Chapter 22

WATER CONTROL

The Base Civil Engineer Officer is responsible for the supervision and accomplishment of all work entailed in providing a safe, sufficient, and satisfactory water supply.

The Director of Base Medical Services (DBMS) is responsible for conducting investigations to determine the suitability of water supply from the standpoint of health preservation and recommending any remedial action indicated. This requires periodic inspection of water sources, treatment measures, disinfection methods, water storage, and distribution, together with the routine collection and analysis of water samples and interpretation of results. Further, the Director of Base Medical Services is responsible for the review of proposed water supply projects and for determining whether necessary safeguards for potability have been incorporated.

Services of bioenvironmental engineers of the Medical Service should be used to evaluate the proposed water supply project.

Reports

Emergency situations related to water supplies, such as an outbreak of water-borne disease or the discovery of a major health hazard, are reported to major commands in a special Aerospace Medicine Report.

Discrepancies found through routine or periodic investigations of a water supply which may endanger potability, normally, are discussed in the recurring Aerospace Medicine Report. If no physical discrepancies exist, the statistical treatment of routine bacteriological water analyses, as set forth in AFM 160-4, serves to determine whether or not the supply meets minimum requirements of bacteriological quality during each reporting period.

Sources

Water for military supplies may be obtained from any of several types of water sources. Table 22-1 lists common sources and general considerations of their use:

Purchase of water from an approved public supply in a neighboring municipality is a widely used method of providing water for military installations. This is ordinarily the cheapest and best method when available, but may be limited in some oversea areas due to considerations of security, dependence, and public health standards.

When a choice of water sources is possible

Source:	Ground	Surface	Spring	Rain	Sea
Concerns:	Well Protection	Watershed Restrictions	Enclosure	Catchment Protection	....
Usual Treatment:	Aeration	Flocculation Sedimentation Filtration	....	....	Distillation
Safeguard:	Chlorination	Chlorination	Chlorination	Chlorination	Chlorination

in planning a military supply, ground water is preferable. Ground waters, normally, have better initial bacteriological quality and require less treatment than surface sources, thus reducing operational problems. In addition, the development of ground water is better suited to military considerations of security, decentralization, and protection against enemy action. However, development of ground-water resources under combat or field conditions is limited in view of requirements for well-drilling equipment and experienced hydrologists, and the time factor involved.

Sanitary surveys of established water sources are required at periodic intervals to insure that adequate protection exists for preventing the entrance of contamination into the supply. Where ground water is obtained through deep wells, the chief concern is that of preventing ingress of surface water through drainage or leakage into wells. With surface-water sources, the detection and elimination of gross contaminations, such as untreated sewage or industrial waste discharges, are the principal considerations.

Treatment

The most common treatment measures used with ground waters are the reduction of hardness and aeration. When large amounts of highly mineralized ground water must be used for industrial needs, such as for boiler water or laundries, softening of all or a part of the supply may be necessary. It is only rarely that ground-water supplies are so brackish that demineralization is necessary to make them satisfactory for consumption; consequently, Medical Service concern in this connection is limited. Removal or reduction of iron, manganese, hydrogen sulfide, and carbon dioxide, which are common objectionable constituents of ground waters, may be accomplished through aeration. Aside from being objectionable in water because of staining porcelain and laundry, imparting unpleasant taste and odor, or causing corrosiveness, presence of these substances above critical levels is of medical concern in attempting disinfection by chlorination. Significant amounts of dissolved iron, manganese, or hydrogen sulfide in water provide inorganic "chlorine demands" that give rise to difficulties in maintaining chlorine residuals. Dissolved carbon dioxide causes corrosiveness that will tend to pick up iron, copper, and lead from distribution lines as well as from service plumbing.

General treatment measures applicable to surface waters include storage, softening, coagulating, and filtration. Storage is frequently used to improve the physical characteristics of surface water through impoundment. Softening, as with some ground waters, may be necessitated for industrial usage. Purification of surface water is generally accomplished by complete treatment. This consists of coagulating the water through flocculation and sedimentation with subsequent filtration through rapid sand-gravity filters. This process mechanically removes the suspended material, varying amounts of tastes, odors and color, and practically all bacteria. Coagulation of water is performed by the addition of computed dosages of coagulant chemicals, followed by gentle agitation to permit the formation of gelatinous adhesive floc, after which a final period of quiescence is provided to allow the floc to precipitate and carry down suspended material. While the primary purpose of coagulation is to relieve filter loading so that long filtration cycles are obtained, it plays an important role in the removal of pathogenic microorganisms. Besides carrying down great numbers of microorganisms during the sedimentation phase, the fine particles of floc carried over to the filter beds form thereon an exceedingly fine bio-filter which effectively filters out virtually all remaining microorganisms. These additive benefits are lost when full surface-water treatment is reduced to rapid sand filtration only, as may be done to save chemicals during dry seasons when raw water turbidities are low.

In summary, Medical Service inspections of water-plant treatment measures should consider the purpose of the treatment employed and the effectiveness of these procedures. The latter is best indicated by appraising the completeness of laboratory control maintained and the technical competence of the operating personnel, provided design characteristics are suitable.

Disinfection

It is a military maxim that all water is to be regarded as contaminated until it has been disinfected. Chlorine is used by the military establishment as the disinfectant of choice for sizeable military water supplies. Because of the importance of proper disinfection of a water supply, Air Force regulations are very specific on this point and rigid requirements have been established. For these reasons, it is imperative that the Flight Surgeon maintain a continuous surveillance to insure that chlorination of the water supply is satisfactory at all times.

Water chlorination has a dual purpose: initial disinfection of the water, and protection of the supply during distribution by providing a chlorine residual to serve as a safety factor in the event of secondary contamination. The residual in the distribution system is generally not high enough to provide additional disinfection; however, the lack of a chlorine residual in the distribution system may be an indication of secondary contamination.

Chlorine is usually added to water as the final step of processing. It is introduced either through chlorinators as an aqueous solution of chlorine gas, or through hypochlorinators or solution feeders as a chlorine solution derived from the commoner hypochlorites. Free available chlorine (HOCl and/or OCl-ions) in water acts as a powerful, relatively quick-acting bactericidal agent. However, when ammonia or nitrogenous compounds are present in water, as is the case with many natural waters and, invariably, with waters which have been coagulated with ammonium alum, chlorine introduced initially reacts to form chloramines.

Chloramines are also bactericidal but have lower oxidizing potentials than free available chlorine; hence, chloramines must be employed in higher concentrations to equal the disinfectant action of free available chlorine. Differentiation of free available chlorine and chloramines in water is accomplished by the orthotolidine arsenite (O.T.A.) test described in "Standard Methods for the Examination of Water and Wastewater." (See References.)

As the bactericidal action of chlorine follows the slow rates of organic chemical reactions and is markedly influenced by factors of pH, temperature, and the form of chlorine present, disinfection is not completed for some time after chlorination. A minimum contact period of 30 minutes between chlorination and distribution to the first consumer is specified by regulation for Air Force-owned and operated water systems. This contact period must be provided for at finished water storage or distribution facilities.

At fixed installations, a measurable chlorine residual, after a 30-minute contact time, will be maintained at all times in the parts of the potable water distribution system under constant circulation. This does not apply to water directly supplied to installations, depots, leased buildings and similar facilities by a satisfactory public water supply distribution system that is approved by the appropriate State health authority. It does apply to military-owned and operated well and surface supplies and to water from municipal or privately owned systems where sanitary, physical, or operating defects and other special hazards are known to exist, or where bacteriological examinations show that satisfactory quality cannot be obtained without rechlorination by the installation.

Thus, for Air Force-owned and operated water supplies, the DBMS's concern with disinfection procedures consists of insuring the provision of an adequate contact period following chlorination, determining the types of chlorine residuals present, and maintaining a sufficiently close check by actual tests to insure that chlorine residuals carried in the active distribution system are satisfactory at all times. This involves the accomplishment of daily chlorine residual tests.

Fluoridation

Fluoridation of Air Force water supplies is becoming common practice. The safe concentration of fluorides in natural waters has been established as 1.5 ppm (parts per million) as set forth in AFM 160-4; concentrations of less than 1.0 ppm are the maximum ordinarily authorized when fluorides are added to water supplies to reduce the incidence of dental caries.

Justification for fluoridation of Air Force water supplies requires careful consideration and cooperation of personnel of the Dental Service and the Aerospace Medicine Service.

The Chief of Dental Services compiles information justifying the use of fluorides in the water supply in terms of the benefits received from fluoridation, the population using the water, and especially the number of minor children served.

The Bioenvironmental Engineer is concerned with accomplishing a complete field investigation of the water supply, type of proposed fluoride-feed mechanism, laboratory control tests, water plant safety regarding handling of fluorides, and economics of the process. Fluoridation of water supplies at Air Force bases should be coordinated with and approved by the Office of the Surgeon General per AFR 161-9.

The Aerospace Medicine Service is responsible for the routine determination of the fluoride residual. The fluoride content should be determined at least as often as the chlorine residual throughout the water distribution system. The method of determining fluoride concentrations may be found in "Standard Methods for the Examination of Water and Wastewater." (See References.)

Storage

Periodic inspections of water supplies should include appraisal of capacity of storage facilities with regard to the contact periods following chlorination. Protection afforded finished water while in storage is likewise important. Storage and distribution tanks should provide adequate protection against dust-borne or other accidental contaminations.

Distribution

Cross-connections constitute major hazards in water distribution systems. A cross-connection is a physical arrangement between a drinking-water supply system and a nonpotable system whereby flow into the drinking-water system is possible. Where dual systems exist for fire protection or industrial usages, consideration must be given to the possibility of such connections existing. Incomplete physical separation between the contents of swimming pools and their supply lines is another type. Faulty plumbing arrangements, such as leaking flush valves and their bypasses, are cross-connections and may cause back-siphonage of toiletbowl contents when partial vacuum conditions exist. Back-siphonage may occur on the uppermost fixtures in buildings when pipe sizes are too small to satisfy simultaneous water demands and when lavatories, sinks and other fixtures have under-the-rim inlets.

Cross-connections are seldom alike; some are in conjunction with equalizing tanks; others are direct connections to different supplies; often they are buried in boiler rooms, or are scattered in buildings over the area served.

Secondary contamination may also gain entrance into distribution systems through leaking joints or fractures, especially when sewer and water lines are in proximity and water tables are high or storm waters percolate around the lines. The greatest hazards of this nature are associated with antiquated distribution systems or military systems constructed from invasion-type materials that have exceeded their useful life.

Maintenance of constant positive pressure throughout a distribution system is of paramount importance against dangers associated with cross-connections and leaks. The occasional military expedient of conserving water in overtaxed supplies by valving off distribution systems or parts thereof is fraught with danger when underground lines are involved. Conservation should stress reduced usage.

Before placing new distribution systems in service, sterilization of all lines with heavily chlorinated water (50-100 ppm chlorine) for 24 hours is essential. This is also an established practice for new extensions to a system and for portions affected following main breaks and replacements or other major repairs.

Testing

Reliance for insuring the continuous potability of Air Force water supplies is placed largely upon the routine tests for chlorine residuals and bacteriological quality. The Director of Base Medical Services is charged with accomplishing these examinations in specified frequency and manner and interpreting the bacteriological findings. Since so much weight is attached to these indicative tests, it follows that every factor affecting their validity must be carefully appraised and appreciated by personnel to whom these responsibilities are delegated.

As the water samples tested are but a minute percentage of the total supply, it is essential that they be as representative of the total supply as possible. Sampling points for routine examinations should be selected by reference to a blueprint of the distribution system. They must be on active portions of the system, preferably from taps having the shortest run of service line from the mains. The number of sampling points chosen should correspond with the number of bacteriological samples to be examined each month and should be so placed over the system as to reflect principal usages. To obtain statistical validity, routine sampling points must remain fixed, with the same points used over each successive monthly testing cycle.

Bacteriological analyses of drinking water are based upon the demonstration of the presence or absence of the coliform group of organisms. Positive returns are only suggestive of the presence of the various waterborne pathogens. For this reason, interpretation of the significance of the analyses is a responsibility of the medical officer submitting the samples, rather than a laboratory responsibility, since the sum total of knowledge arrived at through sanitary surveys, inspections, and tests is necessary for proper evaluation.

The statistical treatment of routine bacteriological water analyses covered in AFM 160-4 is predicated upon establishing the bacteriological quality of the water supply as distributed. This limits consideration to samples taken from one supply and of that supply from the distribution system alone. Samples from raw water sources, treatment stages, off-base locations, other supplies, and those no longer representative of the water in distribution, such as samples from water jugs, mixing faucets, and the like, are of informational value only and are not to be included in the supply evaluation.

Field Supplies

The water purification equipment set, diatomite, portable 50 gpm capacity, is the standard Air Force water plant for producing potable water under field conditions at advanced air bases and temporary installations. The unit is readily transportable by cargo truck or aircraft, can be set up and placed in operation within 8 hours, and is capable of producing up to 60,000 gallons per day of clear, palatable water from any available surface-water source. This equipment was expressly developed to provide a method of field water production which could absolutely guarantee the removal of amebic cysts and schistosome cercariae from raw surface water sources. It became generally available toward the close of World War II and was used in Asia and the Pacific area. Since introduction, it has superseded previous types of field water-purification equipment employing sand-pressure filters, which could not be dependent upon to remove amebic cysts. Diatomite equipment was invaluable during the Korean campaign. (See figures 22-1 through 22-4.)

The principle of diatomite filtration consists of forcing raw water through a thin layer of diatomaceous silica (kieselguhr) plastered over supporting wire septa. Filtration achieved is equivalent to that provided by a laboratory Berkefeld filter. The filtrate produced is exceptionally clear, with more

(L to R) Finished Water Tank; Settling Water Tank; Coagulation Water Tank.

Figure 22–1. Field Water Purification Unit—50 GPM (3,000 Gallon Treatment and Holding Tanks).

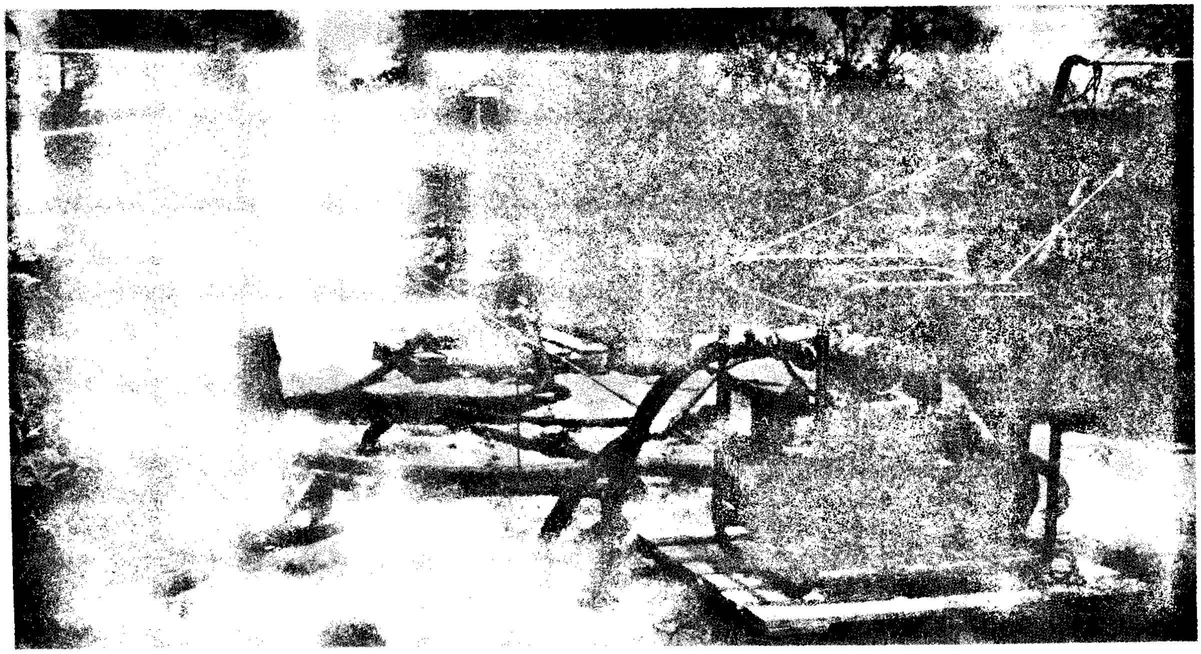
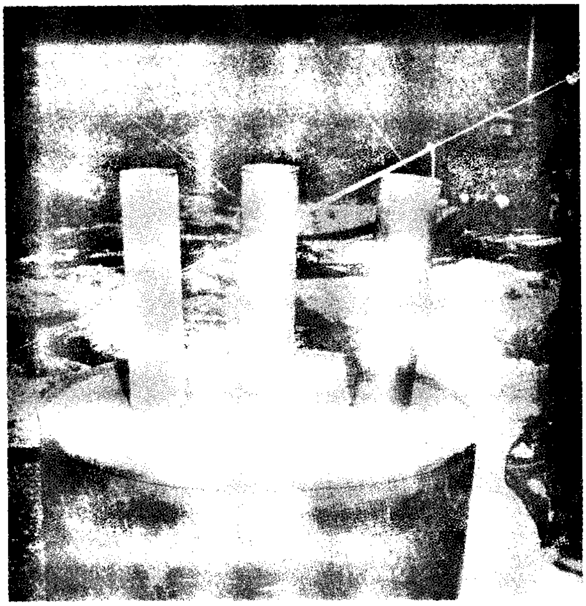


Figure 22–2. Field Water Purification Unit—50 GPM (Water Storage and Treatment Tanks; Diatomaceous Earth Filter Unit; Gasoline-operated Water Pump).



(Left to Right: Basic Septum Core; Septum partially wound; Septum as used in filter.)

Figure 22-3. Diatomaceous Earth Filter Septums.

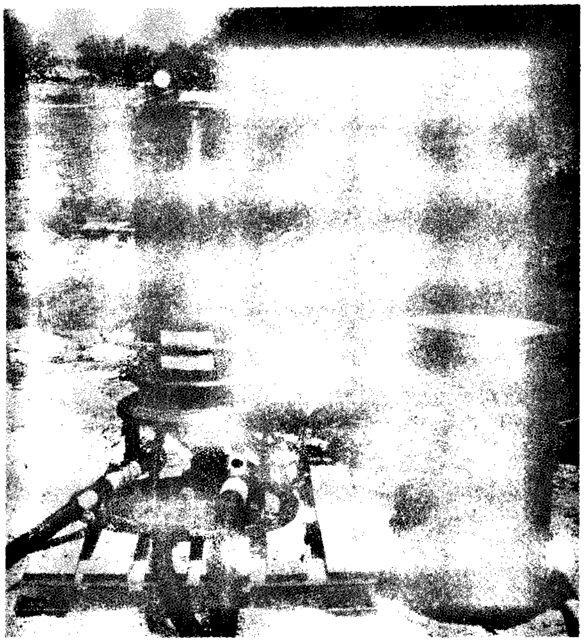


Figure 22-4. Diatomaceous Earth Filter Unit With Precoating, Influent and Effluent Lines.

bacteria filtered out than is possible with conventional sand filters. Amebic cysts and schistosome cercariae, being comparatively large in relation to bacteria, are readily removed during this filtration process. Pathogenic bacteria remaining in the filtrate are destroyed by subsequent chlorination. With this equipment, the danger of amebic cysts surviving normal chlorine dosages is obviated through physical removal.

As with fixed military supplies, field diatomite water-purification equipment is operated by civil engineering personnel. Due to technical operating details and the advisability of coagulating and settling raw surface water prior to filtration, trained operators are of cardinal importance.

In field situations, diatomite water-purification units are usually some distance removed from the airstrip or quartering areas. Rarely is a river, stream, canal, pond, or other source of surface water immediately adjacent to the points of water usage. Distribution from the water point normally becomes a matter of each squadron or unit hauling water as needed in its own water trailers, five-gallon water cans, or other convenient receptacles. This kind of potable water distribution necessitates the closest surveillance to insure that secondary contaminations are not incurred. Disinfection practices for trailers or other containers prior to placing them in routine use, water-handling methods, exposure to dust-borne contaminations while in transit, and rechecking of chlorine residuals before the water is made available to consumers, should be usual concerns under these conditions.

The water purification equipment set, diatomite, pack (man), 15 gpm capacity, is also available through supply channels. This is a smaller unit designed to provide potable water in the field for small, isolated units. Principles of operation and considerations regarding water safety are the same as for the larger 50 gpm equipment set.

Distillation units of various types and capacities have been developed for the production of drinking-water supplies from sea water and brackish water. These units have been widely used on small islands and coral atolls in the Pacific where fresh water is not available. The distillate produced by equipment of this type must be protected by disinfection to prevent contamination by subsequent handling.

In field situations, residual chlorine concentrations of 1.0 ppm or more are required.

The establishment of adequate, safe and potable water supplies in field situations, to include bare base and/or forward areas, is the joint responsibility of the Air Force Civil Engineer and the Medical Service. Close liaison and coordination are essential between these personnel.

Emergency Purification

Under field or survival conditions, situations may arise that will require persons or small units to produce their own drinking water from raw sources or unsafe supplies. Certain items of water-treatment equipment and purification supplies are issued for these purposes. Their use, however, should be regarded as an emergency requirement, and water so processed should never supplant water obtainable from military supplies when the latter is available.

The water-purification unit, hand-operated, knapsack pack, filter pad type, ¼ gpm, was designed to provide small isolated units with a means of producing potable water. This unit consists of a small hand-operated diaphragm pump, double-faced filter disc, clamping ring, canvas carrying-case, paper filter pads, and accessories. It is issued as Water Purification Set No. 1, Knapsack Pack, ¼ gpm. The unit is simple, durable, and lightweight and can produce water of high clarity from turbid raw water. It will remove amebic cysts and schistosome cercariae from the raw water. Disinfection of the filtered water with water-purification tablets is necessary.

Small-scale units for obtaining drinking water from sea water are Air Force stock items used in life rafts and survival equipment. The type MK2 Sea Water Desalting Kit reduces the salt concentration of sea water to tolerable limits through chemical precipitation. The type LL2 Sea Water Distillation Kit accomplishes salt removal by utilizing solar heat on a plastic still.

Disinfection of untreated raw water may be necessary in emergencies. For small groups, the 36-gallon canvas Lyster bag carried in unit supplies for drinking-water storage and dispensing, can be used as a container for disinfecting raw water. The bag is filled to the mark with the clearest raw water available and an ampule of calcium hypochlorite broken and the contents added. After stirring, a 30-minute contact period must be observed before the water is consumed. Two ampules should be used when the water contains organic materials or when the presence of amebic cysts or schistosome cercariae in the raw water is of concern.

On an individual basis in emergencies, water may be disinfected in a canteen with water-purification tablets. These are available as Tablets, Water Purification, Individual, Iodine, containing tetraglycine hydroperiodide ("Globaline") as the active ingredient. The tablets should be used according to the instructions on the vial. *The "Halazone" individual water purification tablets are obsolete and should not be used.*

Under extreme emergency conditions, raw water may be rendered safe by boiling for at least 15 minutes. Quantities required for drinking should be prepared as needed due to the danger of secondary contamination occurring without the safeguard provided by chlorine residuals.

REFERENCES

The reader should insure the currency of listed references.

AFM 88–54, *Air Force Civil Engineer Handbook.*

AFM 160–4, *Sanitary Control of Water Supplies for Fixed Installations.*

AFM 160–25, *Engineering Data, Preventive Medicine and Occupational Health Program.*

AFR 91–10, *Water Works.*

AFR 161–9, *Fluoridation and Defluoridation of Water Supplies.*

AFR 161–14, *Swimming Pools.*

TB MED 190, *Water Treatment in Areas Where Amebiasis and Schistosomiasis Are Hazards.*

TO OO 105C–3, *Ground Water Supply for Military Operations.*

TO OO 105C–4, *Military Water Supply and Purification.*

TO OO 105C–6, *Operation of Water Supply and Treatment Facilities at Fixed Army Installations.*

Public Health Service Drinking Water Standards (1962).

Standard Methods for the Examination of Water, and Wastewater, 11th Edition, American Public Health Association, 1790 Broadway, New York, NY (1960).