WATER RESEARCH CENTRE'S (UK)
CONTRIBUTION TO ICA

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ICA is still a very new endeavor in the treatment and transport of water and wastewater. In the fifty's it was cast iron venturi's and manometers and huge dial gages to measure flow. All analytical data, the measurements, the testing originated in the laboratory. No correction or change to treatment was made on a real time basis. In a sense most of us in the treatment division of environmental engineering watched the sewage come into the plant and leave the plant with little process changes.

Those of us who made this field our life's work wanted something better. We knew that to produce a better effluent and to do it economically required the ability to continually measure the key parameters in particular B.O.D. and suspended solids and make necessary timely periodic changes to the treatment process.

In the sixty's we began to seriously attempt sensing and measuring dissolved oxygen and to find a shorter method for determining B.O.D. We also knew that if we could measure D.O. and suspended solids we could effectively control the activated sludge process. We also worked for better methods of secondary sludge blanket detection and an intelligent return of activated sludge to the aeration tanks or to waste.

In the early sixties when the potential of the computer was being developed we realized that ICA would eventually concern itself not only with sensors and recorders, but also computers.

The sixties, the seventies, the eighties have seen progress in many areas of ICA. We can now sense important treatment parameters, we can modify the process and we have useful computer programs and models. We have come a long way but we still have not arrived at the point where we have a fool proof, reliable system to sense, record and modify the treatment process to achieve a required effluent.

We should not despair, we truly have accomplished much. We have made great progress. The sensors, equipment, computers, computer models and computer programs that were just a dream a few years ago we have today and the work to perfect ICA continues at a fast pace.

The first IAWPRC ICA workshop was held in 1973. Those of us working towards ICA knew that a worldwide effort would be required to solve the many problems and overcome the many obstacles. There was a time when many of us would comment "We can put a man on the moon, we can design, build and debug all the elaborate equipment required yet we can not successfully continually monitor D.O.". It seems in ways the problems we face if not the challenge was more difficult to achieve than placing a man on the moon.

We still have much to do towards ICA. The work continues throughout the world. The United Kingdom, in particular WRc, continues to work diligently to achieve the goal of fool proof ICA.

The purpose of this paper is an interim report of the work done by WRc in the U.K. collaborating with the Thames Water Authority and the Department of Trade and Industry. This paper in particular reports the work done at the Witney Wastewater Treatment Plant located close to Oxford, England. The Witney Plant is operated by the Thames Water Authority.

The object of the work at Witney was to assess and evaluate state-of-the-art ICA and make preliminary recommendations for the application of ICA at other sewage treatment plants. The work started in 1984 and its first (interim) report was completed May 1988.

DESCRIPTION OF THE WITNEY PLANT

Influent. The design flow is 7840 m^3/d. The population equivalent is 33000. The influent flow is the sum of discharge from five remote pumping stations. Each pumping station is operated independently by wet well level elevation. In addition, the plant also receives cesspool wastes by tank truck. All process liquors such as press filtrate and waste activated sludge are returned to the inlet of the plant. The flow rate of each influent is monitored independently and a total of nine closed pipe electro magnetic flowmeters are installed for this purpose.

Preliminary Treatment. The sewage is screened and the grit is removed by Pista Grit Traps. The grit is washed.

Flow Control and Balancing. The flow to treatment is measured by a flume. Any excess flow is bypassed to a storage tank. If the capacity of the tank is exceeded the overflow goes to land treatment areas.

Primary Sedimentation. The flow is subdivided by fixed wiers to three circular shaped sedimentation tanks each 14m in diameter. Sludge is removed from these tanks by hydrostatic head using motorized valves. The removed sludge flows by gravity to a single sludge storage tank.

Activated Sludge Treatment. There are six identical aeration tanks each 12m square having a capacity of 630m^3. The arrangement of motorized valves and flow meters enables control of settled sewage and return activated sludge. Flexibility has been designed into the system to allow different combination of tanks for treatment. Aeration is by a submerged rotating turbine with an air sparging ring.

Secondary Settlement. There are two circular shaped settlement tanks. Magnetic meters and motorized penstocks are used to measure and control the mixed liquor flow. Screw pumps remove the settled sludge. Waste sludge is wasted under automatic control from the return sludge flow.

Sludge Treatment and Disposal. The mixed sludge from the primary tank flows by gravity to a circular holding tank. The sludge is conditioned with a polyelectrolyte and dewatered in two filter plate presses. The resulting sludge is disposed on farm land.

Figure 1 shows in diagram fashion the Whitney Process areas and the portions of the plant included in the supervisory control and data acquisition system (SCADA).

Process and Plant Monitoring. The WRC Whitney Evaluation and Demonstration Facility (EDF) study and subsequent report propose to address the problems encountered in the use of process instrumentation which has handicapped the application of ICA in wastewater treatment.

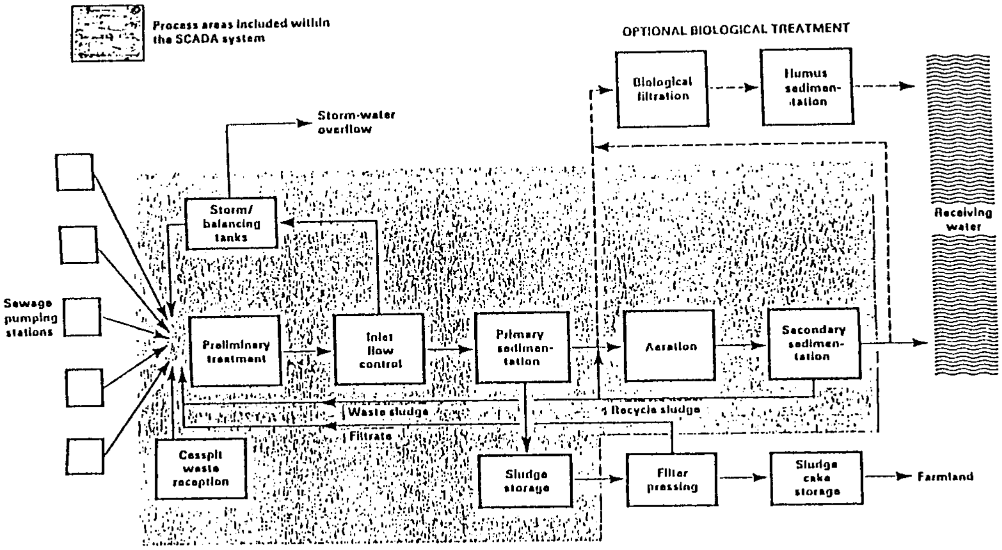

Figure 1 Witney STW - Process Areas and SCADA System

Process instrumentation is required to monitor and many times record pertinent plant parameters to accomplish the following:

- Plant management information
- required manual operations
- automatic process and plant control
- provide date for assessment and process studies

Initially about one hundred process instruments were installed **(Table 1)** at Witney where practical instruments were installed, calibrated and maintained at the manufacturers recommendations.

<u>Measurement</u>	<u>Method</u>	<u>Number</u>
Flowrate - open channel	Pressure transducer	3
- closed pipe	Electromagnetic	29
Liquid level	Pressure transducer	15
pH	Potentiometric	3
Dissolved oxygen	Galvanic (Mackereth type)	18
Temperature*	Thermistor	18
Sludge-blanket level	Light attenuation	6
Suspended solids	Light attenuation	13
"Organic pollution"	Ultra violet absorption	1
Ammonia	Ion selective electrode	3
Sludge density**	Gamma radiation attenuation	1

* Measurement available from DO instruments
** Assessment in progress

TABLE 1
<u>Witney Process Instrumentation</u>

RESULTS

Based on the observed performance, the tested process instrumentation can be divided into two groups; that is, those that were easy to maintain and contributed significantly to the monitoring and control of the works and a second group which were less successful or failed.

The first group includes:

- closed pipe flow measurement
- liquid level
- dissolved oxygen
- mixed liquor suspended solids
- return sludge solids
- secondary tank sludge blanket level
- open channel flow measurement using pressure transducers
- closed pipe measurement

Planned maintenance intervals found necessary in the first group for instruments used in process control were weekly for mixed liquor suspended solids measurement, monthly for dissolved oxygen measurement and liquid level determination and six times monthly for electro magnetic flow meters.

The second group comprise settled sewage measurements covering pH, ammonia, suspended solids, optical measurement of primary tank sludge blanket level and activated sludge effluent measurements of ammonia, suspended solids and organic pollution. Generally instruments in settled sewage were subject to severe fouling and the maintenance requirements were unacceptable. Activated sludge effluent instruments were affected both by installation problems and high maintenance requirements.

CONCLUSIONS

- The majority of the process instrumentation has worked well but depends upon a planned maintenance program by a trained staff.

- use of the process instrumentation has enabled automation of the main process control operations.

- further development work is required in many areas of process instrumentation to meet the needs of automatic operation at wastewater treatment plants.

Triplication

To overcome the lack of confidence in instrument reliability triplication of instruments was used. That is, three instruments were used to make the same measurement and then automatically comparing the results to obtain a single validated output. In the event that one of the instrument consistently disagreeing with the other, the instrument is classed as failed and the output from the remaining two is used. Through the use of triplication it is possible to:

- increase the availability of data
- increase the accuracy of data
- provide early detection of instrument failure.

To enable an assessment of the value of triplication, fifteen triple systems were initially installed. Problems relating to instrument design, installation or fouling affected five of these namely; screened sewage suspended solids, settled sewage pH, settled sewage suspended solids, primary tank sludge level and activated sludge effluent suspended solids. In the above case triplication showed little benefit. Because of this the use of many of the instruments has been discontinued.

The other triples have been used in four applications: that is open channel flow measurement (one) aeration tank dissolved oxygen (six) mixed liquor suspended solids (two) and secondary tank sludge blanket level (one). These have remained in use although quantitatively the benefits of triplication have been small.

The dissolved oxygen instruments were selected for a detailed assessment because of their importance in process operation and the ease of obtaining accurate quantitative data.

ASSESSMENT OF TRIPLICATION AT WITNEY

The assessment has been based on data obtained from the dissolved oxygen instruments used in the activated sludge aeration control system. Improvements in the availability and accuracy of D.O. values and the ability to automatically detect instrument faults were examined.

Test Procedure

Each aeration tank is equipped with three D.O. instruments and the sensors were mounted one meter apart and one meter below the surface. The measured D.O. values were validated and averaged at five second intervals by a triplication program. The resultant validated D.O. was used in the on/off control of the aerators. In addition the D.O. values and instrument status (good or failed) are logged. During the assessment each D.O. instrument was checked for drift at monthly intervals and recalibrated only if outside predefined limits. If a fault was detected by the triplication program the instrument was repaired and recalibrated as soon as practicable.

Results

Maintenance records for four triplicated systems (twelve instruments) covering a period of sixteen months were used. For individual instruments the mean time to failure was found to be sixty-five days and the mean time to repair was seven days which give an overall availability of 90%. From this the theoretical maximum improvement in availability for these instruments was calculated to be 7%. That is, the recovery for one instrument would be 90% and for three instruments 97%. In practice the gain was 2%.

This reflected the long delays when triplication was disabled due to occasional long delays in the recalibration of some instruments.

The effect of averaging three D.O. measurements enabled the accuracy of the values to be improved by 40% and reduced the effects of random drift errors. It was shown that under some conditions the interval between recalibration could be increased from twenty two days for a single instrument to thirty days for a triple.

The triplication program was able to detect major instrument faults automatically and continue control using the other sensors. The method was not so effective at detecting drift faults and most of these were identified by manual calibration checks.

Conclusions

- Triplication will not show a benefit where the instruments used are unreliable.
- Triplication improved the accuracy and availability of D.O. values used for aeration control.
- Triplication can enable the intervals for planned maintenance to be increased but there is a need to respond to alarms arising from automatic fault detection.
- Triplication should be used where high reliability is required.

Control Center Facilities

The Whitney Plant uses a SCADA System . That is, a supervisory control and data acquisition system. It is supplied by Westinghouse Systems Ltd. and is based on WESDAC 6 software.

The outstations called remote technical (RTUS) units are distributed around the plant providing a "distributed plant interface". The supervisory computer located in the control center supports the "operator interface". The success of the computer based process management system depends upon the operator interface. The hierarchical structure of the SCADA system is shown in **Figure 2.**

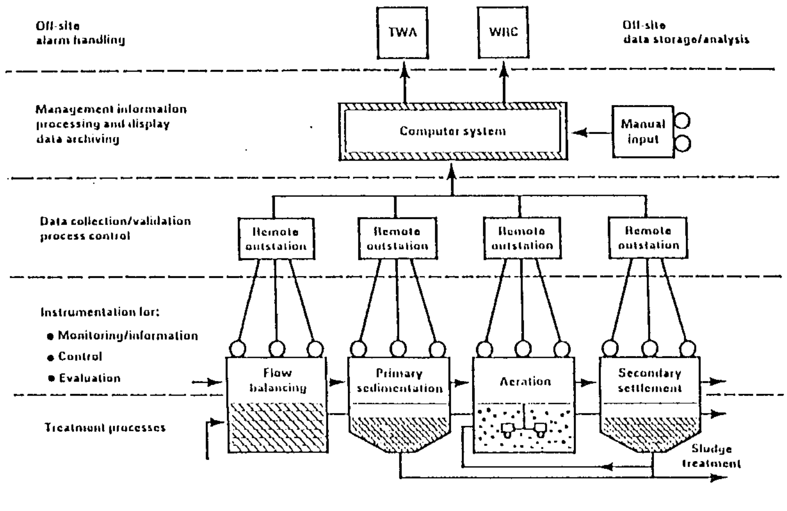

Figure 2 Witney SCADA System

The RTUS are located in the various process areas and carry out all the essential tasks of process monitoring data logging and process control. Each RTU can operate independently and will continue in the event of a failure of either the supervisory computer or any other RTU.

The control center comprises a single supervisory computer (DEC PDP 11/44) three disk drives, two terminals with color displays, a plotter and printers.

A dialout alarm system and a modem link for data transmission to the main VAX computer system are provided. The system supports the following facilities:

1). System redefinition
2). Data storage and display
3). Alarm Reporting
4). Report logs
5). Manual - Remote Control
6). Instrument Maintenance Schedules and Reports
7). User Programming

ICA Conclusions at Witney

Inlet Flow Controls

The System successfully selected the appropriate flow set point required. Overall the degree of control achieved was adequate for process operation and the system remained in use.

Primary Sedimentation

Automatic operation of the desludging process has been achieved using a simple flow measurement method. The system has been shown to be reliable and to have minimal maintenance requirements.

The reduction in sludge solids variability and improvement in the degree of control have enabled a reduction in sludge volumes.

Activated Sludge - Aeration Control

The aeration control system has functioned reliably for over three years and has resulted in considerable annual savings when compared with continuous aeration. However, the use of low efficiency turbine aerators tends to reduce the savings.

Activated Sludge - Wastage Control

Automatic control of sludge wastage has been maintained for extended periods using continuous MLSS measurement. MLSS values are typically within 450 mg/lt of set point value.

Manual intervention has been received as a result of certain process conditions.

Sludge wastage volumes have varied widely within specified control limits reflecting short term changes in sludge growth rate. The degree of MLSS control achieved will be dependent upon the range over which sludge wastage volumes can be allowed to vary.

Activated Sludge - Recycle Control

The flow-proportional recycle control system has been shown to function correctly. Energy savings are small compared with total site operating costs.

The work at Witney continues. A final report will be issued shortly.

REFERENCES

WRc Processes, Stevenage Laboratory, Whitney EDF Process Monitoring and Control Interim Summary Report (1988)