General Research and Development Needs for Early Warning Monitoring Systems

- Development of a continuous monitor capable of detecting low levels of dissolved oil and petroleum products without significant limitations from chemical and physical interferences
- Continued development of rapid and automated sensors for established and emerging pathogens and biowarfare agents
- Development of sensors for simultaneous identification of multiple pathogens (combined biosensors)
- Improvements in sensor sensitivity
- Continuous, online, and remote-sensing monitors for a greater number of chemical parameters
- Improvements in electronic nose technology, especially for detecting odors in surface waters in which the complex chemical composition can create a combination of smells that make it difficult to monitor electronically
- Improvement of biological monitors through better means of sensing behavioral changes in response to sudden exposure to toxins
- Greatly improved technology exchange between the water supply industry and the many different industries developing innovative sensor technologies

fast mechanism for acquiring flow and velocity information. Current flow data for many rivers may be obtained electronically from US Geological Survey or US Army Corps of Engineers gauging stations; alternatively a flow gauge can be installed at the monitoring station.

Water quality models should be used as a guide to what may happen and are intended to supplement (but not replace) collection of actual real-time data as a source of information. Grayman and co-workers (2001) reviewed available models of varying complexity and also developed a one-dimensional Riverine Spill Modeling System that can be easily adapted for use for a wide range of rivers. An example output from such a model (Figure 2) identifies the expected time at which a spill will reach downstream locations.

Response actions and plans must be prepared ahead of time. Often, initial information about the nature and extent of a contamination event is limited. A water utility must first determine whether to act immediately or delay action pending confirmation and additional information. When the warning has been triggered by monitoring at the intake, then the need for near instantaneous decision-making is more acute. Appropriate water supplier responses to changes in source water quality depend on the type and potential extent of contamination, efficacy of existing and available treatment processes, and projected risks to public health or treatment process efficiency. General guidance and operating policies for response activities for a range of possible contamination events should be operative before an event occurs. Policies may include taking immediate action, waiting until the contaminant event has been confirmed and the nature (extent, location, arrival time, etc.) of the event determined, or opting for a more complex action plan determined by the type and location of the warning.

Responses to mitigate the effects of a spill event can include (1) closure of water intakes and use of alternate sources or storage, (2) cleanup of the spill before it can affect water intakes, (3) adjustment of existing treatment processes or use of additional ones, and (4) public notification (e.g., boil-water notices). Closure of water intakes provides the most absolute barrier; for optimum effectiveness, this action should be guided by information from the early warning system to coincide with the period of highest concentrations. If the water intake can be closed for only a limited time period (e.g., a few hours), then this places a premium on accurate predictions of concentration. The availability of raw and finished water storage capacity can help facilitate intake closure. In some cases, the intake location can be switched to draw water from different depths or lateral positions within the same source. Bank filtration and groundwater injection–recovery systems provide for additional treatment and place an additional time lag between the surface water source and the treatment plant.

Communication systems and plans are key to the efficacy of early warning monitoring. The effectiveness of an early warning system relies on accurate and timely information being communicated to those responsible for making response action decisions. The emergency response plan should include detailed instructions for communication between appropriate parties, with decision-makers, and to other stakeholders and the public, as necessary. Means of communication to the various parties can include face-to-face meetings, telephone, facsimiles, e-mail, websites, electronic bulletin boards, the media, and other methods.

Cooperative networks make the most of resources. Although onsite early warning monitoring may be conducted by a single water supplier, source waters used by multiple water utilities (e.g., a large river) offer opportunities for cooperation and pooling of resources for development

TABLE 1 Select approaches for detecting chemical and radioactive threats to drinking water*

	Approach†								
	High End			Middle			Low End		
Threats	$100,000s	Pros	Cons	$10,000s	Pros	Cons	$1,000s	Pros	Cons
Ions (salts)				IC	Fast, broad, sensitive		Ion probe	Sensitive	Selective
Metals	ICP–MS	Fast, broad ID, sensitive	Staff, lab	AAS Polarography	Fast, sensitive Fast, fairly selective	Staff, lab Selective	Ion probe	Sensitive	Selective
Polar organics	LC–MS	Broad ID	Staff, lab	LC TOC	Broad ID Broad ID	Staff, lab Lack of sensitivity	UV		Lack of sensitivity
Nonpolar organics	GC–MS	Broad ID	Staff, lab	LC	Broad ID	Staff, lab			
Volatiles, oil, hydrocarbons	GC–MS	Broad ID	Staff, lab	P&T–GC GC Fluorescence (oil, HC)	Broad ID Broad ID Broad ID	Staff, lab Staff, lab Interferences	Smell bell	Fast	Human testers
Specific compounds	GC–MS, LC–MS	Broad ID	Staff, lab				Immunoassay (pesticides)	Fast, specific	Staff
Biotoxics				Biomonitors‡	Continuous, fast	Lack of specific ID			
Radiation				Tritium Gamma detector Beta or alpha detector	Fast, specific Fast, broad ID, available online Fast	Not available online Lack of specific ID Lack of specific ID, lab, evaporation step, not available online			

*Modified from ILSI (1999)
†AAS—atomic absorption spectrometry (furnace or flame), Broad ID—can monitor for many compounds simultaneously, GC—gas chromatography, HC—hydrocarbons, IC—ion chromatography, ICP–MS—inductively coupled plasma mass spectroscopy, ID—identification, LC—liquid chromatography, MS—mass spectrometry, P&T—purge and trap, Selective—monitors for a single compound, TOC—total organic carbon, UV—ultraviolet
‡Biomonitors—fish, daphnids, mussels, algal fluorescence, and luminescent bacteria

of an integrated early warning monitoring network, including multiple monitoring stations, centralized data management and assessment, and coordinated communication systems. Case studies of such networks are reviewed later and have been discussed by other researchers (Grayman et al, 2001; AWWARF & CRS PROAQUA, 2002).

ANALYTICAL METHODS OFFER PROS AND CONS

Although the technology exists to monitor for regulated compounds in drinking water, it is neither technically nor economically feasible to monitor for all chemical and microbiological parameters. Utilities must consider the tradeoffs between costs and the range and type of monitors used. Selection of the specific methods for monitoring the parameters of concern should be based on a variety of factors, including method-response sensitivity (which should be compared with source water baseline levels), speed, desired frequency of analysis, available means of data development and retrieval, labor and maintenance requirements, initial and ongoing operating costs, and space availability. Potential water quality monitors include physical, chemical, radioactive, and microbiological analyses, as well as bioalarm systems that use living organisms to act as sensors for extreme changes in water quality. Many researchers have examined rapid or online monitoring techniques for the water industry (AWWARF & CRS PROAQUA, 2002; Frey et al, 2001; Grayman et al, 2001; Gullick, 2001; Dippenaar et al, 2000; Pollack et al, 1999; Reinhard & Debreaux, 1999). The following sections offer a brief overview of select methods for early warning.

Some of the more common physical and chemical monitoring methods used in early warning systems include simple probes measuring various parameters (e.g., turbidity, pH, temperature, conductivity, DO, chlorophyll), relatively simple batch tests (e.g., immunoassays for herbicides), and more advanced monitoring for chemicals (e.g., fluorescence for oils and chromatography for oil and petroleum constituents, volatile organic chemicals, and phenols). Some of the primary surrogates used include turbidity, DO, odor, conductivity, and general measures of organic carbon content (e.g., oxidant demand, total organic carbon). However, some of the parameters that are easily and inexpensively monitored via online probes (e.g., temperature, conductivity, pH) provide little information on detecting many spill events (e.g., oil spills). Although the more

FIGURE 5 Schematic of a commercial flow-through fish biomonitor tank

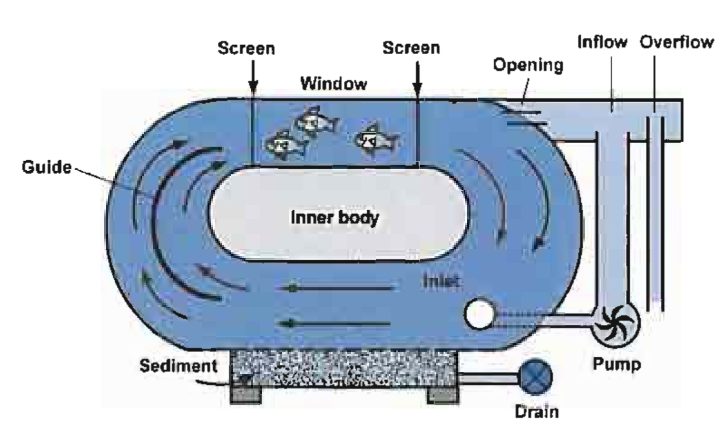
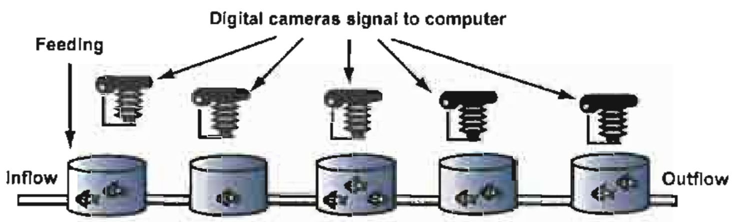


FIGURE 6 Schematic of fish-avoidance monitoring system in Osaka, Japan



advanced monitors are more expensive and require more maintenance and expertise, they are better at detecting many spill events.

Physical analyses offer speed, up-to-date information. Most physical monitoring methods are relatively rapid for most parameters (e.g., turbidity, conductivity, temperature, odor), and many can generate continuous real-time online data. Continuous online turbidity measurements are regularly used in treatment process–control application, and more expensive online particle counters are sometimes also used. Large increases in turbidity are frequently correlated with adverse changes in microbial water quality because both turbidity and microbial concentrations often increase substantially in surface waters during and after storm events because of surface runoff. Figure 3 shows an example of the correlation among increased river flow from storm events, turbidity, and the presence of the protozoan parasite *Cryptosporidium* (LeChevallier et al, 1998). High *Cryptosporidium* loadings at this location can typically be avoided by shutting an intake and using water from onsite storage when turbidity rises above a certain level (e.g., >15 ntu in Figure 4).

The presence of unusual odors can be a useful indicator for certain contamination events, including those resulting from algal by-products such as geosmin and methylisoborneol, phenols, petroleum products, and assorted volatile organics. One means for detecting odors is the "smell bell." Because it requires trained personnel with good noses, the smell bell test is not usually performed more than once per shift or once per day, thus limiting its use in early warning systems. Recent research suggests that it may soon be feasible to use electronic odor-sensing technologies ("electronic noses") that can operate continuously with less bias and greater repeatability and precision (Grayman et al, 2001).

Chemical analyses come in many forms, range of costs. Many standard chemical analyses can be used for early warning monitoring, and several methods have been adapted for automated online applications and remote data access. Table 1 summarizes the relative costs as well as pros and cons for different early warning monitoring technologies for select chemical constituents.

Online analytical probes. Online analytical probes are relatively inexpensive, are easy to use, can provide continuous or nearly continuous monitoring with remote access to data, and are available from a variety of manufacturers. Ion-selective electrodes can quantify many inorganic ions including pH, elemental anions (e.g., chloride, bromide, fluoride, and iodide), ammonium, nitrite/nitrate, cyanide, certain metals (e.g., lead, cadmium, copper, aluminum, and manganese), and several other inorganic pollutants (Table 2). Probes are also available for turbidity, chlorophyll, and DO. Some manufacturers combine a variety of electrodes into one convenient and efficient multiparameter instrument. Because probes can foul in many raw water environments, some models use self-cleaning systems to reduce maintenance requirements.

DO. The DO concentration is a major parameter for the survival of aquatic life and for early warning applications is typically measured with a simple online probe. A decrease in DO can indicate the presence of organic compounds from sewage or surface water runoff. In addition, diurnal fluctuations in DO can be indicative of the presence of algae; for this reason, DO is sometimes used in conjunction with chlorophyll and turbidity measurements to monitor for algal blooms.

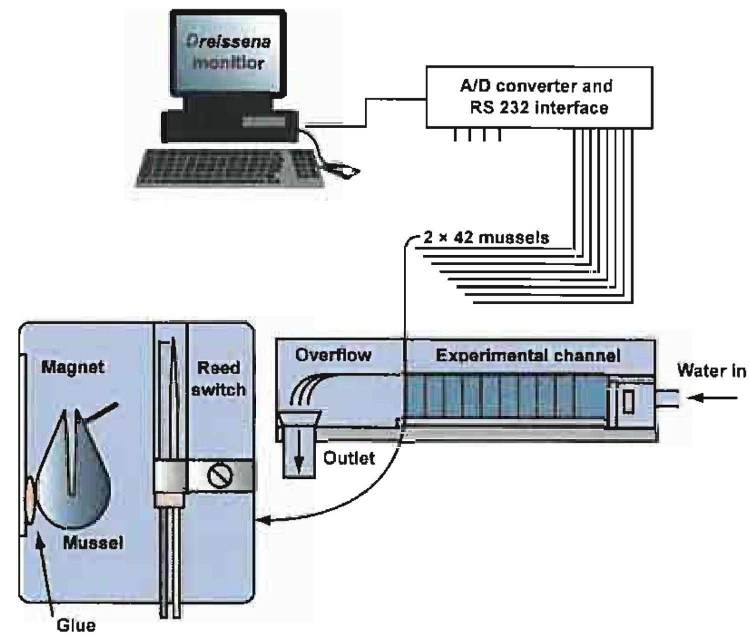
Nitrate and ammonia. Nitrate and ammonia/ammonium may be measured with a specific ion electrode; more sensitive but more expensive instruments for online colorimetric and ultraviolet (UV) analyses are also available. Both parameters may be indicative of agricultural pollution (i.e., fertilizers). Ammonia may come from sewage and animal waste discharges.

Metals. Ion-specific electrodes are available for certain metals, including lead, cadmium, copper, aluminum, and manganese. Anodic stripping voltametry–polarography is an excellent alternative for rapid analysis (<1–10 min) of low concentrations (nanogram-per-litre range) of certain metals and is used online at various monitoring stations in Europe. The instruments are priced in the range of \$10,000–\$17,000 and can detect four to six metals simultaneously; however, the method is restricted to amalgam-forming metals (e.g., cadmium, chromium, copper, lead, and zinc) and is subject to matrix interferences. Colorimetric methods are relatively inexpensive, typically apply to a single metal, and are subject to more interferences than more sophisticated methods. Atomic absorption spectrometry and plasma emission spectroscopy instruments are expensive and typically available only in commercial laboratories. One promising new technology, which has been applied to analysis of zinc, mercury, and cadmium, uses fluorescent molecules that react to specific metals in the presence of UV light (Bronson et al, 2001). Other developing methods for a variety of heavy metals include enzyme sensors and biosensors using genetically engineered microorganisms (Rogers & Gerlach, 1999).

General organic chemical parameters. Total organic carbon (TOC) and UV light absorption at 254 nm (UV_{254}) are general measures of organic content that can be performed in minutes and online. Though TOC is generally more sensitive and thus used more often for early warning, its natural variability in source waters is often greater than the concentrations of specific organics of concern. Simpler bench-scale test kits for organic carbon are also available.

Oxidant demand and oxidant residual. Oxidant demand can be a general indicator of organic carbon content and ammonia in the source water. Because many utilities practice preoxidation (i.e., addition of chlorine, chlorine dioxide, ozone, or permanganate) and use online monitors to measure downstream oxidant residual, the oxidant demand can be calculated if the oxidant dosage and flow rates are known. Of course, oxidant residual is not applicable to raw waters but can be a useful warning measure of changes in distribution system water quality if residual disinfection is used by the utility.

FIGURE 7 **Schematic of a *Dreissena* monitor featuring two channels, each with 42 mussels**

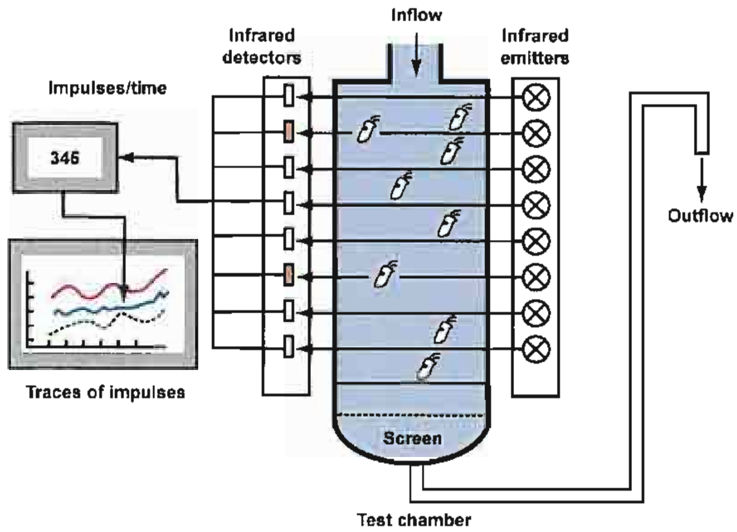


Oil and petroleum. The primary techniques for online oil monitoring use light-scattering for floating oil and fluorescence for dissolved oil although each method has its limitations (He et al, 2001). Common chemical and physical interferences (e.g., particles, detergents, and floating debris) can cause frequent false alarms and make it difficult to track an oil spill during rain events that increase turbidity. Most commercial oil-in-water monitors use light-scattering techniques and thus are primarily useful only for major spills (e.g., for a 0.33 mm [0.013 in.] or greater layer of floating product).

Fluorometry can be used for dissolved gasoline, diesel, jet fuel, and oil components (such as BTEX [benzene, toluene, ethylbenzene, and xylenes]), as well as chlorophyll from algae. Continuous fluorescence oil detectors cost in the range of \$12,000–\$24,000, are very sensitive (low microgram-per-litre range in fairly clean water), and are used in several monitoring programs worldwide, although turbidity and humic substances can interfere. Although manual solvent extraction methods are labor-intensive, some European monitoring stations use an automated system for extraction and spectrophotometric analysis of total dissolved hydrocarbons (between 0.2 and 10 mg/L). Online monitors for low concentrations of oil need improvement. The introduction of genetically engineered microorganisms as biosensors for BTEX (Rogers & Gerlach, 1999) may prove useful in the future.

Organic chemicals. Manual and online gas chromatographs (GCs) range in cost from \$30,000 to \$50,000 and are used in several early warning systems worldwide to monitor for volatiles or other organic chemicals (including fuel oil components). Only a few stations use liquid chromatography, which costs in the range of \$50,000–\$100,000. Analyses can typically be performed in less than an hour by trained operators.

FIGURE 8 Schematic of original *Daphnia* monitor



methods are still being developed or were only recently introduced. However, their use is likely to increase in the future. Relatively rapid existing methods for microbes are summarized in *Standard Methods* (1998) and Venter (2000).

Nucleic acid–based systems measure the genome of the organisms, which gives a high degree of specificity, but sample processing typically takes at least 2–4 hours. Several different kits are available for these tests. Rapid DNA probes are species-specific and use a robot-assisted microplate analysis of amplified samples of DNA (Quist, 1999). DNA microchip arrays are a developing technology that can detect and identify multiple microorganisms within 4 hours. Laser-scanning cytometry can be used to rapidly detect any organism for which there is a specific antibody, but the instruments are expensive.

Immunoassays use target-specific fluorescent antibodies that bind with an antigen of the target species, and test kits for a variety of pathogens are available that are relatively rapid, inexpensive, sensitive and simple to use (www.aoac.org/testkits/microbiologykits.htm).

Commercial methods[1–3] for measuring bacterial counts within 8–24 hours are readily available. Thanks to recent advances, the potential analysis time for bacteria (e.g., total coliforms, *E. coli*, or heterotrophic plate counts [HPC]) has been reduced to 4–8 hours or less. For example, a new modification of method 9211C.1 (*Standard Methods*, 1998) using adenosine triphosphate bioluminescence allows quantification of HPC within minutes (Lee & Deininger, 1999).

The conventional tests for protozoan parasites such as *Giardia* and *Cryptosporidium* (USEPA methods 1622 and 1623) require extensive training and are too time-consuming for early warning monitoring applications. Commercial instruments are available that can provide for screening of protozoan parasites in aqueous samples, but the tests still take a few

Mass spectrometry (MS) is even more expensive and would be used primarily during the event confirmation step to provide accurate identification of organics in select samples. For some chromatography analyses, sample preparation can add significantly to the work required, and the necessary QA/QC can be more time-consuming than that for some of the simpler analyses.

Pesticides. Pesticide (herbicide and insecticide) contamination of surface waters is often seasonal because it primarily results from nonpoint source rainfall runoff from agricultural areas during periods of high pesticide application. The inexpensive batch ELISA (enzyme-linked immunosorbent assay) procedure, which is often used for the herbicide atrazine, takes approximately 40 minutes and compares reasonably well with GC–MS results for concentrations on the order of 3 μg/L, i.e., the level of the USEPA drinking water standard (Lydy et al, 1996).

Radioactivity. Early warning for radioactivity in surface waters may be applicable for facilities downstream from a nuclear power plant or other potential large source of radioactivity. Both gross radioactivity and specific radioactive substances may be measured. Tritium (hydrogen-3) may be an especially good indicator for nuclear power waste because it behaves as a conservative tracer in water and would reach an intake prior to other radioactive constituents that have larger retardation factors. Monitoring stations on the Rhine River measure for total alpha, total beta, tritium, cesium-137, and strontium-90 activity (Grayman et al, 2001).

Advances make microbiological analyses more feasible for early warning use. Conventional methods of microbial analysis require a relatively long time period (e.g., hours or days) for isolation and reproduction (amplification) of the microbial species, and many tests are specific only to a single species or class of organisms. Because of these limitations, these analyses are not often used for early warning applications. However, significant recent advances in microbial monitoring and related technology offer increased sensitivity, specificity, and more-rapid analysis, including deoxyribonucleic acid (DNA) microchip arrays, rapid DNA probes, immunologic techniques, cytometry, laser scanning, laser fingerprinting, optical technologies, and luminescence (Grayman et al, 2001; Rose & Grimes, 2001; Foran & Brosnan, 2000; Quist, 1999; Rogers & Gerlach, 1999). Most of these hours because of sample preparation requirements.

When algae blooms are detected at their earliest stages, the algae can be treated in the reservoir before they grow out of control, thus reducing taste and odor problems and saving on treatment costs. Several commercial continuous monitors are available that rely on an online fluorescence detector to measure chlorophyll a, the principle photosynthetic pigment in all algae. Some probes costing ~$5,000 combine these measurements with those for water clarity (turbidity) and oxygen to provide early warning of algal blooms. A more expensive and sophisticated system was used in Los Angeles, Calif., to detect algae in supply reservoirs and resulted in substantial cost savings for treatment chemicals (Morrow et al, 2000).

Biomonitors track pollutants through their effect on organisms. The sheer magnitude of the number of pollutants of concern and the inability to monitor many of them continuously or at all have led to the use of online biomonitors. Biomonitors measure the changes in the behavior or properties of living organisms resulting from stresses placed on them by the presence of toxic materials. Conceptually biomonitors are analogous to the canaries used by miners to detect the presence of toxic gases. Though biomonitors do not provide information on the specific contaminant or cause of the stress on organisms, they warn that something unusual in the water is affecting the organisms, thus warranting further investigation such as specific chemical analyses (Penders & Stoks, 1999). Some biomonitors respond rapidly to elevated concentrations of a wide range of toxic compounds, and some can also be used to assess low-level chronic contamination by persistent, bioaccumulative toxins (e.g., from xenoestrogens, biocides, pharmaceuticals, and pesticides).

Examples of biomonitors include the dynamic fish (Figures 5 and 6), mussel (Figure 7), and *Daphnia* or water flea (Figure 8) tests as well as delayed algal fluorescence and luminescent bacteria response. The dynamic tests involve measuring changes (typically via electronic means) in movement or physiological responses by an organism as it tries to avoid toxic chemicals in the water. Because different species respond to different chemicals to varying degrees, the simultaneous use of different types of bioalarms (including some from different trophic levels) is often recommended (Penders & Stoks, 1999; LAWA, 1998).

The generally preferred method seems to be the *Daphnia* monitors, especially the newer ones that use digital cameras and are capable of following the behavior of each daphnid. The newer mussel tests appear to be well-suited because of the large filtering capacity of the mussels, their sensitivity, and their longevity. The simpler bacterial tests using luminescent bacteria are promising methods to determine the toxicity of the river water. Likewise, the delayed fluorescence of algae can be measured relatively easily. Although algae and bacteria monitors are not currently in wide use, and more experience with these monitors is needed, neither of these facts should deter water suppliers from using them. A report of German field experiences rated the dynamic *Daphnia* test as the first priority for developing a bioalarm station, followed in order by fluorescent algae, bacteria tests, and mussel monitors (LAWA, 1998). Fish monitors were not recommended primarily because the sensitivity was problematic and not reproducible (e.g., problems were encountered with both false alarms and the systems not responding to pollution events) (LAWA, 1998).

Very few biomonitors are in use in the United States, but dozens are operating in Europe (LAWA, 1998). Practically every station with a biomonitor uses a *Daphnia* test, but some also use fish, mussels, algae, and bacteria to test the water with organisms from different trophic levels. Japan and Korea have installed several of these systems, and the numbers are currently expanding. In the United States, USEPA research laboratories in Cincinnati, Ohio, are investigating the effectiveness of biomonitors at different trophic levels (Haught, 2000), and *Daphnia* toximeters were used for assessing source water quality during the 2002 Winter Olympics in Salt Lake City, Utah (Yates et al, 2002).

Purchase costs for these systems typically range from about $10,000 to near $50,000 and up. The manual

TABLE 2 Specific ion electrodes used in monitoring raw water

Ion	Type	Range—*mg/L*	Interferences*
Ammonium	PVC† membrane	0.1–18,000	K
Bromide	Solid state	0.4–80,000	S, I, CN
Cadmium	Solid state	0.01–11,000	Ag, Hg, Cu, Pb, Fe
Calcium	PVC membrane	0.2–40,000	Pb, Hg, Cu, Ni
Chloride	Solid state	1.8–33,000	S, I, CN, Br, OH, NH_3
Copper	Solid state	0.0006–6,350	Ag, Hg, Cl, Br, Fe, Cd
Cyanide	Solid state	0.1–260	S, I, B, Cl
Fluoride	Solid state	0.02 to saturation	OH
Iodide	Solid state	0.006–127,000	S, CN, Br, Cl, NH_3
Lead	Solid state	0.2–20,700	Ag, Hg, Cu, Cd, Fe
Nitrate	PVC membrane	0.5–62,000	I, CN, BF_4
pH	PVC membrane	1–14 (pH units)	
Surfactant	PVC membrane	1–12,000	
Hardness	PVC membrane	0.4–40,000	Cu, Zn, Ni, Fe

*Ag—silver, B—boron, BF_4—tetrafluoroborate, Br—bromine, Cd—cadmium, Cl—chlorine, CN—cyanide, Cu—copper, Fe—iron, Hg—mercury, I—iodine, K—potassium, NH_3—ammonia, Ni—nickel, OH—hydroxide, Pb—lead, S—sulfur, Zn—zinc

TABLE 3 Summary of advanced early warning systems around the world

River	Country	Administration	Monitoring Program	Comments	Websites
Ohio River	United States	ORSANCO (Ohio River Valley Water Sanitation Commission)	Organics Detection System (15 gas chromatographs)	Federal–state commission working with water utilities	www.orsanco.org
Mississippi River	United States	Louisiana Department of Environmental Quality	8 gas chromatographs for organics detection	Cooperative effort among the state, water utilities, and industries	www.deq.state.la.us/surveillance/ewocds/index.htm
Rhine River	Germany, Holland, Switzerland	International Commission for the Protection of the Rhine	9 international stations plus 20 national monitoring stations	Multinational early warning system; extensive use of biomonitors.	www.iksr.org
River Trent	United Kingdom	Severn Trent Water	1 station at intake	Provides real time warnings and historical database	
River Dee	United Kingdom	Hyder Lab and Sciences	3 stations	Cooperative effort among three water companies and government	
River Tyne	United Kingdom	Northumbrian Water Group	2 stations	Wide range of advanced monitors	
Llobregat River	Spain	Grupas Aguas de Barcelona	10 stations	Extensive network of automated monitors	
River Seine	France	SEDIF (Syndicat des Eaux d'Ile-de-France)	Automatic monitoring stations and samplers serving three plants	Combines sophisticated treatment, monitors, and early warning system	
North Saskatchewan River	Canada	EPCOR Utilities Inc.	2 stations located at intakes	Includes online monitors for chemical dosing decisions	
St. Clair River	Canada	ORTECH Environmental Inc.	1 monitoring station	Effective system in industrialized area since 1987	
Yodo River	Japan	Yodo River Water Quality Consultative Committee	Monitors at intakes	Cooperative effort among 10 water companies; unique monitoring systems	
River Han (and other rivers)	Korea	National Institute of Environmental Research	20 stations on four rivers	Combination of standard and advanced instruments and biomonitors	www.nier.go.kr
Danube River	Parts of 17 European countries	International Commission for the Protection of the Danube River	Mostly conventional monitors	Primarily a network for sharing spill information; 11-nation commission	www.icpdr.org
Moselle River	France and Germany	International Commission for the Protection of the Moselle and the Saar	Several advanced monitoring stations with chemical and biomonitors	Primarily agricultural area with good water quality	www.iksms-cipms.org
Elbe River	Germany and Czech Republic	International Commission for the Protection of the Elbe	17 monitoring stations	Significant improvement in water quality since the reunification of Germany	www.arge-elbe.de www.bafg.de/html/ikse/ikse.htm

batch bacteria tests can be the least expensive in terms of capital costs. The algae, *Daphnia*, and mussel tests are fairly comparable in expense (~$20,000–$40,000) and cost less than fish monitor units (LAWA, 1998; Stoks, 1998). Operating costs are fairly low for all these methods (except the luminescent bacteria test) and primarily involve replacement organisms and electricity.

False-positive results can result from interferences from a variety of environmental factors other than contaminants (e.g., temperature changes or low oxygen). Data on the sensitivity and minimum detection limits of online biomonitors are relatively limited, and the methods demonstrate a relative lack of sensitivity for some chemicals of interest. Other drawbacks include the high cost for more sophisticated biomonitors and maintenance requirements for the living systems. The interpretation of the signals from biological monitors is also an important consideration; as this improves, the value of biomonitors will likely increase.

New monitoring methods emerge, research and development needs identified. Electronic noses and rapid bacterial methods have been identified as areas in which developments are taking place, and the use of these as early warning systems is likely to increase. Selected general research and development needs are summarized in the sidebar on page 64. Numerous research projects by the AWWA Research Foundation and the Water Environment Research Foundation are investigating rapid and online monitoring technologies. Generally speaking, however, many of the advances in monitoring technologies occur from research in other scientific fields (e.g., the food and beverage industry, analytical chemistry, the sensor industry, and the military); these advances include biosensor and biochip technology, fiber optics, genetically engineered organisms, immunoassays, and microelectronics. Research on rapid and online monitoring systems for a variety of contaminants is being conducted by a number of US government organizations including the USEPA (Panguluri et al, 1999; Rogers & Gerlach, 1999) and the US Army's Joint Service Agent Water Monitor program (ILSI, 1999).

SUCCESS OF EXISTING SYSTEMS MAY WIN NEW USERS

Case studies provide snapshots of monitoring applications. There are relatively few advanced early warning systems around the world that are extensive in size and scope, employ significant online state of the art monitoring equipment, and utilize monitoring, modeling, and communications in an integrated system to warn of contaminants in source water. Table 3 summarizes 15 prominent systems described by Grayman and colleagues (2001); taken together, these installations provide a fairly complete picture of the potential for early warning systems. Other research has documented case studies of online monitoring, some of which focus on early warning (AWWARF & CRS PROAQUA, 2002). These references include an evaluation of the successes and limitations of the systems.

There are both significant commonality and diversity among the systems. All of the systems depend on a combination of monitors, self-reporting, and/or public reporting. The monitoring systems used range from simple probes (e.g., pH, turbidity, conductivity) to advanced instruments such as GCs and UV monitors to biomonitors. Many of the systems employ mathematical models to predict arrival times for a spill at downstream intakes. In all cases, some form of institutional structure coordinates efforts and communicates information so that appropriate actions can be taken. The impetus for several of these systems and networks has been an unfortunate large spill or release of a toxic or hazardous chemical.

Systems vary in their degree of complexity (Table 3). For example, the system on the River Rhine has nine international monitoring stations and 20 national stations monitoring for numerous parameters, including general water quality parameters, organic carbon indicators, nutrients, inorganics and metals, organic compounds (pesticides and volatile organics), and radioactivity. Other systems may contain only a single monitoring station. Systems also vary in terms of the frequency of analysis and degree of automation. Many of the systems are highly automated, with both alarm signals and maintenance performed remotely. The more sophisticated networks include a coordinated monitoring, modeling, communication, and response program for an extended stretch of river.

With a few notable exceptions (e.g., the Ohio River and Lower Mississippi River), US experience with advanced early warning monitoring systems and networks is limited, and many US water suppliers have little or no early warning system in place. However, interest in early warning monitoring networks has increased in recent years, and such systems are currently being developed for the Upper Mississippi, Schuylkill, Delaware, Allegheny, Monongahela, and Susquehanna rivers (Gullick, 2003).

Future holds developments for early warning systems. A vision for the future of early warning monitoring systems would address the reduction of contamination events and a plan to mitigate the effects of unexpected discharges. Key elements would include (1) an active program for reducing the likelihood of the discharges, (2) an enforced set of regulations that strongly encourages self-reporting of any nonroutine discharges, (3) a monitoring system for detecting contaminants in the source waters, (4) a mathematical tool (model) for predicting the movement of a contaminant from its source to the water intakes, (5) a communications and organizational infrastructure for coordinating and disseminating information on the contaminant event, and (6) effective means for reducing the effects of the contaminant on the water system through intake closure, treatment, and use of raw or finished water storage or alternative sources.

This vision is looking brighter but has not yet been fulfilled. In some instances, early warning systems that include many of these elements have been implemented. However, most raw water sources continue to be vulnerable to contamination, and the water community still has far to go to safeguard water supplies. Ongoing research is expected to produce substantial advances in monitoring technologies in the near future.

ACKNOWLEDGMENT

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American Water, headquartered in Voorhees, N.J. The cooperation and assistance of participating American Water utility subsidiaries and other participating utilities are greatly appreciated, as are the comments and suggestions from Mark W. LeChevallier.

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FOOTNOTES

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APPENDIX C. COMMUNICATION PLAN

THRASHER

COMMUNICATION PLAN

FOR THE

BERKELEY SPRINGS WATER WORKS

MORGAN COUNTY, WEST VIRGINIA

PWSID No. WV3303301

JULY 2016

THRASHER PROJECT No. 101- 010-1046.805

COMMUNICATION PLAN
FOR THE
BERKELEY SPRINGS WATER WORKS
PWSID No. WV3301811

Prepared By:
Project Engineer

THE THRASHER GROUP, INC.

600 White Oaks Boulevard
Bridgeport, West Virginia 26330
www.thrashereng.com
Phone: 304-624-4108 Fax: 304-624-7831

Certified Operator: Terry Largent

Contact Phone Number: (304) 288-1102

Contact E-mail Address: water.town@hotmail.com

Plan Developed On: July 1,2016 Plan Update Due On: July 1, 2019

ACKNOWLEDGMENTS

This plan was developed by The Thrasher Group Inc. to meet certain requirements of the Source Water and Assessment Protection Program (SWAPP) and the Wellhead Protection Program (WHPP) for the State of West Virginia, as directed by the federal Safe Drinking Water Act (SDWA) and state laws and regulations.

THRASHER PROJECT No. 101-010-1046.805

- CONTENTS -

INTRODUCTION

Legislative Rule 64CSR3 requires public water systems to develop a Communication Plan that documents how public water suppliers, working with state and local emergency response agencies, shall notify state and local health agencies and the public in the event of a spill or contamination event that poses a potential threat to public health and safety. The plan must indicate how the public water supplier will provide updated information, with an initial notification to the public to occur no later than thirty minutes after the supplier becomes aware that the spill, release or potential contamination of the public water system poses a potential threat to public health and safety.

The public water system has responsibility to communicate to the public, as well as to state and local health agencies. This plan is intended to comply with the requirements of Legislative Rule 64CSR3, and other state and federal regulations.

TIERS REPORTING SYSTEM

This water system has elected to use the Tiered Incident or Event Reporting System (TIERS) for communicating with the public, agencies, the media, and other entities in the event of a spill or other incident that may threaten water quality. TIERS provides a multi-level notification framework, which escalates the communicated threat level commensurate with the drinking water system risks associated with a particular contamination incident or event. TIERS also includes a procedural flow chart illustrating key incident response communication functions and how they interface with overall event response / incident management actions. Finally, TIERS identifies the roles and responsibilities for key people involved in risk response, public notification, news media and other communication.

TIERS provides an easy-to-remember five-tiered **A-B-C-D-E** risk-based incident response communication format, as described below. **Table 1** also provides associated risk levels.

> **A = Announcement**. The water system is issuing an announcement to the public and public agencies about an incident or event that may pose a threat to water quality. Additional information will be provided as it becomes available. As always, if water system customers notice anything unusual about their water, they should contact the water system

> **B = Boil Water**. A boil water advisory has been issued by the water system. Customers may use the water for showering, bathing, and other non-potable uses, but should boil water used for drinking or cooking.

> **C = Cannot Drink**. The water system asks that users not drink or cook with the water at this time. Non- potable uses, such as showering, bathing, cleaning, and outdoor uses are not affected.

D = Do Not Use. An incident or event has occurred affecting nearly all uses of the water. Do not use the water for drinking, cooking, showering, bathing, cleaning, or other tasks where water can come in contact with your skin. Water can be used for flushing commodes and fire protection.

E = Emergency. Water cannot be used for any reason.

Table 1. Tier Categories

Tier	Tier Category	Risk Level	Tier Summary
A	**A**nnouncement	Low	The water system is issuing an announcement to the public and public agencies about an incident or event that could pose a threat to public health and safety. Additional information will be provided as it becomes available.
B	**B**oil Water Advisory	Moderate	Water system users are advised to boil any water to be used for drinking or cooking, due to possible microbial contamination. The system operator will notify users when the boil water advisory is lifted.
C	**C**annot Drink	High	System users should not drink or cook with the water until further notice. The water can still be used for showering, bathing, cleaning, and other tasks.
D	**D**o Not Use	Very High	The water should only be used for flushing commodes and fire protection until further notice. More information on this notice will be provided as soon as it is available.
E	**E**mergency	Extremely High	The water should not be used for any purpose until further notice. More information on this notice will be provided as soon as it is available.

COMMUNICATION TEAM

The Communication Team for the water system is listed in the table below, along with key roles. In the event of a spill or other incident that may affect water quality, the water system spokesperson will provide initial information, until the team assembles (if necessary) to provide follow-up communication.

Table 2. Water System Communication Team Members, Organizations, and Roles

Team Member Name	Organization	Phone	Email	Role
Codi Ford	Berkeley Springs Water Works	[redacted]	codi.ford@gmail.com	Primary Spokesperson
Scott Merki	Berkeley Springs Water Works		court@wvdsl.net	Secondary Spokesperson
Terry Largent	Berkeley Springs Water Works		Water.town@hotmail.com	Member
Jim Close	Berkeley Springs Water Works		N/A	Member

In the event of a spill, release, or other incident that may threaten water quality, members of the team who are available will coordinate with the management staff of the local water supplier to:

Collect information needed to investigate, analyze, and characterize the incident/event
Provide information to the management staff so they can decide how to respond
Assist the management staff in handling event response and communication duties
Coordinate fully and seamlessly with the management staff to ensure response effectiveness

COMMUNICATION TEAM DUTIES

The communication team will be responsible for working cooperatively with the management staff and state and local emergency response agencies to notify local health agencies and the public of the initial spill or contamination event. The team will also provide updated information related to any contamination or impairment of the source water supply or the system's drinking water supply.

According to Legislative Rule 64CSR3, the initial notification to the public will occur no later than thirty minutes after the public water system becomes aware that the spill, release or potential contamination of the public water system poses a potential threat to public health and safety.

As part of the group implementing the Source Water Protection Plan, team members are expected to be familiar with the plan, including incident/event response and communication tasks. Specifically, team members should:

Be knowledgeable on elements of the Source Water Plan and Communication Plan
Attend team meetings to ensure up-to-date knowledge of the system and its functions
Participate in periodic exercises that "game out" incident response and communication tasks
Help to educate local officials, the media, and others on source water protection
Cooperate with water supplier efforts to coordinate incident response communication
Be prepared to respond to requests for field investigations of reported incidents
Not speak on behalf of the water supplier unless designated as the system's spokesperson

The primary spokesperson will be responsible for speaking on behalf of the water system to local agencies, the public, and the news media. The spokesperson should work with the management staff and the team to ensure that all communication is clear, accurate, timely, and consistent. The spokesperson may authorize and/or direct others to issue news releases or other information that has been approved by the system's management staff. The spokesperson is expected to be on call immediately when an incident or event which may threaten water quality occurs. The spokesperson will perform the following tasks in the event of a spill, release, or other event that threatens water quality:

Announce which risk level (A, B, C, D, or E) will apply to the public notification
Issue news releases, updates, and other information regarding the incident/event
Use the news media, email, social media, and other appropriate information venues
Ensure that news releases are sent to local health agencies and the public
Respond to questions from the news media and others regarding the incident/event
Appear at news conferences and interviews to explain incident response, etc.

INCIDENT / EVENT COMMUNICATION PROCEDURE

The flow chart in this section illustrates how the water system will respond when it receives a report that a spill, release, or other contamination event may have occurred. Key elements of the flow chart are described below.

Communication during Threat Incidents

Upon initial notification of the incident/event, system managers and staff will collect information and verify the need for further investigation. If further investigation is warranted, and the initial facts support it, the water system spokesperson will issue a public communication statement consistent with the threat level. In addition, water system personnel and partners will be dispatched to conduct reconnaissance, a threat assessment, and a threat characterization, if present. This work may include:

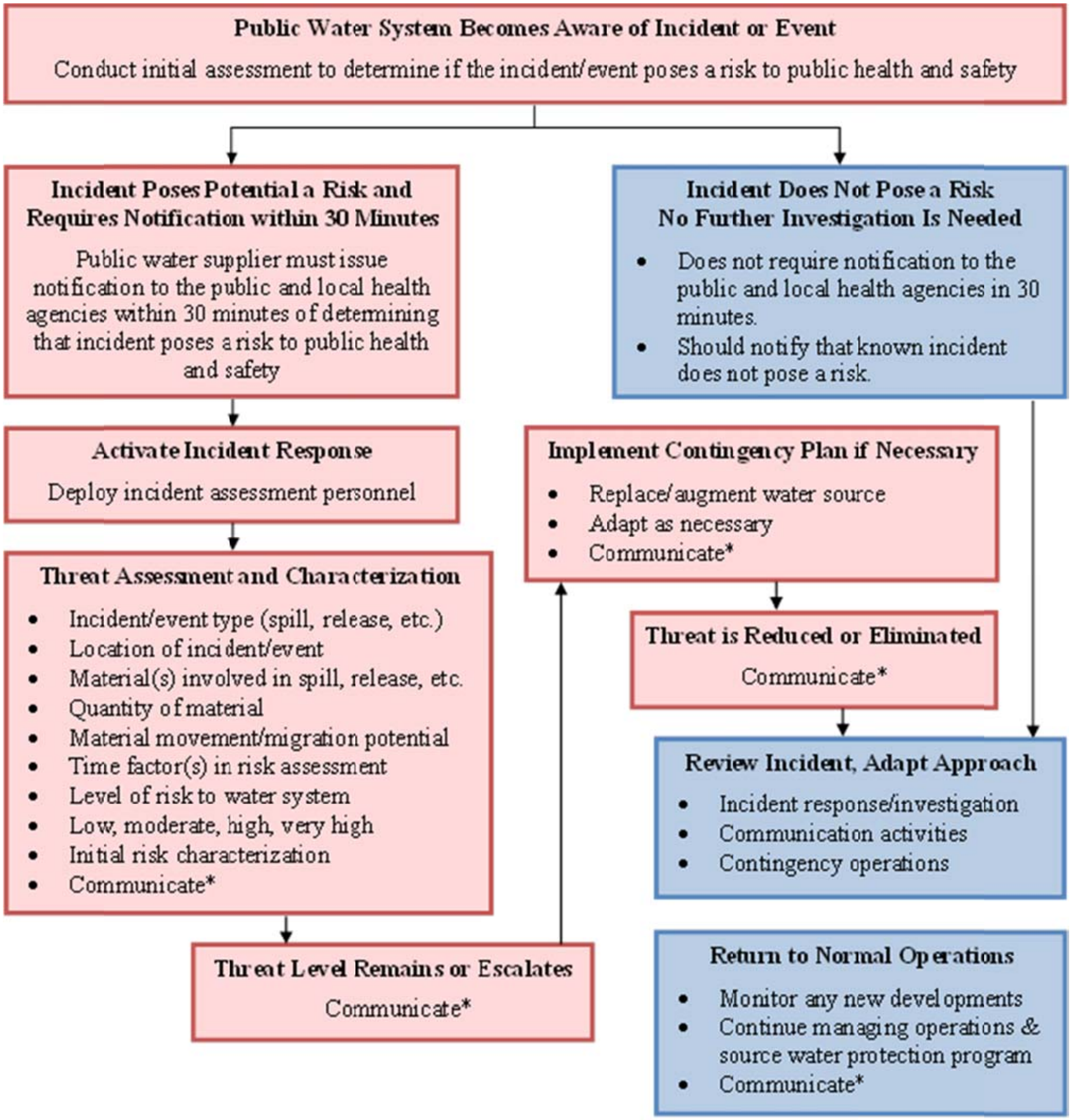
- Verification of the incident type
- Location of incident/event
- Quantity of material involved
- Relevant time factor(s) in the risk assessment
- Type of material(s) involved
- Potential of the material to move, migrate, or be transported
- Overall level of risk to water system
- Development of the initial risk characterization

As the flow chart indicates, several iterative cycles will occur after the initial threat assessment, including communication with local agencies and the public, further investigation of the incident, possible implementation of the water system's contingency plan, and eventual elimination of the threat and a return to normal operations. Communication activities during this period will include:

- The initial release (i.e., Announcement, Boil Water, Cannot Drink, Do Not Use, Emergency) sent to local health agencies, the public, and the news media within 30 minutes
- Notification of the local water system's source water protection and communication teams if warranted by initial findings regarding the spill, release, or incident
- Notification of the WV Bureau of Public Health as required
- Periodic information updates as incident response information is received
- Updates to the applicable A-B-C-D-E advisory tier, as necessary

After the threat level is reduced, and operations return to normal, the water system staff, the communication and source water protection teams, and their partners will conduct a post-event review and assessment. The purpose of the review is to examine the response to the incident, relevant communication activities, and overall outcomes. Plans and procedures may be updated, altered, or adapted based on lessons learned through this process.

TIERS FLOW CHART



Communicate*

Constant communication with local agencies, public, and the media is critical throughout the entire process. The initial notification should include all pertinent information, depending on the TIERS level. Regular information updates should be provided. The **A-B-C-D-E** TIERS should be updated and explained as necessary.

PRESS RELEASE ATTACHMENTS

UTILITY ISSUED NOTICE – LEVEL A

PUBLIC WATER SYSTEM ANNOUNCEMENT

A WATER SYSTEM INVESTIGATION IS UNDERWAY

On __________ at ___:____ AM/PM, the ____________________________ Water System began investigating an incident that may affect local water quality.

The incident involves the following situation at this location: ____ ____ ____.

There are no restrictions on water use at this time. As always, if water system customers notice anything unusual about their water – such as abnormal odors, colors, sheen, etc. – they should contact the water system at _____________________.

At this time there is no need for concern if you have consumed or used the water. Regular updates will be provided about this Announcement as water system staff continue their investigation. Again, there are no restrictions on water use at this time.

State Water System ID# __________________________ Date Distributed: ____________

UTILITY ISSUED NOTICE – LEVEL B
BOIL WATER ADVISORY
A BOIL WATER ADVISORY IS IN EFFECT

On __________ at ___:____ am/pm, a water problem occurred causing contamination of your water. The areas that are affected are as follows:

□ Entire Water System or □ Other: ____

____

CONDITIONS INDICATE THERE IS A HIGH PROBABILITY THAT YOUR WATER IS CONTAMINATED. TESTING HAS NOT OCCURRED TO CONFIRM OR DENY THE PRESENCE OF CONTAMINATION IN YOUR WATER.

What should I do?

DO NOT DRINK THE WATER WITHOUT BOILING IT FIRST. Bring all water to a boil, let it boil for one minute, and let it cool before using, or use bottled water. Boiled or bottled water should be used for drinking, making ice, brushing teeth, washing dishes, bathing, and food preparation **until further notice**. Boiling kills bacteria and other organisms in the water.

What happened?

The problem is related to ____

What is being done?

The water system is taking the following action: ________________________

____

What should a customer do if they have consumed or used the water?

____

We will inform you when you no longer need to boil your water. We anticipate resolving the problem within __________ hours/days. For more information, please contact ______________________ at _______________ or _____________________ at __________.

General guidelines on ways to lessen the health risk are available from the EPA Safe Drinking Water Hotline at 1 (800) 426-4791.

Please share this information others who use this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice was distributed by ____
State Water System ID# ___________________________ Date Distributed: ____________

UTILITY ISSUED NOTICE – LEVEL C
“CANNOT DRINK” WATER NOTIFICATION
A LEVEL C WATER ADVISORY IS IN EFFECT

On _________ at ___:____ am/pm, a water problem occurred causing contamination of your water. The areas that are affected are as follows:

□ Entire Water System or □ Other: ______________________________________

____

CONDITIONS INDICATE THERE IS A HIGH PROBABILITY THAT YOUR WATER IS CONTAMINATED. TESTING HAS NOT OCCURRED TO CONFIRM OR DENY THE PRESENCE OF CONTAMINATION IN YOUR WATER.

What should I do?

DO NOT DRINK THE WATER. You can’t drink the water, but you can use it for showering, bathing, toilet-flushing, and other non-potable purposes.

BOILING WILL NOT PURIFY THE WATER. Do not drink the water, even if it is boiled. The type of contamination suspected is not removed by boiling.

What happened?

The problem is related to ____

What is being done?

The water system is taking the following action: ______________________

____

What should a customer do if they have consumed or used the water?

____

We will inform you when the water is safe to drink. We anticipate resolving the problem within _________ hours/days. For more information – or to report unusual water conditions such as abnormal odors, colors, sheen, etc. – please contact _______________ at __________ or ___________________ at _________.

Please share this information others who use this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice was distributed by ____
State Water System ID# ________________________ Date Distributed: ___________

UTILITY ISSUED NOTICE – LEVEL D
“DO NOT USE” WATER NOTIFICATION
A LEVEL D WATER ADVISORY IS IN EFFECT

On _________ at ___:____ am/pm, a water problem occurred causing contamination of your water. The areas that are affected are as follows:

□ Entire Water System or □ Other: ______________________________________

____

CONDITIONS INDICATE THERE IS A HIGH PROBABILITY THAT YOUR WATER IS CONTAMINATED. TESTING HAS NOT OCCURRED TO CONFIRM OR DENY THE PRESENCE OF CONTAMINATION IN YOUR WATER.

What should I do?

> **DO NOT DRINK THE WATER.** The water is contaminated.
>
> **DO NOT SHOWER OR BATHE IN THE WATER.** You can’t use the water for drinking, showering, or bathing. It can be used for toilet flushing and firefighting.
>
> **BOILING WILL NOT PURIFY THE WATER.** Do not use the water, even if it is boiled. The type of contamination suspected is not removed by boiling.

What happened?

The problem is related to ____

What is being done?

> **The water system is taking the following action:** ______________________

What should a customer do if they have consumed or used the water?

> ____

We will inform you when the water is safe to drink. We anticipate resolving the problem within _________ hours/days. For more information – or to report unusual water conditions such as abnormal odors, colors, sheen, etc. – please contact _______________ at __________ or ___________________ at _________.

Please share this information others who use this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice was distributed by ____
State Water System ID# ________________________ Date Distributed: ___________

UTILITY ISSUED NOTICE – LEVEL E
EMERGENCY WATER NOTIFICATION
A LEVEL E WATER ADVISORY IS IN EFFECT

On _________ at ___:____ am/pm, a water problem occurred causing contamination of your water. The areas that are affected are as follows:

□ Entire Water System or □ Other: ____________________________________

____

CONDITIONS INDICATE THERE IS A HIGH PROBABILITY THAT YOUR WATER IS CONTAMINATED. TESTING HAS NOT OCCURRED TO CONFIRM OR DENY THE PRESENCE OF CONTAMINATION IN YOUR WATER.

What should I do?

DO NOT DRINK THE WATER. The water is contaminated.

DO NOT USE THE WATER FOR ANY PURPOSE! You can't use the water for drinking, showering, or bathing, or any other use – not even for toilet flushing.

BOILING WILL NOT PURIFY THE WATER. Do not use the water, even if it is boiled. The type of contamination suspected is not removed by boiling.

What happened?

The problem is related to ____

What is being done?

The water system is taking the following action: ________________________

What should a customer do if they have consumed or used the water?

____

We will inform you when the water is safe to drink. We anticipate resolving the problem within _________ hours/days. For more information – or to report unusual water conditions such as abnormal odors, colors, sheen, etc. – please contact _______________ at __________ or ___________________ at _________.

Please share this information others who use this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice was distributed by ____
State Water System ID# ________________________ Date Distributed: ___________

EMERGENCY INFORMATION FORMS

Emergency Communication Information

<table>
<tr><th></th><th colspan="2">Name</th><th colspan="2">Phone Number</th><th colspan="2">Email</th></tr>
<tr><th>Designated Spokesperson</th><td colspan="2">Codi Ford</td><td colspan="2" rowspan="2">[redacted]</td><td colspan="2">codi.ford@gmail.com</td></tr>
<tr><th>Alternate Spokesperson</th><td colspan="2">Scott Merki</td><td colspan="2">court@wvdsl.net</td></tr>
<tr><th>Designated Location to Disseminate Information to Media:</th><td colspan="6">Berkeley Springs Water Works
99 Wilkes Street, Berkeley Springs WV 25411</td></tr>
<tr><th rowspan="3">Methods of Contacting Affected Residents:</th><th>Word of mouth</th><td colspan="2">✓</td><th>Posted Notices</th><td colspan="2">✓</td></tr>
<tr><th>Door-to-door canvasing</th><td colspan="2"></td><th>Radio</th><td colspan="2">✓</td></tr>
<tr><th>Newspaper</th><td colspan="2">✓</td><th>Other</th><td colspan="2">Call System</td></tr>
</table>

<table>
<tr><th rowspan="4">Media Contacts</th><th>Name</th><th>Title</th><th>Phone Number</th><th>Email</th></tr>
<tr><td>Kate Shunney</td><td>Editor</td><td>304-258-1800</td><td>editor@morganmessenger.com</td></tr>
<tr><td>Hugh Breslin</td><td>General Manager</td><td>301-797-440</td><td>news@whag.com</td></tr>
<tr><td>Stacy Drake</td><td>Station Manager</td><td>304-258-1010</td><td>max929@mail.com</td></tr>
</table>

Emergency Services Contacts

	Name	Emergency Phone	Alternate Phone	Email
Local Police	Bath Police Dept.	911	(304) 258-1198	N/A
Local Fire Department	Berkeley Springs VFD	911	(304) 258-3191	N/A
Local Ambulance Service	Morgan County EMS	911	(304) 258-1348	N/A
Hazardous Material Response Service		911		N/A

Key Personnel

	Name	Title	Phone	Email
Key staff responsible for coordinating emergency response procedures?	Terry Largent	Chief Water Operator	[redacted]	Water.town@hotmail.com
Staff responsible for keeping confidential PSSC information and releasing to emergency responders:	Terry Largent	Chief Water Operator		Water.town@hotmail.com

Sensitive Populations

Other communities that are served by the utility:	None		
Major user/sensitive population notification:	**Name**	**Emergency Phone**	**Alternate Phone**
	Schools Kristen Tuttle	(304) 258-2430	ktuttle@k12.wv.us
EED District Office Contact:	**Name**	**Phone**	**Email**
	Bradley Reed	304-725-9453	bradley.r.reed@wv.gov
OEHS Readiness Coordinator	**Name**	**Phone**	**Email**
	Warren Von Dollen	304-356-4290(main) 304-550-5607(cell)	warren.r.vondollen@wv.gov

Downstream Water Contacts:	**System Name**	**Contact Name**	**Emergency Phone**	**Alternate Phone**
	Berkeley County PSWD	Steve DeRidder	[redacted]	
		Chris Thiel		

Are you planning on implementing the TIER system?	Yes

Emergency Response Information

Has the utility developed a detailed Emergency Response Plan in accordance with the Public Health Security Bioterrorism Preparedness and Response Pan Act of 2002 that covers the following areas?	Yes
When was the Emergency Response Plan developed or last updated?	October 2015

Emergency Contact Information

State Emergency Spill Notification

1-800-642-3074

Office of Emergency Services

http://www.wvdhsem.gov/ Charleston, WV- (304) 558-5380

WV Bureau for Public Health Office of Environmental Health Services (OEHS)

www.wvdhhr.org/oehs

Readiness Coordinator- Warren Von Dollen

Phone:	304-356-4290
Cell:	304-550-5607
e-mail:	warren.r.vondollen@wv.gov

Environmental Engineering Division Staff

Charleston, Central Office	(304) 558-2981
Beckley, District 1	(304) 256-6666
St. Albans, District 2	(304) 722-0611
Kearneysville, District 4	(304) 725-9453
Wheeling, District 5	(304) 238-1145
Fairmont, District 6	(304) 368-2530

National Response Center - Chemical, Oil, & Chemical/Biological Terrorism

1-800-424-8802

WV State Fire Marshal's Office

1-800-233-3473

West Virginia State Police

1-304-746-2100

WV Watch – Report Suspicious Activity

1-866-989-2824

DEP Distance Calculator

http://tagis.dep.wv.gov/pswicheck/

APPENDIX D. SINGLE SOURCE FEASIBILITY STUDY

Berkeley Springs currently has sufficient water storage capacity to continue service in the event the primary water source becomes contaminated.

1. **Backup Intake**

   The Berkeley Springs water treatment facility obtains water from springs at Berkeley Springs State Park. Warm Springs Run is the nearest alternative water source, flowing through Berkeley Springs State Park and into Berkeley Springs. The USGS Surface-Water Database reports instantaneous-data for Warm Springs Run from October 2011 to present. According to the data collected within that time, Warm Springs Run has a minimum mean daily discharge of 2.0 cubic feet per second (cfs), or 898 gpm. However, the minimum stream flow stream flow reported by the DEP database was only 0.101 cfs, or 45.3 gpm.

   The treatment facility requires a flow rate of at least 220 gpm to supply Berkeley Springs' average water demand. The minimum supply is satisfied by Warm Springs Run during normal conditions, but is not during low flow conditions. Due to the inconsistent stream flow characteristics, Warm Springs Run was not evaluated in the feasibility matrix.

   The Potomac River does maintain adequate flow to supply Berkeley Springs average water demand. The USGS Surface-Water Database records a minimum mean daily discharge of 164 cfs, or 73,608 gpm, satisfying the treatment requirements. Thus, the construction of a backup intake located on the Potomac River near the location shown on the map in **Appendix E** including 14,000 feet of 6" raw water line from the intake to the water treatment facility will be considered in the feasibility analysis.

2. **Interconnection**

   Berkeley Springs is not currently interconnected with another utility. The only water producing utility within reasonable proximity is Warm Springs PSD, located 11.4 miles south from the Berkeley Springs system at the Industrial Park on U.S. Route 522. Warm Springs PSD has a treatment capacity of 60,500 GPD and produces an average of 3,000 GPD. Berkeley Springs currently consumes an average of 316,900 GPD. If Berkeley Springs were to become fully reliant, the required production by Warm Springs PSD is calculated to be:

   $$3{,}000\ GPD + 316{,}900\ GPD = 319{,}900\ GPD$$

   Therefore, an interconnection with Warm Springs PSD could not support the average demand of Berkeley Springs and was not evaluated in the feasibility matrix.

3. Existing Water Storage

Berkeley Springs total water storage capacity is 1,106,000 gallons comprised of five (5) treated water storage tanks, and one (1) raw water storage tank. According to the most recent monthly operating reports provided by the utility, the water treatment facility produces an average of 316,900 GPD and the maximum quantity produced in the last year was 521,400 gallons.

Senate Bill 373 requires utilities to maintain a minimum system storage capacity equal to two (2) days of the system's maximum level of production experienced within the past year. The minimum required storage capacity for Berkeley Springs is calculated to be:

$$521{,}400 \; gallons \; per \; day \times 2 \; days = 1{,}042{,}800 \; gallons$$

Therefore, the system currently meets the minimum required system water storage capacity. Berkeley Springs' days of water storage is calculated to be:

$$\frac{1{,}106{,}000 \; gallons}{521{,}400 \; gallons \; per \; day} = 2.12 \; days$$

The use of existing treated water storage providing Berkeley Springs with approximately 2.12 days of water storage based on maximum production was analyzed in the feasibility matrix.

4. Additional Water Storage

In the event the utility wished to implement supplemental source water protection, additional water storage could be constructed. The WV BPH requires that all distribution tanks be controlled to provide an adequate turn-over of at least twenty percent (20%) of the total volume each 24 period, i.e., no more than five (5) days of treated water storage based on average production. The maximum treated water storage Berkeley Springs could retain is calculated to be:

$$316{,}900 \; gallons \; per \; day \times 5 \; days = 1{,}584{,}500 \; gallons$$

Therefore, the maximum additional treated water storage Berkeley Springs could construct is calculated to be:

$$1{,}584{,}500 \; gallons - 1{,}106{,}000 \; gallons = 478{,}500 \; gallons$$

The construction a 438,000 gallon water storage tank was evaluated in the feasibility matrix, allowing for a potential decrease in water production. The utility could also construct additional raw water storage without regard to the turn-over requirement.

Feasibility Matrix **Berkeley Springs Water Works** **PWSID#: WV 3303301** **Date: June 2016** **Completed By: Project Engineer - The Thrasher Group, Inc.**

Criteria	Question	Backup Intake	Feasibility	Interconnect	Feasibility	Existing Water Storage	Feasibility	Additional Water Storage	Feasibility	Other	Feasibility
Economic Criteria											
What is the total current budget year cost to operate and maintain the PWSU (current budget year)?		$511,920.00		$511,920.00		$511,920.00		$511,920.00		$511,920.00	
O and M Costs	Describe the major O&M cost requirements for the alternative?	Labor, power, materials for maintenance	2	Labor, power, materials for maintenance	–	No additional cost	3	Labor, materials for maintenance	3	N/A	
	What is the incremental cost ($/gal) to operate and maintain the alternative?	$0.00004	3	$0.00016	–	–	3	$0.00000	3		
	Cost comparison of the incremental O&M cost to the current budgeted costs (%)	0.00%	3	0.00%	–	–	3	0.00%	3		
O and M-Feasibility Score			***2.7***		***–***		***3.0***		***3.0***		***–***
Describe the capital improvements required to implement the alternative.		Construction of raw water pump station and intake line		N/A		N/A		Construction of a additional water storage			
Capital Costs	What is the total capital cost for the alternative?	$1,170,625.00	2	$0.00	–	$0.00	3	$638,875.00	1		
	What is the annualized capital cost to implement the alternative, including land and easement costs, convenience tap fees, etc. ($/gal)	$0.00011	3	$0.00000	–	–	3	$0.00006	3		
	Cost comparison of the alternatives annualized capital cost to the current budgeted costs (%)	0.00%	3	0.00%	–	–	3	0.00%	3		
Capital Cost-Feasibility Score			***2.7***		***–***		***3.0***		***2.3***		***–***
Technical Criteria											
Permitting	Provide a listing of the expected permits required and the permitting agencies involved in their approval.	WV DEP, WV DNR, ACOE, WV SHPO, US FWS, WV DOH and County Floodplain	2	N/A	–	N/A	3	WV DEP, WV DNR, ACOE, WV SHPO, US FWS, and County Floodplain	3		
	What is the timeframe for permit approval for each permit?	WV DEP (90 days), WV DNR (60 days), ACOE (90 days), WV SHPO (60 days), US FWS (60 days), WV DOH (90 days) and County Floodplain (90 days)	2	N/A	–	N/A	3	WV DEP (90 days), WV DNR (60 days), ACOE (90 days), WV SHPO (60 days), US FWS (60 days), and County Floodplain (90 days)	3		
	Describe the major requirements in obtaining the permits (environmental impact studies, public hearings, etc.)	Environmental impact studies, water sampling	1	N/A	–	N/A	3	Environmental impact studies	3		
	What is the likelihood of successfully obtaining the permits?	Good	2	N/A	–	N/A	3	Good	3		
	Does the implementation of the alternative require regulatory exceptions or variances?	No	3	N/A	–	N/A	3	No	3		
Permitting-Feasibility Score			***2.0***		***–***		***3.0***		***3.0***		***–***
Flexibility	Will the alternative be needed on a regular basis or only used intermittently?	Intermittently, but can be used permanently	3	N/A	–	Intermittently	2	Intermittently	2		
	How will implementing the alternative affect the PWSU's current method of treating and delivering potable water including meeting Safe Drinking Water Act regulations? (ex. In the case of storage, will the alternative increase the likelihood of disinfection byproducts?)	No impact	3	N/A	–	No impact	3	No impact	3		
Flexibility-Feasibility Score			***3.0***		***–***		***2.5***		***2.5***		***–***
Resilience	Will the alternative provide any advantages or disadvantages to meeting seasonal changes in demand?	Yes	3	N/A	–	No	3	No	3		
	How resistant will the alternative be to extreme weather conditions such as drought and flooding?	Drought may limit availability of water	2	N/A	–	Drought may limit availability of water	2	Drought may limit availability of water	2		
	Will the alternative be expandable to meet the growing needs of the service area?	Yes	3	N/A	–	Yes	2	Yes	2		
Resilience-Feasibility Score			***2.7***		***–***		***2.3***		***2.3***		***–***
Institutional Requirements	Identify any agreements or other legal instruments with governmental entities, private institutions or other PWSU required to implement the alternative.	None	3	N/A	–	N/A	3	None	3		
	Are any development/planning restrictions in place that can act as a barrier to the implementation of the alternative.	No	3	N/A	–	N/A	3	No	3		
	Identify potential land acquisitions and easements requirements.	Property acquisition for pump station and easements for waterline	1	N/A	–	N/A	3	None	3		
Institutional Requirements-Feasibility Score			***2.3***		***–***		***3.0***		***3.0***		***–***
Environmental Criteria											
Environmental Impacts	Identify any environmentally protected areas or habitats that might be impacted by the alternative.	None are known.	2	N/A	–	N/A	3	None	3		
Environmental Impacts-Feasibility Score			***2.0***		***–***		***3.0***		***3.0***		***–***
Aesthetic Impacts	Identify any visual or noise issues caused by the alternative that may affect local land uses?	Fencing and control panel for pump station	3	N/A	–	N/A	3	None	3		
	Identify any mitigation measures that will be required to address aesthetic impacts?	Clearance from Culture and History and Local Zoning Commission will be obtained	3	N/A	–	N/A	3	N/A	3		
Aesthetic Impacts-Feasibility Score			***3.0***		***–***		***3.0***		***3.0***		***–***
Stakeholder Issues	Identify the potential stakeholders affected by the alternative.	Water Customers	3	N/A	–	N/A	3	Water Customers	3		
	Identify the potential issues with stakeholders for and against the alternative.	Rate Increase may be needed to implement construction	1	N/A	–	N/A	3	Rate Increase may be needed to implement construction	2		
	Will stakeholder concerns represent a significant barrier to implementation (or assistance) of the alternative?	No	2	N/A	–	N/A	3	No	3		
Stakeholder Issues-Feasibility Score			***2.0***		***–***		***3.0***		***2.7***		***–***
Comments				There are no known utilities that can supply adequate capacity for the treatment facility.		Utilize existing water storage to intermittently continue service during an emergency.		Supplement existing water storage for additional source water protection.		A fifth alternative was not evaluated	

Feasibility Matrix **Berkeley Springs Water Works** **PWSID#: WV 3303301** **Date: June 2016** **Completed By: Project Engineer - The Thrasher Group, Inc.**

Alternative Strategy Description	Economic Criteria					Technical Criteria							Environmental Criteria						Final Score	Total Capital Cost	Comments
	Operation & Maintenance Costs	Capital Costs	**Total**	**Total %**	**Weighted Total**	Permitting	Flexibility	Resilience	Institutional Requirements	**Total**	**Total %**	**Weighted Total**	Environmental Impacts	Aesthetic Impacts	Stakeholder Issues	**Total**	**Total %**	**Weighted Total**			
Backup Intake	2.7	2.7	**5.3**	**88.9%**	**35.6%**	2.0	3.0	2.7	2.3	**10.0**	**83.3%**	**33.3%**	2.0	3.0	2.0	**7.0**	**77.8%**	**15.6%**	**84.4%**	**$1,170,625.00**	
Interconnect	–	–	**0.0**	**0.0%**	**0.0%**	–	–	–	–	**0.0**	**0.0%**	**0.0%**	–	–	–	**0.0**	**0.0%**	**0.0%**	**–**	**$0.00**	There are no known utilities that can supply adequate capacity for the treatment facility.
Existing Water Storage	3.0	3.0	**6.0**	**100.0%**	**40.0%**	3.0	2.5	2.3	3.0	**10.8**	**90.3%**	**36.1%**	3.0	3.0	3.0	**9.0**	**100.0%**	**20.0%**	**96.1%**	**$0.00**	Utilize existing water storage to intermittently continue service during an emergency.
Additional Water Storage	3.0	2.3	**5.3**	**88.9%**	**35.6%**	3.0	2.5	2.3	3.0	**10.8**	**90.3%**	**36.1%**	3.0	3.0	2.7	**8.7**	**96.3%**	**19.3%**	**90.9%**	**$638,875.00**	Supplement existing water storage for additional source water protection.
Other	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	A fifth alternative was not evaluated

Scoring:

0 - Not feasible. Criterion cannot be met by this alternative and removes the alternative from further consideration.
1 - Feasible but difficult. Criterion represents a significant barrier to successful implementation but does not eliminate it from consideration.
2 - Feasible. Criterion can be met by the alternative.
3 - Very Feasible. Criterion can be easily met by the alternative.

Matrix Explanation

The alternative analysis matrix evaluates the utility's ability to implement each of the additional sources outlined. Alternative sources are evaluated for economic, technical, and environmental feasibility. The matrix uses a zero (0) to three (3) rating system, with three (3) being very feasible and zero (0) being not feasible. Each category has sub questions to develop an average for the alternative. Once all areas are evaluated, a final feasibility score is given for each of the alternatives for use in determining which option will best suit the utility's needs.

Economic factors evaluated in the matrix include all information needed to fund the alternative source. The matrix considers the current utility budget available per the latest annual report, operation and maintenance costs for each alternative, and the capital cost needed to construct each alternative. Supporting documentation is included in **Appendix E** of the report, which provides a breakdown of costs for each alternative that are used as capital costs in the matrix. The economic feasibility of each alternative is compared on a cost per gallon ratio. This ratio is determined by dividing the capital cost of the improvements by the total number of gallons of water produced per year. An average of the economic feasibility factors is then calculated and entered into the overall feasibility matrix found in **Appendix D**.

Technical criteria evaluated include permitting, flexibility, institutional and resilience factors. Permitting costs are included in all supporting documentation for each alternative source. The permitting factors included the permits that would be needed to construct the alternative source for the utility. An additional environmental factor is the feasibly of obtaining each permit. Permits were rated from zero (0) to three (3) based on the difficulty of obtaining the permits for the project. Depending on the project area, some permits may be very difficult and costly to obtain. Flexibility factors evaluate the ability of the alternative to be used as a permanent source of water or if it can only be used on a temporary basis.. The intake and interconnections can be used as both temporary and permanent sources. The alternatives' ability to help the utility during seasonal or population increases is also evaluated in the resilience factors. The alternatives that can produce additional water were rated as very feasible (3). Additional criteria evaluated are easements and rights-of-ways that will need to be acquired to construct the alternative source. For interconnections and intakes rights-of-ways would be needed to lay the new water line. The feasibility of obtaining the rights-of-ways was evaluated. All technical criteria was averaged and entered into the feasibility summary in **Appendix D**.

Environmental aspects for each alternative include impacts, aesthetics and stakeholders. Environmental impacts included any areas in the proposed alternative source area that are protected. Areas that are protected would have a low feasibility because the impacts could be large if the project were constructed. Aesthetics factors include noise, visual impacts, and mitigation measures that could affect the project's feasibility. The aesthetic factors relate to the stakeholder factors. The stakeholders' portion of the environmental criteria involves the community and their acceptance of the new source alternative and the structures that will be constructed.