of the MSquared DWLRs still have to be tested and will be installed after successful completion of the tests. During installation standard tape is used for manual observations. (Some electrical tapes were procured locally but are not functioning properly). Four teams of the Mines and Geology Department have connected virtually all piezometers to MSL by total station double run levelling.

SSWD officers witness the installation of the DWLRs. The reference levels are obtained from staff gauge readings. The staff gauges are connected to GTS benchmarks by dumpy level.

MP, no details available

OR

Installation was executed by SGWD under supervision of the Vendor. Metal tapes were used for reference measurement. The department executed the levelling using dumpy levels.

TN

The Vendor, witnessed by PWD, installed the DWLRs. Reference measurements to connect the DWLR readings to MSL were executed with PWD tape. It is not known if malfunctioning units were encountered.

Levelling was done by dumpy level in double run by two instruments. A GPS receiver has been used in the Chennai area on trial basis to verify the station coordinates. Differences were smaller than one minute. The GPS coordinates replace the toposheet coordinates.

5.3 Training

AP

About 60 persons have been thoroughly trained, both in classroom and in field.

GU, no details available

KE

The manufacturer gave the introductory classroom training, it took half a day and was given to all staff involved in the DWLRs. The Vendor of the DWLRs gave the field training during installation. Each field hydro-geologist got multiple opportunities to familiarise himself with the use of the DRS and the DWLR. The level of training was satisfactory.

KA

SGWD, the In-situ representative gives hands on training during installation, after completion, classroom training will be given on the theoretical aspects.

MSquared has given oral classroom training to scientists and field operators, there were no handouts, which is entirely unsatisfactory for the Mines and Geology Department.

SSWD, during installation demonstration-type instructions were given, the official training is scheduled for Dec / Jan 2000 / 2001. The training will comprise a classroom part and a field part. the latter to be given to all field observers.

MH

The training was executed at several levels. At state level, training was generic. At district level in depth training was given to field staff (at junior and supervisor level). Checklists for field use have been prepared and are in use.

MP, no information available

OR

Training was given for the first 60 units; it comprised about 3 days classroom training and about 4 days field training during installation. For the next 160 units training still is to be given. In particular the software has changed considerably, hence; also the experienced staff needs additional refresher training.

TN

The initial training was given to field officers. For In-situ, Greenspan and Ott the quality of training was satisfactory. To date most of the trainees have been shifted to other jobs. Subsequent training to incumbent staff is given in-house by PWD staff.

6 Operational aspects

Day to day Operation, encountered defects, maintenance procedures and Vendor support are addressed in subsequent subchapters.

6.1 Operation

AP

Initially, the DWLRs were put to a recording interval of 1 hour; presently most units operate at a recording interval of 6 hours. The responsible staff retrieves the data in the period from 20th to 30th day of the month. Also a manual observation is made during the data retrieval visit. Back in office, the data are loaded into a PC and checked for conspicuous errors. It is planned to reduce the data retrieval interval to 3 months. The manual observations may still be taken on a monthly basis.

GU no details available

KE

About every fortnight a hydro-geologist collects the data for his district. At the same occasion the functioning of the DWLR is checked and a reference water level measurement is taken manually with the electric dipper tape. One hydro-geologist supervises the data collection and handling.

KA

SGWD, pending the completion of the installation, no operational procedures have been implemented.

SSWD, operation up to date is satisfactory. Gauge observers take manual readings on a daily basis.

MH, regularly data are collected and reference measurements taken.

MP, no details available

OR

Monthly visit to the sites for data retrieval, checks and manual observation. Back in office the data are transferred to PC, findings are reported on standard forms. Some plots are made. The operational procedures have not been fully implemented yet.

TN

Monthly data is offloaded by PWD staff. Simultaneously a manual observation is taken for reference and validation purposes. The accuracy of manual observations needs to be assessed. Preferably good quality electric dipper-tape is implemented, alternatively, provided well tested procedures are applied, also steel tape may be used. Presently differences of more than 0.3 m are observed DWLR and tape reading; in many cases the manual reading is at error then.

PWD uses the same model palmtop PC for all the DWLR brands, however, each palmtop PC is fully dedicated to a single brand of DWLR. Combination of software on a single palmtop PC is technically possible but not done because of memory constraints (more memory to be procured) and to avoid conflicts between Vendors in case of malfunctioning. All data are kept in the palmtop as additional backup.

6.2 Defects

AP

Several causes of data loss were identified: 4 units were flooded, 2 units got stuck due to root growth, 1 unit stopped unexpectedly due to a data recording interval of 1 minute instead of 1 hour, which rapidly depleted the batteries. The other units failed due to some internal error, e.g. sensor giving constant values, or not responding to commands.

KE

A week before a scheduled visit of the manufacturer, four defective DWLRs were found. The manufacturer has repaired them. At the same occasion, the batteries have been replaced. The kind of defects is not known, possibly they are related to water ingress.

KA

SSWD, no defects developed, yet.

MH

During purging and water quality sampling the DWLRs are taken out of the well. About 4 out of 700 have been damaged due to mishandling/accidents; this is expected to decrease when more experience is gained.

Greenspan: to date 89 units are not responding, they are still in the piezometers, awaiting a visit by the Vendor. However, the Vendor is not available due to work in other states.

Some units were replaced/repaired due to moisture/water ingress.

In-situ: a few units turned defective due to moisture/water ingress

OR

MSquared has supplied 220 units, some defects have developed. Occasionally water ingress was mentioned, however, the Vendor did not supply defect assessment/repair reports. Almost all the units failed due to excessive power consumption, the manufacturer is executing a replacement scheme. The problems started at the end of 1998.

TN

In-situ: two units have been replaced because of wrong data. All Iris DWLRs turned defective. Of the Greenspan DWLRs no quantitative information on defects is available.

6.3 Maintenance

AP, under warrantee and AMC.

GU, no details available

KE

A few months prior to expiring of the warrantee period, the Vendor has checked all DWLRs. No other maintenance is executed. The execution of the AMC is about to be implemented. The Vendor recommended keeping a bag of about 100 g silicagel in the wellhead of the piezometer, next to the top box. Since the bag is in the open moist air of the wellhead, the silicagel is quickly saturated.

No calibration done.

It is not know if spare parts are available with the local Vendor.

KA, warrantee, AMC

MH

GS&D wants the DWLRs maintained at a 3 monthly interval. It is envisaged that a service engineer of the Vendor visits the stations jointly with a GS&D officer. However, the exact conditions of the AMC contracts are still under discussion.

No (re-)calibration has been executed yet.

MP, no details available

OR

No maintenance implemented. The local Vendor has no spare units in stock.

TN

First year after delivery, the DWLRs were/are under warrantee and maintained by the Vendor. For the second to fourth year an Annual Maintenance Contract is under execution. In practise, maintenance is done upon request, apparently only the In-situ representative accompanies PWD staff during field visits but only in the vicinity of Chennai.

No DWLR batteries were replaced yet. The DRS batteries last two months. The DRS backup battery was replaced once (after about one year).

The air-vent bag and the silica gel desiccator of the SW type Greenspan DWLR were not replaced yet.

No calibration has been done yet.

6.4 Support

AP, support by the local Vendor is satisfactory.

GU, no details available

KE

The Vendor has trained a local technician to act as representative and to render technical support to SGWD. Presently there are no complaints about the Vendor.

KA

Swan (In-situ): up to date the support by the Vendor is satisfactory, a local office has been established.

AMSH/PEC (MSquared): the support is characterised as very bad, Vendor does not respond, the consignment had to be recovered from the airport by the Department of Mines and Geology. The Vendor operates from Delhi, through a local agent at Bangalore.

SSWD, still in implementation stage, no complaints about Vendors.

MH

Each district has a spare palmtop DRS with cables.

Vendors are reluctant to deliver service.

Swan: The AMC contract with Swan is disputed. Swan has no office in Pune. The replacement of defective units takes very long time (6 months), instruments have to come from USA.

Greenspan: The local office has 6 service engineers, which also cater other states. Replacement of instruments takes about 2 months, action on a large number of complaints is still awaited (the service engineers are reported to be in other states).

MP no details available

OR

The support of the local Vendor is virtually non-existent. Presently, the communication with the manufacturer is swift.

TN

Handling and responsibility are delegated to the regional offices. At PWD / Chennai the technical details are not entirely known.

Iris: In the case of the Iris problem, the support by the Vendor is minimal, the progress with fact finding and reporting was only achieved after pressure by PWD.

In-situ: The defective In-situ DWLRs have been replaced after some time.

Greenspan: The status with defective Greenspan DWLRs is: “waiting for return/replacement”.

Ott: no comments

7 Data aspects

The DWLR data are transferred to the GW-DES and SW-DES systems. A special module has been added to the DES systems to support the loading of bulk data as generated by the DWLRs. Because some of the DWLR data formats are not compatible with the HP standard specifications, the data entry is not always possible automatically. In particular Greenspan and Ott generate data with an entirely incompatible format.

The data processing procedures and the appreciation of the data by the Agencies are discussed below.

7.1 Processing

AP

All DWLR are routinely processed and reported in graphical format. Data Reports are also distributed to various administrative levels, ranging from the Chief Minister to district level.

MH

Data processing has been implemented, timeseries plots are routinely generated.

KE

No processing in place, in November 2000 training was going on.

KA

No processing in place due to non-availability of data.

Upon arrival in office, the data will be transferred to a PC and visualised in graphical form. Printing of the graphs for reporting purposes is not practised, yet. The transfer of the data to GW-DES is about to be implemented, in preparation staff is being trained.

OR

Data loaded in GW-DES, plots of the data are produced to support DWLR performance monitoring and validation.

TN

Initially, all raw data were send to PWD/Chennai. This process has been stopped. Now the data are kept in PCs in the local offices for further processing. GW-DES has been implemented, end of November 6 staff will complete training in the use of GW-DES.

Presently, upon transfer to the PC, the data are visualised in graphical form to detect conspicuous / evident errors. After finishing of the monthly data retrieval cycle a report is submitted.

No further processing takes place, yet. For the transfer of DWLR data of the GW-DES and other data handling aspects, two IT experts have been appointed, initially on a temporary contract. Presently a backup of the data is kept on diskettes.

7.2 Data Usability

Some of the appreciations by the Agencies are listed are:

- DWLRs yield more detailed information, new understanding, objective, more dependable, better timing, increased efficiency.
- Deficiency detection / recharge monitoring.
- Better data makes scientist more interested.
- Data quality is expected to improve, due to increased temporal detail and consistent measurement.
- SSWD, data collection continuous at day and night, even during floods.
- Groundwater usage assessment can be done more accurately. More precise planning of water conservation/extraction on regional and local scale.

8 Experiences and improvements

The difficulties and suggestions as reported by the Agencies are summarised below.

8.1 Difficulties

- The Compaq Aero handheld PC loses its program and data after depletion of the internal main and backup batteries. Adding flash memory to the PC could solve this. The communication cable is fragile. The Weathertronics shaft encoder DWLR cannot display beyond 99.99 m, which implies that the readings can only be presented relative to MSL in coastal areas.
- Occasionally, data transfer from DRS to PC poses problems due to difficulties with cables and software. The importing of DWLR data into GW-DES is not always successful; the prime difficulty is due to incompatibility of the file formats. Not all file formats as generated by the Vendor software comply with the HP specifications.
- Greenspan/In-situ: The characters on the palmtop display are small, some people use a magnification glass. On the Greenspan DWLR the zoom function is used.

- Greenspan: The palmtop user interface is easy to use.
- In-situ: On the palmtop (DRS) many keys have to be pressed for simple actions, selection of data subsections (between dates) is not possible.
- Iris: The DRS (HP Jornada) occasionally got stuck, the Iris software is not robust and causes problems due to wrong handling.
- MSquared: the user interface on the handheld terminal has evolved a lot, presently it is rather easy to use. Refresher training is required to absorb the new functionality of the user interface. The MSquared DWLR in KA appears to be incapable to deliver a specified maximum recording interval of 24 hours.

8.2 Suggestions by the State Agencies

- The character size on the palmtop PCs is very small and should be increased for better readability.
- Spare cables would be useful, in particular for connection of the DRS to DWLR and to PC.
- It is to be expected that the DOS type palmtops will be become obsolete in the near future, an alternative is required to be located. The DOS palmtop PC using Agencies may, in a concerted action, request the Vendors to develop a solution for the Windows CE environment, or to maintain an adequate stock of spare DOS palmtop PCs.
- In future, the communication could be executed via the IrDA interface of the palmtop PC, for the DWLR a small IrDA adapter is needed then.
- Rigorous data back-up procedures may be implemented; it is not recommended to rely on back up on diskettes.