KBR

Report Of Findings & Root Cause
Water Mission B4 Ar Ramadi
13May2005

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1. SUMMARY

This document is the result of an investigation prompted by communications sent to Halliburton/KBR officials alleging personnel exposure to unfit water conditions at B4 Ar Ramadi. The cursory investigation was performed by William Granger (author) "Senior Technical Professional Leader" specializing in water quality and Kevin Pope "Theatre HSE Special Projects".

Causal factors indicated in this report identify program control deficiencies and guide early corrective actions as noted. The basic reason for investigating and reporting the cause of this event is to verify the occurrence of an event, and, in the case of such an event, enable the identification of corrective actions adequate to prevent recurrence and thereby protect the health and safety of KBR personnel, subcontractors, and the military client.

2. DEFINITIONS

Facility. Any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include storage areas, testing laboratories, and production or processing plants to include reverse osmosis units run by/or both Military and KBR.

Reportable Occurrence. An event or condition, to be reported according to the criteria defined in KBR corporate policies.

Occurrence Report. An occurrence report is a written evaluation of an event or condition that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications and evaluate actions being employed to correct the condition or to avoid recurrence.

Event. A real-time occurrence that may be documented or not and is also anything that could seriously impact the intended mission of KBR.

Condition. Any as-found state, whether or not resulting from an event, that may have adverse safety, health, quality assurance, security, operational, or environmental implications. A rendition is usually programmatic in nature; for example, an (existing) error in analysis or calculation, an anomaly associated with (resulting from) design or performance, or an item indicating a weakness in the management process are all conditions.

Cause (Causal Factor). A condition or an event that results in an effect (anything that shapes or influences the outcome). This may be anything from noise in an instrument channel, a pipe break, an operator error, or a weakness or deficiency in management or administration. In the context of this document there are seven major cause (causal factor) categories. These major categories are subdivided into a total of 32 subcategories (see Appendix A).

Causal Factor Chain (Sequence of Events and Causal Factors). A cause and effect sequence in which a specific action creates a condition that contributes to or results in an event. This creates new conditions that, in turn, result in another event. Earlier events or conditions in a sequence are called upstream factors.

Direct Cause. The cause that directly resulted in the occurrence. For example, in the case of a leak, the direct cause could have been the problem in the component or equipment that leaked. In the case of a system misalignment, the direct cause could have been operator error in the alignment.

Contributing Cause. A cause that contributed to an occurrence but, by itself, would not have caused the occurrence. For example, in the case of a leak, a contributing cause could be lack of adequate operator training in leak detection and response, resulting in a more severe event than would have otherwise occurred. In the case of a system misalignment, a contributing cause could be excessive distractions to the operators during shift change, resulting in less-than-adequate attention to important details during system alignment.

Root Cause. The cause that, if corrected, would prevent recurrence of this and similar occurrences. The root cause does not apply to this occurrence only, but has generic implications to a broad group of possible occurrences, and it is the most fundamental aspect of the cause that can logically be identified and corrected. There may be a series of causes that can be identified, one leading to another. This series should be pursued until the fundamental, correctable cause has been identified.

For example, in the case of a leak, the root cause could be management not ensuring that maintenance is effectively managed and controlled. This cause could have led to the use of improper seal material or missed preventive maintenance on a component, which ultimately led to the leak. In the case of a system misalignment, the root cause could be a problem in the training program, leading to a situation in which operators are not fully familiar with control room procedures and are willing to accept excessive distractions.

3. Occurrence Data Collection

The initial collection of data for this report occurred >35 days after the signifying event (alleged larvae). This considerable length of time allowed for the apparent loss of significant data from the local site. This loss is attributed to demobilization and/or termination of key personnel, the loss of hard drives, and a general disregard for data creation. Investigators made medium efforts to retrieve data from before, during, and after the occurrence to include personnel involvement. A level of medium effort was used as this investigation was defined as a “fact finding” mission and not the definitive legal summary of the occurrence and subsequent impacts. With that understanding, written statements, data mining, digital forensics, recordings, inquiries into military logs, and access to military personnel was very limited or not initiated.

4. Report of Findings

Summary of Occurrence:

KBR personnel allegedly discovered unidentified larvae in a commode at B4 Ar Ramadi on 23March2005. Initial investigation by a water purification operator (Ben Carter) found that the camp's non-potable water system showed no free chlorine and believed that the system had been contaminated and that the immediate actions taken should include disinfecting the camp's non-potable water distribution system. Additional deficiencies to system configurations were noted and those deficiencies were corrected in a timely manner. These deficiencies were the lack of chlorination pumps, an open manway to tank, and vertical vents turned upward to environment. It would appear that the personnel immediately notified were the site Harold Orr - HSE Supervisor, Suzanne Raku-Williams – Site Manager - and the site ROWPU foreman-Walter Myers

The system was taken out of service for a period of 24 hours while the disinfection evolution was in progress. A safety stand down meeting was convened and all personnel were told at that time not to use shower water until told otherwise. The system after 24 hours was declared safe and was returned to service. After that regular chlorination of the system continued for an unspecified amount of time. The termination of regular chlorination is believed to be tied directly to the demobilization of the water purification operator (Ben Carter) who had taken "ownership" of the practice. At that time (est 07Apr 2005), exposure to non-disinfected non-potable water continued. The exposure was still in progress when the investigating team showed up on site to collect data for this report. Upon receipt of the lab analysis initiated by the investigating team, recommendation to commence chlorination immediately was made to both "B" site DPM's.

The initial incident report is attached and located in section 7.

Points of interest:

- Key personnel missing during this signifying event is the current KBR waterpoint supervisor and the medic who were both on R+R.
- KBR waterpoint was not commissioned at the point of the signifying event or subsequent identification by the investigating team.
- Water supplied to KBR camp came from Army 3k ROWPU via subcontractor.
- In the interim between the Larvae event and the investigating team arriving on site, the camp manager and chief of services were terminated and replaced.
- In the interim between the Larvae event and the investigating team arriving on site, the Acting Lead Rowpu operator demobilized.

Problem Identification:

The alleged discovery of unidentified larvae in an LSA toilet at B4 Ar Ramadi in late March immediately revealed:

- **No disinfection to non-potable water was occurring for water designated for showering purposes. This caused an unknown population to be exposed to potentially harmful water for an undetermined amount of time**

The approximate beginning date of the exposure to personnel has not yet been established. Military records would most likely determine the start date of such an exposure, as long as records were kept and appropriately taken. The very minimum time of exposure would be 6 weeks less 15 days (the time that recovery efforts were made then subsequently dropped). The maximum amount of time of exposure would be concurrent with the establishment of the water mission by the Army.

The number of personnel exposed has not yet been determined. This is in part due to not having established the duration of the casualty. Realistically, all personnel having showered during the established dates of exposure (to be determined) would have been exposed. This would include all base camp personnel (military and civilian) and would include transients to the camp who showered using the non-disinfected water.

The subsequent investigation revealed that while the exposure to personnel was valid, the effects of exposure seemed to be negligible if any. Documentation of medical visits during the timeframe shows no deviation in number of medical visits by either expats or subcontractors. The medical facility onsite maintained an average number of 16 visits per month. No abnormal numbers of gastrointestinal symptoms or rashes were documented.

The consequences of this particular event are understood to be minimal at the time of this report. The greatest impact will be realized if documentation of chronic related sicknesses surface or if this matter is brought to arbitration or litigation. **This event should be considered a "NEAR MISS" as the consequences of these actions could have been VERY SEVERE resulting in mass sickness or death.**

The likelihood of recurrence of a similar event is considered high if no actions to correct widespread program deficiencies are taken. The deficiencies of the camp where the event occurred is not exclusive to that camp; meaning that country wide, all camps suffer to some extent from all or some of the deficiencies noted.

Within B4 Ar Ramadi there existed several contributing causes to the event.

- Lack of procedure defining roles and responsibilities when receiving outsourced water.
- No training provided to key individuals
- Inadequate documentation control
- Work organization deficiency
- Inadequate technical oversight
- Improper resource allocation
- Policy not adequately defined, disseminated, and enforced

Contributing Cause Definitions:

Lack of procedure defining roles and responsibilities when receiving outsourced water.

The circumstance where KBR was receiving water from the Military was an abnormal situation not clearly defined in any procedure or administrative guideline. Such documentation would have defined roles and responsibilities in regards to the disinfection of the water intended for shower use. The military was unaware of the intended use of the water being delivered to KBR. The uses could vary from making concrete, dust abatement, car washes, or well drilling. The military most likely assumed that KBR would disinfect the water if they used it for an application that required disinfection (such as showers). Local KBR management was either unaware of the requirements concerning shower water or assumed the military would disinfect the water.

No training provided to key individuals.

The event revealed that possibly only one person on the camp was aware of the governing documents that determined the disinfectant requirements of shower water; a letter from Ben Carter to camp management offering a corrective action to the event determined this to be most likely. The realization that only one person was in the "know" creates vulnerability to an organization in that human error prevention techniques recommend one or more subject matter experts be allowed to interact in the decision matrix to ensure the qualification, validation, and verification of proposed evolutions are fundamentally sound in nature. Simply put, this is called a "peer check". There was no one to countermand or validate the corrective actions put in place. While Ben Carter's immediate actions were well intended, there were some instances where he was wrong in the interpretation of regulations and not correct in his shock treatment of the camp distribution main. A peer check by another trained individual at this point would have beneficial to the organization.

Additionally, this letter shows direction and information flowing upward through the organization rather than downward. It has been demonstrated that Project Managers rely on their DOL's to run their services. DOL's rely on their waterpoint supervisors. There are no formalized training programs in place for any ROWPU operators in Iraq. Formalized training is defined as a documented On The Job Training / Task Performance Evaluation (OJT/TPE) process to include training records and guidance involving the LOTD, SOW, SOP's, standardization efforts, and regulations concerning the process that they are involved in.

Theatre wide there is no formalized training for anyone at any level in concerns to water operations.

Inadequate documentation controls.

The investigation revealed that little to no documentation had been generated or retained in regards to water inventories, chemistries, audits, QA/QC, meetings, safety stand-downs, procedures, or issues of standing orders.

This lack of documentation shows a lack of oversight and understanding as to the requirements necessary for the production, distribution, consumption, and uses of water; both potable and non-potable. Documentation is necessary to validate the quality of our services to prevent both liability and injury.

Could not find any record of:

- QA/QC performing any audit functions on the non-potable water system.
- Delivery times and quantities to the non-potable water holding tanks.
- Chlorine residuals for any water supplied to the non-potable water system.
- Preventative medicine filings or inspections in regards to the non-potable water system. Tanks inspected etc. Preventative Medicine should have these reports on file, but it is necessary for us to retain copies of these reports for liability purposes.
- SOP performance dates
- Minutes of Safety Stand Downs for time frame of the event or for earlier dates.
- SOP for water operations.
- Standing orders or special instructions issued in regards to water operations.
- Inspections of subcontractor's delivery vehicle stating it was acceptable and within specification to deliver waters.
- Logs showing alterations, modifications, or operator "work arounds" to non-potable system
- A "Procedure in Place" during an abnormal evolution. (Chlorination of the non-potable water system via submersible pumps)

Work Organization Deficiency

Leaning on semi-skilled labor

As stated in earlier sections, it has been demonstrated that Project Managers rely on their DOL's to run their services. DOL's rely on their waterpoint personnel to run their water operations. Within the camp structure waterpoint personnel are considered "subject matter experts" and are the focal point of decisions regarding water operations. It should be noted however that KBR has identified the ROWPU worker and associated department as "semi-skilled LABOR" and pays them as "Unskilled" in the KBR Compensation Classification Structure. This is an apparent conflict of logic and is a poor defense in litigation as we have essentially labeled our "Subject Matter Experts" as "Semi-skilled" and have paid them as "Unskilled".

Communication breakdown

The event that was submitted in a report to local camp management should have been classified as a recordable occurrence and communicated to senior management in a

timely manner. The primary awareness to this event came through threat of domestic litigation.

Inadequate Technical Oversight

Document Interpretation and collection

The generation of reports required should have been a monitored event by a managerial entity in the form of oversight. The absence of these reports from a centralized work center would have been an indicator revealing the non-performance of required documentation by a camp or camps. The current structure of management countrywide does not support the ability to identify sites with non-performance issues in regards to required paperwork. The identification of these deficiencies is only identified after a problem has occurred and this is considered "reactive" rather than "proactive".

Additionally, it should be noted that a centralized point of collection is not adequate in itself. The interpretation of the results, parameters, and specifications will ensure that the work has been performed satisfactorily, and that there are no indicators that are suspect to the work/ surveillance being performed. This requires knowledgeable oversight from the engineering and science fields.

Guided Response to Abnormal Events or Casualties

In the case of Ben Carter responding to the abnormal event, he identified the appropriate document to work from. He, however, did not interpret various readings correctly and did not properly sanitize the non-potable water system. While the effort to respond was noble, the action is not defendable in litigation, as procedure was not followed. Had there been a policy in place that required reporting of the abnormal event to an organization of with technical oversight, the event or casualty could have been mitigated in a timely manner with assurance that it was dealt with correctly. Furthermore, it would reassign the decision making during abnormal events or casualties from the least knowledgeable employees to an employee set that has been recognized for their education, expertise, and pay grade.

Improper Resource Allocation

It could be argued that the entire event could have been prevented had KBR water operations been fully commissioned and functional. The investigation revealed that Reverse Osmosis Units had been on site for a considerable amount of time without assembly and that this lead to the continued reliance on a non-KBR water production point.

Various interviews revealed a general consensus of a vote of "no confidence" toward the current waterpoint foreman. It was conveyed that he allegedly has resisted forward progress by consistently creating artificial barriers. It is believed that he does not want the waterpoint operational, as it would expose his weak knowledge base once it is operating. It was communicated that he is aggressively seeking a transfer as the waterpoint is nearing operational status. The time constraints of our investigation along with his absence from site for issuance of a new badge prevented a detailed inquiry into this allegation. A meeting with a subject matter expert from the Theatre Quality offices who spent considerable time on the site assembling the waterpoint conveyed strong doubts about the abilities of this individual. This matter was communicated to the DPM David Stallard for further observations on his part.

Policy not adequately defined, disseminated, and enforced

Adequate Definition

SOP 1M "Water Operations Standard Operating Procedure" states in section 1;

> *1.0 Purpose*
> *KBR will provide management and oversight for all water operations, including production, testing, maintenance, troubleshooting, repairs, and reporting.*

- There is no place in the procedure that discusses management roles and responsibilities, communication standards, oversight, or any classical hierarchy associated with business structure,
- Troubleshooting is not addressed in the procedure.

The section on Operations and Production is 199 words. This is supposed to be the definitive document on conduct of operations. It is assumed to be the definitive document as no other KBR procedures could be procured or found that detailed fully the operations and production methodology.

The section on testing does not mention standards and methodologies that are normally associated with laboratory analysis. It mentions only chlorine levels, pH, and microbiological testing. It makes no mention of the minimum 10 other parameters required for testing. Additionally it misstates the requirements for microbiological testing and acceptable pH ranges. The microbiological testing requirement stated is not acceptable as it is less conservative than the guidance given to us in our LOTD. The pH range quoted is more conservative than the LOTD parameters and thus should be designated within the procedure as an "administrative control".

The section on Maintenance and Repair states that all competencies will be developed by "on the job " training. KBR has no documented "on the job" training program for water operations and equipments.

The section on reporting states that KBR will maintain accountability of all water issued, produced, and received. The instruction does not define the "accountability" in terms of definition of reports to be generated, frequency, parameters, etc.
If B4 had been working from this procedure at the time of the event, then a more stringent definition would have been an indicator to them as to their deficiencies.

The last section of the procedure is the reference section. It is missing references clearly defined in our LOTD – Continuing Operations, DAAA09-02-D-007.

Dissemination

This procedure was not found at B4 Ar Ramadi so the adequate dissemination of this procedure is suspect. A more thorough investigation will have to be conducted to determine the breakdown in the communication of this document.

Enforcement

The enforcement of this procedure is to be done under an audit function of QA/QC. It would appear that this was not done at B4 Ar Ramadi.

5. Corrective Actions

B4 Ar Ramadi:

Immediate:

- After a disinfection of the camp distribution main as defined per appendix C TB Med 577, commence chlorination of non-potable shower water to 2.0-4.0 ppm. The minimum for shower water is defined as 1.0 ppm but placing a more conservative administrative control so as to ensure compliance reflects safe and conservative operations standpoint.

- Place placards on all points of distribution that are affected by non-potable water. The placard should read " NONPOTABLE WATER: DO NOT DRINK". This should include such sources as showers, construction water points, untested water faucets, cisterns, vehicle washing supplies etc. This is defined in 4-5 of TB Med 577

- Chlorine levels of the non-potable system will be checked every 8 hours and will be ensured to contain 2.0 ppm. This is defined in 8-10a of TB Med 577.

- Obtain a letter from the command surgeon general or IMA to approve the use of lower quality water for personal hygiene. This is directed to us in the LOTD – Continuing Operations, DAAA09-02-D-007.

NOTE: This last step need only be done if the current waterpoint will not be commissioned immediately.

Near Future:

- Send a remediation team to the site to educate the camp management and applicable personnel as to the full scope or work and responsibilities associated with water operations.

(Corrective actions continued)

KBR Organizational

The nature of this event revealed massive programmatic issues that will have to be dealt with at a very elevated level of management to ensure that prevention of recurrence is eliminated and thereby protects the health and safety of KBR personnel, subcontractors, and the military client. Additionally, senior management shall ensure that the corrective actions are compatible with company commitments and other obligations. Once accepted, the corrective actions should be implemented in a timely manner, as any delay in the identification of similar conditions within the company would lend itself as an enabler of a possible secondary event with perhaps even greater consequences.

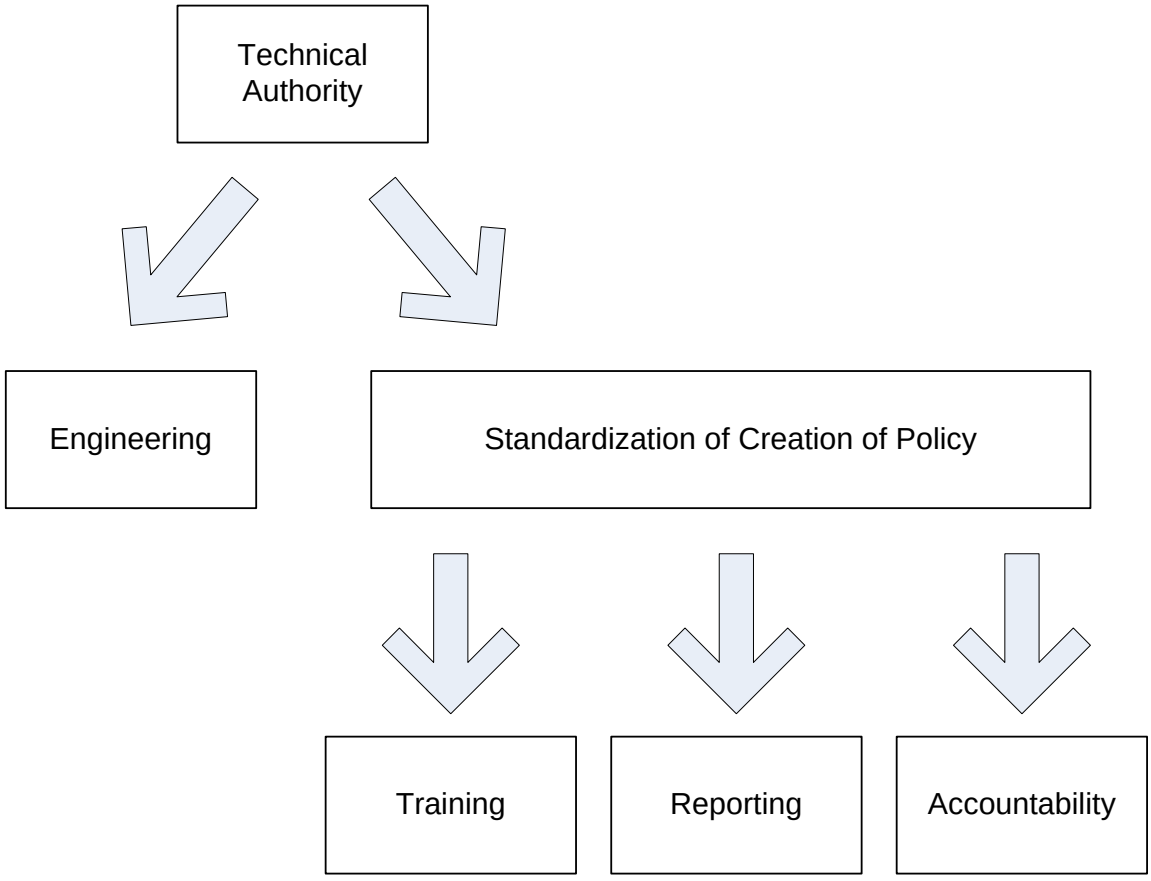
The recommendations to follow are based on the premise that standardization and technical oversight is necessary to protect the company from future litigation and programmatic breakdowns. Standardization is needed to ensure that a cohesive mission is in place that can react to administrative as well as technical changes. As standardization is achieved, reporting will allow for the easy identification of anomalies towards compliance measures. Technical oversight is needed to drive policy and procedure and to perform the audit function of the standardization. Together, these two facets will steer the water mission towards a stature of control and compliance.

The water mission needs technical guidance from above. It needs management with the authority to dictate policy; policy that will be standardized, disseminated, and audited across all water missions. This technical oversight needs to be placed in the organization above the project manager level to ensure compliance is absolute and above reproach.

Beyond the benefits to the internal customer, this approach is even more beneficial to our external customer. It allows for the military to have a centralized point of interface to communicate changes in expectations, discuss potential problems, receive clarifications, transmit information, and work casualty scenarios in an efficient manner. Rather than them try to communicate to numerous water missions through area Preventative Medicine Units, they can contact one office in KBR and be satisfied knowing that transmittal will be completely received throughout the organization.

The Technical Management team created will as a mission perform:

- Policy development to be implemented country wide.
- Engineering of specific needs for individual sites.
- Development of specific training for targeted positions that interface with the water mission
- Development of standardized reporting
- Auditing of sites for compliance to determined policies
- Review of reports to identify deficiencies
- Dissemination of changes in SOW, Regulations, or special concerns.
- Take command and control of casualty situations and abnormal events.
- The function of liaison with client to receive clarification and to provide support to the military.
- The function of a “solutions center” for specific questions from site personnel on various issues.
- Development of programs to harness cost avoidance measures.



This diagram shows a technical team, that when given authority over the country wide water program, will create policy for:

1) Training– standardization of a training policy for all levels of site management to target the specific needs for each level of the organization that interfaces with the water mission.

2) Reporting – standardization of a reporting policy will enable visibility into each site to measure its compliance and to verify the success of a site. It will follow production, training, process control parameters, burn rates, and allow for upward reporting of unusual events or casualty scenarios.

3) Accountability – standardization of accountability will occur through a policy that clearly defines the roles and responsibilities of each member in the organization during normal and abnormal operations to include definition of training required, knowledge base necessary, reports required, communication standards mandatory, and overall business conduct in regards to the water mission. Once in place, auditing of the water program will be streamlined.

6. Technical Rationale

Military Water Quality Standards and their application to B4 Ar Ramadi

Military regulations pertaining to water and all of it's facets from production, storage, disinfection, and distribution, can be found in varying military documents, ranging from field expedient Technical Bulletins, (577) to Garrison document (OEBGD 4715.5g)

- Technical Bulletin 577 Occupational And Environmental Health Sanitary Control and Surveillance Of Field Water Supplies (March 1986)
- Technical Bulletin 576 Occupational And Environmental Health Sanitary Control and Surveillance Of Water Supplies At Fixed Installations (March 1982)
- DoD 4715.5-g Overseas Environmental Baseline Guidance Document (Chapter 3 Water)(March 2000)

For all referencing in this report, I will show that under worse case scenario (field use), there is a proper use and procedure for water disinfection.

I will refer to each chapter on scenarios involving this report document. Some may be a slight stretch, and can be interpreted as such.

Source water

B4 Ar Ramadi military installation uses a raw water intake directly from the Euphrates River.

Treatment Technique

Conventional water purification uses many techniques such as

- Chemical coagulation
- Flocculation
- Sedimentation
- Filtration
- Disinfection.

The removal of suspended material (measured in NTU-Nephelometric Turbidity Unit), dissolved organic material (measured in TOC – Total Organic Carbon), and disinfection (killing effect to remove *Giardia lamblia, Cryptosporidium homini, Escherichia coli,* and other enteric protozoa, bacteria or virus causing intestinal tract disease)

Purification basically removes dirt (turbidity), filters fine particles, and disinfects the water to prevent water borne disease. BAT (Best Available Technology) removes particles at the micron level (1-5 μm) disinfection removes any pathogens making it through the process that are less than $\leq$ 1-5 micron level.

Reverse Osmosis is primarily used in beverage, microchip/microprocessor, or medical industry. It has application in the military field in that its removal efficiency is on the molecular level. Microfiltration, ultrafiltration, nanofiltration, and reverse osmosis are the most commonly used membrane processes for microbial removal. Microfiltration membranes have the largest pore size (≥0.1 μm), while reverse osmosis membranes have the smallest pore size (≥0.0001 μm) (Taylor and Weisner, 1999). This treatment technique is used for the ability to reject aqueous salt, metal ions, and all matter of pathogens and virus that may be used in a hostile manner against the military for sabotage.

The extreme efficiency of this technology shows a high percent of removal, (many cases a 99.8% salt reject) that it virtually strips the water of all contaminants. The following example shows a calculation to configure total dissolved solids (TDS). This is a measure of the dissolved material in solution. The reverse osmosis system is based on two flow streams; permeate (finished water passing through the membrane - purified), concentrate (waste stream rejected from the process and is a concentrated waste stream)

Example: measure of TDS in mg/L example using a number range derived from current KBR water operations on site at B4.

Raw Water	Multimedia (sand) filtration	Reverse Osmosis	
		(Permeate)	(Concentrate)
600 mg/L	600 mg/L	50mg/L	1150 mg/L

These numbers are based on historical data from Euphrates River water (The raw water intake is outside the security wire at B4, and therefore could not get a sample on this visit). The following formula derives the Concentrate TDS in mg/L

$(C1)(V1) + (C2)(V2) = (Cr)(Vr)$

C1 (Concentration of concentrate)	= X mg/L
V1 (Volume concentrate)	= 50,000 gallons
C2 (Concentration of permeate)	= 50 mg/L
V2 (Volume permeate)	= 50,000 gallons
Cr (Concentration of raw)	= 600 mg/L
Vr (Volume raw)	= 100,000 gallons

(X mg/L) (50,000 gals) + (50 mg/L) (50,000 gals) = (600 mg/L) (100,000 gals)

(50,000 X) + (2,500,000) = 60,000,000

$$X = \frac{(60,000,000) - (2,500,000)}{50,000}$$

X = 1150 mg/L

This exercise shows the inherent problem with the existing setup at B4. The military's choice of using Concentrate waste stream, as a non-potable water source for ablution and shower blocks, has many ramifications. The visible 92% increase in concentration of dissolved solids is a verifiable physical parameter. We can surmise the concentration of all physical constituents in the raw water would thus be concentrated at levels equivalent to this. Most naturally occurring bodies of water are exposed to waste from warm blooded animals (in this case mammal). The Euphrates would have an increased exposure due to untreated wastewater effluent upstream (infrastructure and regulatory compliance departments are fledgling at best in the new Iraqi government). It would reason that increased concentrations of *Giardia* cysts, *Cryptosporidium* oocysts, along with *e coli* would significantly increase the exposure risk to contraction of disease(s) related to these organisms.

The B4 water point would theoretically be at lower risk if it were to pump raw water straight from the Euphrates and use it for ablution and shower water.

TB MED 577 Purification Discharge Requirements

Below is an excerpt from TB MED 577 in discussion on the topic of wastewater (concentrate) from field purification reverse osmosis unit.

5–5. Special procedures

a. Waste disposal.

(*1*) *Environmental considerations.* According to AR 200–1, paragraph 3–5*b*(1), the U.S. Environmental Protection Agency (EPA) or a State may require a discharge permit for field water purification units. Commanders with field water purification units participating in field training exercises in the United States or its possessions will coordinate with the installation facility engineer's environmental officer to determine how to dispose of wastewater and other treatment wastes. The environmental officer can assist the commander in securing a discharge permit if it is required. Outside the continental United States, commanders will coordinate wastewater disposal with the environmental agency in the host country.

(*2*) *Procedures.*

(*a*) *Regulated discharges.* In cases where a discharge permit has been secured, the water purification section chief will comply with the permit to prevent contamination of the receiving water body. In cases where a permit has been denied, the section chief should contact the environmental officer of the installation to determine if wastewater could be discharged into a sanitary manhole. Such action should also involve coordination with the chief of the wastewater treatment plant.

(*b*) *Unregulated discharges.* Even when a discharge permit is not required, the section chief should still take precautions to avoid contaminating a

receiving body of water which may be needed somewhere downstream or along the shore for a water source for another activity. Wastewater should be discharged at least 25 yards (23 meters) away from the raw water intake and downstream for flowing sources or downwind for standing bodies of water. Filter backwash water and sludges should be discharged into sumps to prevent gross contamination of the water source. When the unit vacates the area, sumps will be closed out and properly marked to include the closing date and type of waste.

(*3*) *Technical assistance.* Requests for technical assistance in disposing of wastewater should be referred to the appropriate Army agency or laboratory listed in appendix B.

If you refer to section 5-5 Special procedures
(a) Waste disposal (1) Environmental considerations. This stipulates that a permit is required to discharge wastewater from field water purification unit. It gives no standards for re-use of this waste stream.

Section 9 Conservation Recycle and Reuse (TB MED 577)

In the following excerpt we see minimum standards for re-use or recycled water in areas with minimal supply. In 9-3 it states that a procedure must be followed to treat the water (physical/chemical) Section 9-4 lists the minimum standards, which include pH and chlorine residual of no less than 5 mg/L (water temperature above 68 deg F) and no less than 10 mg/L (water temperature below 68 deg F)

9–3. Treatment

Batch treatment for recycling can be accomplished with stave tanks and onsite treatment processes. Advice of water treatment experts in environmental engineering medical detachments (LC Teams) should be obtained to plan and implement treatment systems. A physical/chemical treatment system might include coagulation, sedimentation, filtration, and the addition of powdered activated carbon. Disinfection will be required in all cases of recycling involving human contact with the water.

9–4. Recycled water standards

a. Purpose. The purpose of these standards is to protect the health of the troops, including prevention of skin and eye irritation from recycled shower water.

b. Standards. These standards represent the maximum acceptable limit of each constituent.

(1) pH: 6.5 to 7.5 units.
(2) Turbidity: 5 NTU.
(3) Hardness: 500 mg/L.

c. Chlorine residuals. The recycled water will be disinfected with chlorine using a minimum contact time of 30 minutes. The chlorine residual will be maintained at 5 ppm for water temperatures at or above 68 °F (20 °C) and at 10 ppm for water temperatures below 68 °F (20 °C).

9–5. Operational control monitoring

Personnel operating recycling equipment will perform monitoring to control the process involved. Assistance in determining the operational control monitoring required can be obtained from LC teams. Water recycled for operations involving personal contact will be tested hourly for chlorine residual.

9–6. Preventive medicine inspection program

a. Purpose. Sanitary inspections of recycling operations safeguard the health of the troops by ensuring the treatment and handling of recycled wastewater is conducted properly.

b. Inspection requirement. Water recycling equipment will not be evaluated in the garrison situations unless it cannot be evaluated in the field training envi-

9–1

Further investigation shows that there has a military regulation for proper shower testing and maximum contaminant levels.

8–12. Shower water samples

a. The PVNTMED inspector will collect shower water samples from shower heads at each shower point. These samples will be analyzed for the following constituents:

(1) Chlorine residual.
(2) Chemical agents.
(3) Radioactivity.
(4) Water temperature.

b. Concentrations of chemical agents and radioactivity will not exceed the standards for those constituents listed in table 3-2. The chlorine residual and water temperature should conform to the levels specified in paragraph 8-10*a*.

The following section deals with No consumptive uses in 3-3 a. Rationale. It states the standard is to prevent contact with skin, inhalation, or ingestion in small amounts.

3–3. Nonconsumptive uses

a. Rationale. The standards in table 3–3 were established to protect troops from contracting diseases from water that comes in contact with their skin or are incidentally inhaled or ingested in small amounts. The standards were also designed to protect equipment and clothing from deterioration.

b. Standards. Water quality standards for nonconsumptive uses are presented in table 3–3.

c. Variances from water quality standards.

(1) Water of the next higher quality may be used for any of the purposes listed in table 3–3 when water conservation considerations permit.

(2) *Water of the next lower quality will not be used unless an emergency exists.* The PVNTMED personnel will evaluate the situation and provide alternatives to the command surgeon. The command surgeon will recommend the use of lower quality water.

Table 3–3. Water quality standards for nonconsumptive uses

Water quality	Uses include
Potable water	*a.* Mess operations such as food washing. *b.* Personal hygiene such as shaving, brushing teeth, helmet baths, and comfort cooling. *c.* Medical treatment. *d.* Photo processing for quality control. *e.* Ice production for food preservation and cooling. *f.* Water hose and pipeline testing and flushing.
Disinfected nonpotable fresh water	*a.* Centralized hygiene such as field showers. *b.* Decontamination of personnel. *c.* Retrograde cargo washing. *d.* Heat casualty body cooling. *e.* Graves registration personnel sanitation. *f.* Well development.
Nonpotable fresh water	*a.* Vehicle coolant. *b.* Aircraft washing. *c.* Pest control. *d.* Field laundry. *e.* Concrete construction. *f.* Well drilling.
Seawater	*a.* Vehicle washing.* *b.* Electrical grounding. *c.* Fire fighting. *d.* Nuclear, biological, and chemical (NBC) decontamination of materiel. *e.* Road construction.

*Seawater may lead to significant corrosion of some mechanical parts. Consider nonpotable fresh water if available.

Under disinfected nonpotable fresh water (a) Centralized hygiene such as a field shower

Conclusion:

- Reverse Osmosis treatment technique is highly effective at removing pathogens, virus, and bacteria, as well as aqueous salts and metal ions.
- The military is required to acquire a discharge permit for the concentrate or rejected waste stream from the reverse osmosis process.
- The military has a procedure for the reuse or recycle of water for other operations (other than human consumption)
    - Physical/chemical treatment
    - Maximum Turbidity; minimum pH, and Chlorine disinfection standards
- Non consumptive uses for water state that showers can use disinfected nonpotable water

The logic/rationale for the operation of using concentrate waste stream for non-potable ablution/shower consumption is incorrect. Perhaps someone surmised the total water passing through the reverse osmosis system, had effectively gone through a treatment process. The illogical portion is this: the concentrate is just that, it is concentrated waste that was removed from the treatment process. Again it would be more logical to use untreated raw Euphrates water as non-potable use. The problem is further intensified by the blatant disregard of disinfection use and the necessary contact time for an effective kill.

7. Initial Report From Ben Carter

From: Ben Carter
Sent: Thursday, March 24, 2005 10:40 AM
To: Suzanne Raku-Williams; Warren Smith
Cc: Lisa Waterman; Walter Meyers
Subject: Incident report from 23-March-2005 Water contamination
On Wednesday morning I was notified by our Labor Foreman #1 of suspected micro-organisms in his water. Electric#1 had done a visual inspection and reported to me that he also had seen "small worms" moving in the toilet bowl. I went to inspect this myself and saw what I believe were mosquito larvae. This is by no means to be considered to be a fact. I then immediately tested the cold water from the lav sink in Labor #1's hooch for free chlorine. There was none detected. It had been my understanding that this water was non-potable but was chlorinated.

I then proceeded to test several other locations including directly from the water storage tanks. I decided it was necessary to super chlorinate the entire KBR man camp water system. Also after close inspection of the water system, I noticed the storage tank air vents were completely open to outside contamination from a variety of sources. I directed the plumbers to cap the 2" vents on each tank and to install turned down elbows with screens on the 4" openings. This has been completed. There is still improvement needed in securing the manhole covers from future contamination. I obtained two submersible pumps from rowpu and installed them in the tanks, the electrical department responded immediately to install the required wiring. The water tanks were then dosed with HTH chlorine of 68%. After a short period of time a free chlorine residual of 11ppm was obtained. I ran water in the man camp at the furthest point from the tanks until a residual of 13ppm was obtained. At this point in time, we directed all personnel to run the water in their hooch's until chlorine was present at all points. It was determined that the water system should be allowed to sit for a 24 hour period of time. All personnel were directed to not shower or wash clothes until after 24 hours elapsed.

During this same period of time I went out to the military rowpu site to inquire of SFC Roux (Spelling?) about the chlorination of their non-potable water. I was informed that they do not chlorinate this water at all. It is pumped only through their multi-media filter and dispensed from there. This is absolutely unsatisfactory for numerous reasons. To protect from hard-shell cysts, the only approved method is filtration down to 1 micron. Giardia cysts can range in size, but typically 5 micron is acceptable. These cysts cannot be killed effectively with chlorination. It is my opinion that the water source is without question contaminated with numerous micro-organisms, including Coliform bacteria. There is little doubt that raw sewage is routinely dumped upstream of intake much less than the required 2 mile distance. Therefore it is my conclusion that chlorination of our water tanks, while certainly beneficial is not sufficient protection from parasitic exposure. Possibly this can be remedied by additional filtering at the military rowpu through their cartridge filter system. My plan for now until the Water Works rowpu is operational is to perform routine chlorine analysis of the water, and to maintain a 5.0 ppm free chlorine residual at all times. To ensure the success off this new task, I must be informed of every new delivery of water to the tanks prior to filling.

If there is anything I have missed, please feel free to contact me with any questions.

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8. References

- U.S. Code of Federal Regulations, Title 40, Part 141, National Primary Drinking Water Regulations, 1989, amended 1998
- U.S. Code of Federal Regulations, Title 40, Part 143, National Secondary Drinking Water Standards, 1999 Edition
- U.S. Department of Defense, Overseas Environmental Baseline Guidance Document (OEBGD), 15 March 2000
- Army Regulations (AR) 40-5, Preventive Medicine 15 October 1990
- Technical Bulletin Medical (TB MED) 577, Occupational and Environmental Health Sanitary Control and Surveillance of Field Water Supplies, 7 March 1986
- TB Med 576, Sanitary Control and Surveillance of Water Supplied at Fixed Locations, 15 Mar 1982
- USA CHPPMTG 179, Guidance for Providing Safe Drinking Water at Army Installations, Nov 1995
- DOE Order 5000.3A, *Occurrence Reporting and Processing of Operations Information,* U.S. Department of Energy, May 30, 1990.
- *Accident/Incident Investigation Manual,* SSDC 27, DOE/SSDC 76-45/27, November 1985, second edition, U.S. Department of Energy.
- D. Fillmore and A. Trost, *Investigating and Reporting Accidents Effectively,* SSDC-41,DOE-76-45/41, EG&G Idaho, Inc.
- D. L. Gano, "Root Cause and How to Find It," August 1987.
- Chong, Chiu, *A Comprehensive Course in Root Cause Analysis and Corrective Action for Nuclear Power Plants,* (Workshop Manual), Failure Prevention Inc., San Juan Capistrano, CA, 1988.
- R. J. Nertney, J. D. Cornelison, W. A. Trost, *Root Cause Analysis of Performance Indicators,*WP-21, System Safety Development Center, EG&G Idaho, Inc., Idaho Falls, ID, 1989.
- J. D. Cornelison, *MORT-Based Root Cause Analysis,* WP-27, System Safety Development Center,EG&G Idaho, Inc., Idaho Falls, ID, 1989.
- J. R. Buys and J. L. Clark, *Events and Causal Factors Charting,* SSDC-14, System Safety Development Center, EG&G Idaho, Inc., Idaho Falls, ID, August 1978.
- W. A. Trost and R. J. Nertney, *Barrier Analysis,* SSDC-29, System Safety Development Center, EG&G Idaho, Inc., Idaho Falls, ID, July 1985.
- M. G. Bullock, *Change Control and Analysis,* SSDC-21, System Safety Development Center, EG&G Idaho, Inc., Idaho Falls, ID, March 1981.
- N. W. Knox and R. W. Eicher, *MORT Users Manual,* SSDC-4, Rev. 2, System Safety Development Center, EG&G Idaho, Inc., Idaho Falls, ID, 1983.
- G. J. Briscoe, WP-28 (SSDC), *MORT-Based Risk Management,* EG&G Idaho, Inc., Idaho Falls, ID, 1991.
- J. L. Harbour and S. G. Hill, *HSYS, A Methodology for Analyzing Human Performance in Operational Settings, Draft,* EGG-HFRU-3306.
- C. H. Kepner and B. B. Tregoe, *The New Rational Manager,* Princeton Research Press, Princeton, NJ, 1981.