



COLORADO DEPARTMENT OF PUBLIC HEALTH AND ENVIRONMENT

SAFE DRINKING WATER PROGRAM

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**GUIDANCE ON USE OF MICROSCOPIC PARTICULATE
ANALYSIS FOR EVALUATION OF SURFACE WATER
TREATMENT PROCESSES**

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PURPOSE

Public water systems make extensive investments in physical, managerial, operational and quality assurance infrastructure to provide safe drinking water to their consumers. The results of a microscopic particulate analysis (MPA) can help indicate if these investments are producing the desired results. The purpose of this guidance is to help ensure that each MPA produces this benefit. It provides guidance on:

- MPA sampling,
- MPA test limitations,
- MPA test results interpretation, and
- Recommended plant actions if test results indicate low removal performance.

The intended audience includes water treatment plant operators, managers, and quality assurance staff, laboratory analysts, and staff of the Colorado Safe Drinking Water Program.

INTRODUCTION

The federal Safe Drinking Water Act, Colorado statutes and the Colorado Primary Drinking Water Regulations (CPDWR) require public water systems to control regulated contaminants in the drinking water provided to consumers. The regulated microbiological contaminants (i.e. disease-causing viruses, bacteria and protozoan cysts) are required to be controlled by the installation and proper operation of specified treatment techniques. The prescribed treatment techniques include removal and/or inactivation processes that must achieve specified performance requirements.

There is not one, generally available, real-time analysis that comprehensively measures a treatment plant's microbiological contaminant removal performance, but the MPA provides a useful tool for assessing such performance at a particular point in time. Absent a practical real-time tool, the next best approach to assess a treatment plant's removal performance would be to enumerate and compare the number of all regulated pathogenic (disease-causing) organisms in the untreated versus the filtered drinking water. This approach is not practical because the regulated organisms may only be present some of the time, are generally

Direct Measurement of Pathogen Removal Performance Is Impractical:

- *Pathogen Presence is Ephemeral*
- *Pathogens Often Present In Low Concentrations*
- *Pathogens Difficult To Isolate, Identify & Enumerate*

present in relatively low numbers and are almost always very difficult to enumerate.

As an alternative to direct identification and enumeration of regulated organisms, the MPA enumerates the number of organisms in each of 12 different categories of microbiological organisms that are most often present in untreated surface water. The MPA approach requires the enumeration procedure to be performed on a plant's untreated water and the results compared against results from a companion sample of its treated water.

These results may be interpreted in various ways, with two basic perspectives:

- Interpretation based upon reduction of the gross number microorganisms. Reduction of microorganisms is commonly described in terms of "log removal". Log removals of Cryptosporidium or Giardia are regulatory benchmarks, for example.
- Interpretation based upon the number and type of organisms found in the sample of treated water. This guidance provides a tool for interpretation called "the significance model".

The combination of these two perspectives provides valuable insight into the effectiveness of a treatment plant's microbiological removal process. Plants that remove a substantial level of these common microbiological organisms (as measured by log removal) and that do not show substantial numbers of certain types of organisms in the treated water (as measured by the significance model) are considered to be proficient at removing the regulated pathogenic organisms.

Under the authority of Article 1.6.2 CPDWR (11/30/2010, Reference 1) the Colorado Safe Drinking Water Program (Program) requires public water systems treating surface water or ground water under the direct influence of surface water (GWUDI) to periodically conduct the MPA. In accordance with Safe Drinking Water Program Policy 4 (Reference 2), the MPA results (among other factors) are used by Program staff to prioritize on-site plant evaluations termed sanitary surveys. Plants with MPA removal less than 3 log or having significance model

Microscopic Particulate Analysis (MPA)

- *Is A Surrogate For Direct Measurement of Pathogen Removal Performance*
- *Relies On Counting Common Microorganisms In Samples Of Treated and Untreated Water*
- *Removal Of Common Microorganisms Believed To Correlate Well With Removal Of Pathogens*
- *Poor Removal in Number and Specified Type May Indicate Increased Risk Of Illness From Pathogens And Is Cause For Investigation*

scores less than 3 may be identified for increased scrutiny during required sanitary surveys. Plants with the lowest MPA removals and the lowest significance model scores will be accorded the highest priority for increased scrutiny.

MICROSCOPIC PARTICULATE ANALYSIS - A VALUABLE TOOL

The MPA is a valuable tool to help regulators, plant operators and managers assess and respond to a plant's particulate removal performance. It provides a realistic indicator of a plant's ability to remove microbiological organisms of concern. Since it analyzes a sample of the plant's untreated (raw) water and its treated (filtered) water, it assesses the combined effectiveness of all of the plant's intervening unit processes including (if used) coagulation, flocculation, sedimentation and filtration. Additionally, when the water characteristics at the time of the test are observed and recorded along with treatment process operational parameters, evaluation of multiple MPA test results may be able to identify conditions that correlate with the best (or worst) removal performance.

The required routine MPA is expected to be conducted during normal operating conditions. However, a plant's operators are encouraged to arrange additional tests during periods of plant stress (maximum flow, cold water temperatures, low alkalinity, low influent particle count, etc.) to assess how the plant responds to such conditions. The results of these tests can provide a better understanding of circumstances likely to produce low microorganism removal levels. Armed with information about removal performance under routine or stressed conditions, plant staff can and should modify operational controls to address reduced performance before it leads to treatment failure and possible consumer illness.

MICROSCOPIC PARTICULATE ANALYSIS LIMITATIONS

While the MPA is a useful water treatment process evaluation tool, it needs to be applied and interpreted with some sophistication to be most useful. Evaluators must recognize and account for the test's limitations as addressed below.

MPA Assesses Performance at Only "One Point in Time"

The routine MPA is only required once annually by the Safe Drinking Water Program, because it is relatively expensive both in terms of its direct analytical cost and its indirect sample collection costs. Critics of this infrequent testing approach maintain that a "one point in time" measurement does not adequately describe current day plant performance and therefore, significantly decreases its value. More frequent MPAs would likely yield additional beneficial information and therefore plant staff are encouraged to arrange additional tests, especially during periods of plant stress. Nevertheless, each MPA result provides significant insight to a plant's microbiological removal performance, regardless of its relationship to the last or to the next test. This point in time result can be considered analogous to a living person's annual health screening using laboratory analysis of their blood. Just as a person's out of

range laboratory test result is cause for further investigation, so too is an MPA result that indicates low particulate removal or a low significance model score.

MPA Sampling Requires Attention to Detail

Many operators are unfamiliar with the somewhat complex sampling apparatus used to sample for MPA and if the samples are not properly collected, the test results will not provide meaningful information. Therefore, persons collecting MPA samples should take time to review the sampling protocol (Appendix II) and familiarize themselves with the sampling equipment prior to arriving at the sampling site.

The MPA procedure has detailed sampling directions that address the most common questions associated with properly sampling the raw and filtered water including: filter handling; sample preservation and shipping; sampling locations in plants that recycle solids; de-chlorinating water samples (if chlorine is present); and required sample collection data. These same directions shown in Appendix II of this guidance are also available from the laboratories that perform MPA tests.

Sometimes, in spite of diligent sampling, errors occur during required routine MPA testing that lead to apparent low particulate removal levels or low significance model scores. The MPA test interpretation algorithm, depicted in Figure 1, anticipates this possibility: it provides treatment plants one opportunity to resample and use the results of this second sampling event (in lieu of the original sample results) to meet the routine MPA analysis requirement if sampling or analytical error is suspected in the original sample.

Additionally, samplers should be aware of and prepare themselves to address the following sampling challenges:

- High concentrations of microbiological particulates in the untreated (raw) water - To get the best picture of routine operation, samples should be collected over a period of 12 to 24 hours. However, raw waters that have high levels of particulates may clog the sample filter before the desired sampling period is attained. A representative sample of raw water known to have high particulate counts can be obtained by lowering the usual recommended minimum sampling rate from one (1) to one half (0.5) gallons per minute;
- Sample start-time sequencing - To determine particulate removal effectiveness, two samples must be collected: one of the raw water entering the treatment plant, and one of this same water leaving the plant's filtration processes. Ideally to sample the same water, transit time through the plant should be accounted for by appropriately delaying collection of the filtered water sample. For plants where the time of travel through the plant is long, it may not be feasible to delay finished water sampling, as the maximum sample holding time of untreated water may then be exceeded. In such circumstances, the raw and finished water samples are started simultaneously. The results are considered suitable for comparison when other

variables (raw water quality including turbidity, number of filters in service, filter head loss, etc.) are known and have not experienced large changes over the period of the sampling.

Growth of Microorganisms in Treatment Plant Can Skew Results

Some water treatment plants achieve a high degree of microorganism removal, but simultaneously contribute certain non-pathogenic algae that grow in the plant's treatment process. These treatment plants may appear to provide poor microorganism removal performance based on unadjusted MPA results when, in fact, their good performance is obscured by the in-plant growth of non-pathogenic algae. The most common organisms associated with this phenomenon are *Chlorella* and *Dictyosphaerium minutum*. Plants that experience this situation, may request their analytical laboratory to quantify the numbers of these organisms found in the raw and filtered water samples and eliminate both counts from the log removal calculation, provided such adjustment is made by laboratory staff and noted on the laboratory report form along with the raw and filtered water counts for this organism. The MPA interpretation algorithm depicted in Figure 1 accounts for this adjustment.

Low Raw Water Microorganism Levels Make 3 Log Removal an Impractical Performance Assessment Criterion

Some Colorado public water systems have untreated surface sources that routinely contain so few microbiological organisms, that the raw to filtered water microorganism removal level is not, by itself, a meaningful performance assessment criterion. Nevertheless, MPA results can yield useful information about a plant's microbiological removal processes by also considering the "significance" of the microorganisms present in the treated sample. The significance model (Appendix V) provides insight in this regard. The significance model and a results interpretation flow chart that address this limitation are discussed in the section of this guidance titled: MPA Results Interpretation.

Accurate Analysis Requires Specialized Equipment and Techniques

The MPA test relies on use of specialized equipment and sophisticated laboratory techniques by properly trained analysts.

Laboratory analysis issues include:

- Sample concentration - Microorganisms are so widely dispersed in water, even in untreated water, that it is sometimes difficult to gather enough under a microscope to be quantified. To overcome this problem, microorganisms in water must be concentrated before analysis. This is accomplished by filtering a large volume of water, preferably over a significant time interval, under conditions that cause minimal damage to the microorganisms present. In the laboratory, analysts move the material trapped on the filter into a volume that is much smaller than the original volume filtered. This small volume is concentrated further using a centrifuge. At the conclusion of this process, the microorganisms present in gallons, or even hundreds of gallons,

are concentrated into a few milliliters for analysis. Properly conducting each step of the concentration process is crucial to obtaining meaningful results.

- Laboratory Certification - Though the MPA procedure is fully described in EPA Publication 910-R-96-001 (Reference 3), there is no formal third party laboratory certification procedure to ensure the laboratory performing the procedure has the appropriate equipment and sufficiently qualified analysts to properly perform the test. Since meaningful MPA results require sophisticated laboratory techniques, equipment and analysts, water systems are urged to ensure that the party that conducts their MPA meet the following minimum criteria:

Required Laboratory Equipment :

- Centrifuge, with swinging bucket rotors having a capacity of 15 to 250 mL or larger per conical tube or bottle.
- Microscope capable of bright field, phase contrast, differential interference contrast (DIC) or Hoffman modulation optics (HMO).
- Microscope should be equipped with at least 10, 40, and 100x objectives.
 - The 40x objective must have sufficiently long working distance to function with either a Palmer-Maloney or Sedgwick-Rafter counting chamber.
- Analysis must be conducted using either a Palmer-Maloney counting chamber, or Sedgwick-Rafter counting chamber.

Analyst Qualifications :

- Analyst should have academic background and/or experience in limnology, and freshwater biology totaling at least 2 years as well as an academic background and/or training in parasitology, protozoology, phycology, invertebrate zoology, microbiology and bacteriology.
- Analyst should have extensive light microscope experience with skills in brightfield, phase contrast and DIC or HMO microscopy.
- Analyst should have experience in examining a sufficiently large number of surface water MPA samples to become proficient. The laboratory should be able to provide written evidence that analysts have examined, under close supervision of a qualified analyst, at least 100 slides of samples collected over at least a one year period (i.e., having a wide diversity and concentration of organisms). Initial training includes examination of such slides in duplicate with the supervising analyst.
- Laboratories should be able to provide evidence that analysts maintain proficiency by conducting at least one MPA every calendar quarter.
- A working knowledge of conventional and direct treatment plants, slow and rapid sand filters, and alternative filtration methods is essential to providing adequate interpretation of the results and recommendations for controlling treatment plant conditions.

REPORTING MPA RESULTS

The proper interpretation of MPA results relies on having accurate information about a number of variables including: source water quality, sampling conditions, plant processes and laboratory findings. Thus, it is necessary that a number of important pieces of meta-data accompany the MPA analysis request and laboratory results. Some of this information must be recorded by the person collecting the sample, and some of it provided by the laboratory performing the analysis. Plants that desire to adjust results for growth of non-pathogenic algae must arrange for their analytical laboratory to make these adjustments and report them on the laboratory report form. The reporting form provided in Appendix III (and the accompanying form directions) provides an opportunity to record and transmit important meta-data and laboratory results. Its use is highly recommended.

MPA RESULTS INTERPRETATION

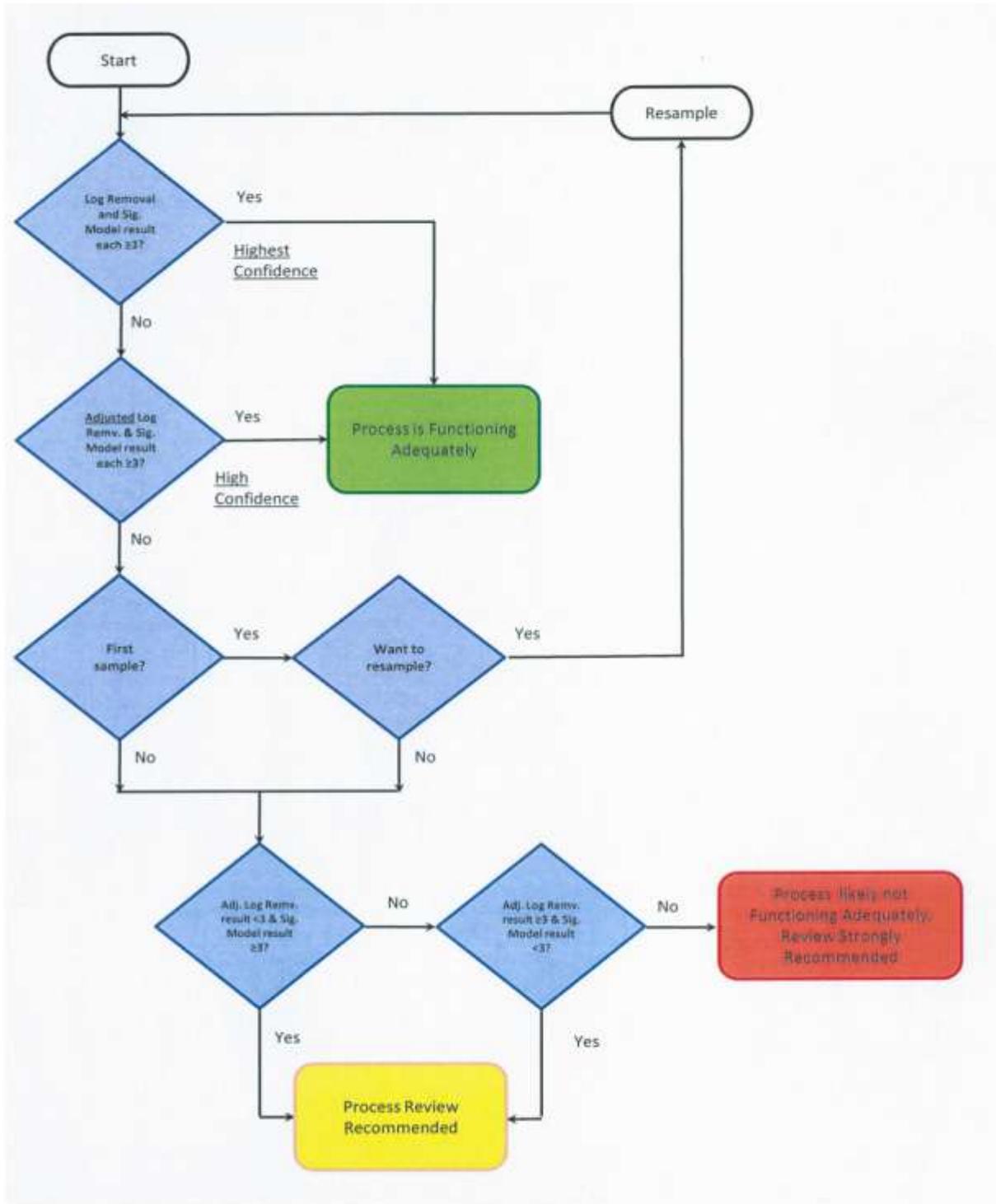
Figure 1 provides a summary of the MPA result interpretation

process. Tables 1-3, summarize the possible test outcomes and the rationale associated with each outcome including:

- Table 1 - adequate microorganism removal and good plant performance;
- Table 2 - possible inadequate removal with the possible need for treatment process assessment, and
- Table 3 - removal process is most likely not functioning adequately and operational practices should be reviewed.

The narrative discussion in the paragraphs following the tables provides additional information about MPA results interpretation and the relative confidence level associated with each MPA outcome.

Figure 1 - MPA Results Interpretation Summary



| Table 1 - MPA RESULTS INTERPRETATION SUMMARY – Adequate Removal | |
|--|--|
| MPA Outcomes Indicating Adequate Microorganism Removal | Rationale |
| 1. The difference in number of microbiological particulates in the untreated (raw) water MPA sample as compared to the treated (filtered) water sample shows there is at least a 99.9% (3 log) reduction and the Significance Model result is greater than 3. | Empirical data from plants and laboratories indicate high MPA removal levels (≥ 3 log) and high significance model score (≥ 3) are associated with non-detects for the regulated pathogenic cysts. |
| 2. The difference in number of microbiological particulates in the raw water sample as compared to the filtered water sample shows there is at least a 99.9% (3 log) reduction after excluding raw and filtered water <i>Chlorella sp.</i> or <i>Dictyosphaerium minutum</i> counts and the Significance Model result is greater than 3. (MPA log removal results where the count of these organisms is excluded from the raw and treated samples are referred to as “Adjusted” log removal results in Figure 1 and Tables 2 and 3). | Plants may have enough <i>Chlorella</i> (or other non-pathogenic algae recognized by the Program, such as <i>Dictyosphaerium minutum</i>) in the filtered water, to cause the log removal to drop below 3 log. If the utility has requested their laboratory enumerate these select organisms in their raw and filtered water samples, it is permissible to submit an adjusted log removal result that excludes the count for these specific organisms in both the raw and filtered water. This approach is justified through the knowledge that the plant is effectively removing particulates of a size comparable to pathogenic microorganisms despite growing non-pathogenic microorganisms in the treatment process. |

| Table 2 - MPA RESULTS INTERPRETATION SUMMARY – Possible Inadequate Removal | |
|--|--|
| MPA Outcomes Indicating Possible Inadequate Microorganism Removal | Rationale for Interpretation |
| Unadjusted or adjusted MPA result indicates ≥ 3 log reduction of microorganisms, but significance model score is less than 3. | The significance model provides low scores when elevated levels of undesirable microorganisms are present in the treated water sample. This situation would indicate that the treatment plant is removing significant levels of some microorganisms, but the process may not be sufficiently removing organisms or these undesirable organisms are growing someplace in the treatment train. Please refer to the detailed Table 2 narrative below. |
| Unadjusted or adjusted MPA result indicates < 3 log removal, but significance model score is ≥ 3 . | A significance model score of ≥ 3 generally indicates the absence of larger microorganisms associated with a poorly functioning removal process, but this outcome needs to be viewed in conjunction with additional information to gauge plant removal performance especially when low removal performance is not associated with in-plant growth of <i>Chlorella</i> . Please refer to the detailed Table 2 narrative below. |

| Table 3 - MPA RESULTS INTERPRETATION SUMMARY – Likely Inadequate Removal | |
|---|--|
| MPA Outcomes Indicating Likely Inadequate Microorganism Removal | Rationale for Interpretation |
| Unadjusted or adjusted MPA result indicates <3log removal, and significance model score is < 3. | The significance model provides low scores when elevated levels of undesirable microorganisms are present in the treated water sample. This situation would indicate both the presence of undesirable organisms and low levels of overall microorganism removal, This combination indicates that the treatment plant’s removal processes are likely not performing adequately and an immediate investigation is appropriate. |

Table 1 MPA Results – Highest Confidence of Adequate Plant Removal Performance

1. MPA results that demonstrate 99.9% or more (≥ 3 log) removal play to the strength of the MPA test and are accompanied by a high confidence that the plant is effectively removing microbiological organisms and is therefore effective at removing similar sized regulated pathogens such as *Giardia* and *Cryptosporidium*. An associated significance model score of 3 or more reinforces this confidence because organisms associated with poor removal are not present. So, a result indicating both high removal effectiveness and a high significance model score are accorded the highest confidence that the treatment process is effectively removing microbiological contaminants of concern.
2. MPA results that demonstrate 99.9% or more removal (≥ 3 log) after removing from count results certain non-pathogenic algae that grow in the treatment process (such as chlorella) provide the same degree of confidence as those that demonstrated 3 or more log removal without adjusting for such in-plant growth, and when accompanied by a significance model score of 3 or more provide a high level of confidence that the treatment process is effectively removing microbiological contaminants of concern.

Table 2 MPA Results – Removal and Significance Model Results Alone May Be Insufficient to Determine Plant Removal Performance

Table 2 results summarize conditions where the removal data and significance model diverge, that is, the results show good removal but low significance score, or low removal and a high significance score. This situation is the most difficult to interpret and warrants investigation of test results and treatment process effectiveness, unless historical data resulting from multiple past process investigations provide evidence that the plant is consistently effective at removing the microorganisms of concern.

High (≥ 3 Log) Removal, Low (<3) Significance Model Score

When MPA results show a high level of removal, but a low significance model score, it indicates good removal of some microorganisms, such as algae and diatoms, but a significant presence of other larger organisms. These larger organisms include ciliates, rotifers and nematodes. Their presence in the treated water sample could be interpreted in two ways:

- As an indication of poor removal performance, or
- A normal condition, independent of removal performance.

Poor removal performance is more likely the correct interpretation when the MPA results show a significant level of these same organisms in the untreated (raw) water sample. The plant's failure to effectively remove these larger organisms points to the possible existence of a pathway for the smaller pathogens to be present in the treated water. Under these conditions further investigation of other plant performance monitoring results is highly advised and pending the outcome of the investigation there should be decreased confidence in the plant's removal performance. For suggested parameters to review, refer to the section of this guidance titled: "Plant Response to Low Significance Model Scores or Microbiological Particulate Removal Levels".

A normal condition, independent of removal performance (with increased confidence in the plant's removal performance) is more likely the correct interpretation when there is evidence to show that the presence of these larger organisms is due to their growth in the treatment process, particularly within the filters themselves. This is common where the plant does not employ any pre-disinfection process upstream from the filters. Confidence in this interpretation can be increased by a review of other plant monitoring data that indicates effective removal performance. For suggested parameters to review, refer to the section of this guidance titled: "Plant Response to Low Significance Model Scores or Microbiological Particulate Removal Levels".

Low (≤ 3 Log) Removal, High (>3) Significance Model Score

It is possible for a plant to show low removal efficiency on the MPA test and yet be providing effective microbiological contaminant removal efficiency. This has been shown to occur when the concentration of microorganisms in the sample of untreated water is low. Some Colorado source waters are sometimes so low in microorganisms, that it is virtually impossible for their treatment processes to provide 3 log reduction. If these plants consistently have high significance model results, coupled to other evidence that the plant is operating effectively, confidence can increase in the plant's ability to effectively remove microorganisms of concern, even though the removal level is low. So, significance model scores of 3 or above where the raw water microbiological organism count is low (\leq about 1,000,000/100L) are worthy of more confidence in a plant's effective removal performance than the same significance model score where the raw water microbiological organism count is higher (\geq about 1,000,000/100L). Confidence in a plant's removal effectiveness can be further increased by having additional evidence of good removal performance such as low treated water particle counts or turbidity, and positive Comprehensive Performance Evaluation (CPE) results during periods of low MPA removal.

Where the untreated sample has normal or high levels of microorganisms, and MPA results indicate a low log removal, but a high significance model score, it indicates the microorganisms such as algae and diatoms are not being removed and larger microorganisms (ciliates, rotifers, nematodes) are either

being removed or were not present in the untreated source. A possible reason for this outcome is in-plant growth of algae such as *Chlorella*. If this cause has been ruled out or accounted for by adjusted raw and finished water counts, this MPA test outcome warrants further investigation including an operational review to determine the reasons for the low microorganisms log removal level. If review of the MPA results from the untreated sample indicates a similar absence of the larger microorganisms as found in the treated sample results, the importance of a thorough treatment process evaluation is heightened and confidence in the plant’s ability to effectively remove particulates should decrease.

Table 3 MPA Results – Plant Removal Performance Most Likely Inadequate

An MPA result that indicates less than 3 log removal, combined with a significance model score less than 3 indicates the presence of microorganisms at concentrations usually associated with ineffective treatment processes for microbiological particulate matter and strongly indicates an impaired ability to remove microbiological organisms. There should be significantly decreased confidence in the ability of plants with these results to adequately remove the regulated pathogenic microorganisms in the event that they are present in the untreated (raw) source water. The relative confidence of each possible scenario that may exist is summarized in Table 4.

| Table 4 – MPA & Significance Model Results Interpretation Summary | | | |
|---|------------------------|---------------------------|---|
| CONDITIONS | | | RELATIVE CONFIDENCE OF HIGH PLANT REMOVAL |
| MPA LOG REMOVAL | MPA RAW PARTICLE COUNT | SIGNIFICANCE MODEL RESULT | |
| ≥3Log (with or without algae adjustment) | High (>10k/L) | ≥3 | Highest |
| <3 Log | Low (<10k/L) | ≥3 | High ¹ |
| <3 Log | High (>10k/L) | ≥3 | Uncertain ² |
| ≥ 3 Log | High (>10k/L) | <3 | Uncertain ³ |
| <3 Log | Low | <3 | Lower ⁴ |
| <3 Log | High | <3 | Lowest ⁵ |

¹ If accompanied by other evidence that supports high removal effectiveness of the treatment process

² Review Other Treatment Process Monitoring Data to Determine if Operational Review Warranted

³ Review Other Treatment Process Monitoring Data to Determine if Operational Review Warranted

⁴ Treatment Process Operational Review Warranted

⁵ Immediate Treatment Process Operational Review Imperative

OPPORTUNITY TO RESAMPLE

When required to perform and report routine MPA analyses (generally an annual requirement), plants may conduct and submit the results of one MPA re-test (in lieu of the original result) for one of the following reasons:

- They have determined their original routine MPA sampling event or analytical procedure was defective, or
- The original MPA analysis request did not authorize the laboratory to adjust the log removal determination to account for in-plant growth of *Chlorella* and sample results indicate this is a likely cause of poor removal results.

The MPA re-sampling event and re-analysis must immediately follow the plant's receipt of evidence of sampling or analytical error. This "no penalty" opportunity to resample is justified since detailed knowledge of the sampling apparatus and analysis procedure is required and overlooking any one detail may cause an error that should not be associated with the removal performance of the plant.

To indicate adequate particulate removal performance, the repeat MPA result must achieve one of the outcomes described in Table 1 above.

PLANT RESPONSE TO LOW SIGNIFICANCE MODEL SCORES OR MICROBIOLOGICAL PARTICULATE REMOVAL LEVELS

It is anticipated that most filtration plants will achieve at least a 3 log reduction of microbiological organisms as measured by a MPA of raw and filtered drinking water unless their raw water is very low in microbiological organisms, as previously discussed. Plants not achieving at least a 3 log reduction and a significance model rating of 3 or greater, should first review their MPA sampling and analytical protocols: if deficiencies in either are identified, they should resample. If no sampling or analytical discrepancies are identified or if the repeat sample shows low particulate reduction level or a significance model score of less than 3, the plant staff should review all other process monitoring results. Parameters to review should include: particle counts and turbidity spikes, filter turbidity profiles, excursions in flow rate, correlations or the lack of such with solids recycle flows or variations in other parameters linked to removal performance (e.g., temperature, pH, alkalinity) during the MPA sampling period. Minus strong evidence from these other monitoring efforts that contradict the MPA findings, the operational practices and condition of each of the plant's particulate removal unit processes should be reviewed. This would include: coagulation, flocculation, sedimentation, and filtration unit processes. After any actions intended to improve microbiological removal performance are instituted, additional MPA testing is recommended to verify that the actions taken are resulting in improved microbiological particulate removal performance.

The operational practices of a treatment plant that does not demonstrate effective microbiological particulate removal are subject to additional scrutiny by the Safe Drinking Water program during, or advanced scheduling of a plant's required sanitary survey.

It is beyond the scope of this document to provide detailed treatment process operational guidance. However, a succinct list of the minimum elements to be reviewed in response to low MPA performance is provided in Appendix VI. Detailed information on proper treatment plant operations is provided in References 5, 6 and 8. Additional process design and operational information is available from the American Water Works Association (<http://www.awwa.org>).

Plants With Low MPA Removal (<3 Log) and Low MPA Significance Model Score (<3):

- *Are At Increased Risk Of Passing Pathogens If Their Raw Water Quality Is Challenged*
- *Should Review:*
 - *Their Other Process Control Monitoring Results*
 - *Their Operational Practices Especially With Respect To Coagulation, Flocculation, Sedimentation & Filtration*
- *May Be Accorded Higher Priority For Safe Drinking Water Program On-Site Review*

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9. Colorado Department of Public Health and Environment, Water Quality Control Commission, Water and Wastewater Facility Operators Certification Requirements, Regulation No. 100, 5 CCR 1003-2, June 30, 2012.

APPENDIX I – Use of MPA Results by the Colorado Safe Drinking Water Program – Historical Perspective

The Colorado Safe Drinking Water Program has required filtration and disinfection of surface water sources by public water systems since 1977, predating EPA surface water treatment requirements by over a decade. The results of MPA tests have been used by the Department since 1978 to assess particulate removal effectiveness and to identify surface water treatment plants that may be at increased risk of disease outbreaks by allowing significant passage of *Giardia Lamblia* cysts. From the time that Colorado’s Safe Drinking Water Program was approved by EPA to implement the national surface water treatment rule in 1994, until publication of Policy 4 (Reference 2) in 2010, the Program relied on MPA test results as one major consideration in determining water treatment plant compliance with the Rule’s total removal and/or inactivation performance requirements for *Giardia Lamblia*. Under this approach, unique to Colorado, compliance with the total removal/inactivation requirement was largely determined by summing a plant’s actual removal performance as determined by MPA test results and its inactivation level. The inactivation level achieved by treatment plants was assumed to be 0.5 log inactivation of *Giardia Lamblia* and 4 log inactivation of viruses, if the plant provided a free chlorine residual of 0.2 mg/L and a 30 minute detention time prior to the first customer. Plants not achieving the required levels of removal were considered for an on-site comprehensive performance evaluation (CPE) and their compliance status determined by weighing plant configuration and location, MPA removal, turbidity monitoring and CPE results. This approach for determining removal credit was retained as the Rule was updated over ensuing years and later revised to include control of *Cryptosporidium*.

Colorado Safe Drinking Water Program Policy 4 was published in October of 2010, and revised how MPA test results are used by the Program. In lieu of using MPA test results to determine removal credit as part of a direct compliance determination, MPA results are used to identify plants that may benefit from a more detailed or more immediate on-site evaluation of their treatment practices. Under this approach, detailed in Policy 4, the Colorado Safe Drinking Water Program is more aligned with the national approach to implementing the Surface Water Treatment Rule and its enhancements. Accordingly, in assessing regulatory compliance, properly operated treatment plants are accorded EPA-developed table value removal credit for the regulated microbial contaminants. Treatment plants must then demonstrate that inactivation required to meet the total performance requirements (i.e., removal and inactivation) is achieved by using plant-specific operational data and EPA-provided inactivation tables. Additionally, Policy 4 specifies that MPA test results be used by the Colorado Safe Drinking Water Program to “help assess treatment system microbiological contaminant removal effectiveness” and the assessment be used to help prioritize scheduling of the treatment element of required sanitary surveys. This approach will focus limited resources on those treatment plants that are most likely to benefit from a more detailed operational review.

EPA-developed table value removal credits for properly operated plants range from 2 to 2.5 log for *Giardia Lamblia* and from 2.5 to 3 log removal for *Cryptosporidium*, based on the type of treatment process in use (excluding membranes). Since MPA removal performance is believed to correlate with *Giardia* and *Cryptosporidium* removal performance, plants achieving MPA results indicating 2.5 log removal would not be expected to have any significant deficiencies in their particulate removal treatment operations. To be conservative, the Colorado Safe Drinking Water Program selected less than 3 log removal as one factor to be considered (among others including compliance history, enforcement status, recent acute situations, prior sanitary survey results, system overdue for a survey or never surveyed) to make plants eligible for more detailed or earlier scheduling of routine, required on-site plant review activities (sanitary surveys). It is not expected (although it is still possible) that plants that provide MPA removal of ≥ 3 log and significance model scores of ≥ 3 would have any significant operational deficiencies in their particulate removal treatment train. As a plant's MPA removal level and significance model score decline, the odds increase that treatment deficiencies exist. Accordingly, plant MPA test results will be arrayed and those with the lowest MPA and significance model scores will be the highest priority for increased on-site scrutiny and allocation of limited Program staff and resources for this prioritization factor.

APPENDIX II – Sampling Procedures For Microscopic Particulate Analysis (MPA) For Surface Water (And GWUDI) Treatment Plants

1.0 Sample Device and Materials (Some analytical laboratories will provide the required sampling equipment upon request and payment of an additional fee)

1.1 The MPA Sampling device consists of the following parts (refer to Appendix II, Figures 1 and 2, below)

- 1.1.1 Inlet hose, preferably disposable,
- 1.1.2 Backflow preventer (Watts No. 8) or equivalent (not generally used for raw water samples or for finished water samples where the effluent line of the sample kit is provided with an air gap discharge to the waste sewer).
- 1.1.3 Pressure regulator (Watts 26A), or equivalent,
- 1.1.4 Pressure gauge, 0-100 psi.
- 1.1.5 Proportioning injector (See Figure 2 for sampling sources that have been chlorinated), Model 203 B. T. injector, 100-15P-87, or equivalent (Dema Engineering).
- 1.1.6 For sampling chlorinated sources and using proportioning injector, an additional pressure gauge (see Figure 2).
- 1.1.7 Commercial filter model LT-10 filter housing (if using polypropylene yarn-wound filter; not necessary for samples using Envirochek HV filter).
- 1.1.8 One (1) micron nominal porosity filter.
- 1.1.9 Water flow meter, readable in gallons or liters.
- 1.1.10 Flow control valve (limiting flow orifice) rated at 1.0 gallon per minute (gpm) for finished water or low turbidity raw waters, 0.5 to 1.0 gpm for most raw water sources. (Rationale for this modification is to allow collection for a longer period prior to plugging of the filter in higher turbidity raw waters).
- 1.1.11 Effluent discharge hose.
- 1.1.12 Pump, for use with non-pressurized sources to be sampled. NOTE: The sample pump, if required, is usually and preferentially configured to supply a pressurized sample to the influent side of the sampling train. In instances where this is not possible, the sample may be drawn through the sampling apparatus by connecting the vacuum side of the pump to the sample effluent line.
- 1.1.13 Miscellaneous brass, or PVC, fittings for unit assembly.
- 1.1.14 Optional pitot tube installed at sampling port is recommended to reduce problems caused by flow dynamics in the pipe.

1.2 Sampling Materials

Criteria for MPA Filter Selection

Polypropylene yarn-wound

- Not Desired to enumerate *Giardia* or *Cryptosporidium*
- Raw water has relatively high particle counts
- Desire to minimize filter costs

Envirochek HV

- Low raw water particle counts (filter plugs easily)
- Desire to enumerate *Giardia* or *Cryptosporidium*
- Extra filter cost reduces lab elution cost or sampler set up time
- Sampler is satisfied that requisite reduced sampling time will be sufficient to capture sample representative of all normal plant operations such as filter backwash and solids recycling

- 1.2.1 Ten inch, 1 micrometer (μm) nominal porosity, polypropylene, yarn-wound, cartridge filter, Commercial Honeycomb filter tube (M39R10A) or Envirochek HV Sampling Capsule (Pall Corporation 12099). See text box for criteria for selecting filter type. Be sure to coordinate with your laboratory to ensure they have capacity to process the type of filter selected and for advice on which filter may be most appropriate for your needs.
- 1.2.2 Whirl pak plastic bags (5" x 14") or zip loc heavy duty quality freezer bags.
- 1.2.3 Sanitary latex gloves.
- 1.2.4 Two (2) % stock sodium thiosulfate solution (for samples with chlorine residual) in sanitary container with weighted feed tube.

2.0 **Sample Collection Parameters**

Note: Instructions below are for typical surface water treatment systems. Atypical, systems may require alteration of these instructions to provide accurate results. Any deviations from these procedures should be clearly indicated on the Microscopic Particulate Analysis (MPA) Form: Analysis and Utility Report (referred to as the Analysis Request Form) sent to the laboratory and also submitted to CDPHE along with the sample analysis results in the event the laboratory does not report results directly to CDPHE.

- 2.1 **Untreated (Raw) water** - Raw surface water should be sampled prior to chemical addition and after any pre-sedimentation basins (if no chemicals were added prior to pre-sedimentation). The main objective in raw water sampling is to collect a sample representative of the water entering the treatment system; therefore, if recycling operations are practiced, the raw water should be sampled downstream from the recycling input. Such sampling should allow for adequate mixing of the recycled flow prior to sampling. Temporally, the raw water sample should be initiated before the finished water sampling, the time differential being equivalent to the expected detention time through the treatment processes between sampling locations. The collection sites should be selected to avoid stratification of the water to be sampled both in the conveyance pipes of the treatment plant and in the sample collection equipment.
- 2.2 **Filtered water** - The sample of filtered water should be obtained after filtration, prior to chlorine addition, and prior to any post treatment storage, if possible. If it is not possible to collect the finished water sample prior to disinfection, sodium thiosulfate (final concentration 50 mg/l) for de-chlorination should be injected into the sample as it is collected (if this is not possible, follow instructions in sidebar, Appendix II, section 3.6). Samples collected downstream from post treatment storage may be more difficult to analyze, given the propensity for algal growth in these circumstances. Ideally, the time elapsed between the beginning of raw sampling and the beginning of filtered water sampling should be equivalent to the estimated detention time of the system between sampling locations based on the flow rate anticipated at the treatment plant during the sampling period. The filtered water sample is normally collected in the combined filter effluent pipe prior to disinfection. Plants that desire to sample their worst-case removal performance may want to collect their finished water sample in the effluent line of their worst performing filter as determined by turbidity filter profile, particle count profile, or other filter performance test. Results

from the worst performing filter that show good microbiological removal efficiency should increase confidence that the remaining filters are performing well.

2.3 **Treatment plant conditions during MPA sampling** - Given that the test is designed to provide information about the plant's normal, every-day treatment performance, it is necessary to operate the plant during the test in the same manner as it is operated during periods when the plant is not being tested. To accurately assess treatment efficiency, filtered water sampling should be designed to encompass a full treatment cycle run or a minimum 24-hour sampling (recognizing that test filter plugging may be limiting in some circumstances), including at least one backwash cycle during the sampling period. If a plant has multiple filters, backwashes and filter return to service should be performed on the same schedule that would be employed were a MPA test not in progress, but the test should be scheduled to include at least one backwash cycle. Similarly, plants that recycle filter backwash water or other process streams should ensure that the usual practices are implemented during the MPA test period which should be scheduled to include a typical recycle event. The sampler's signature on the Analysis Request Form is interpreted by the Colorado Safe Drinking Water Program as certification by the sampler that the conditions at the time of the sampling were representative of normal operating conditions.

2.4 **Sample Collector Qualifications** - Samples collected to meet the routine monitoring requirements of the Colorado Department of Public Health and Environment should be collected by the Operator in Responsible Charge as defined by Regulation 100 (Reference 9), a party authorized by the Operator in Responsible Charge or the plant's management-authorized process, compliance monitoring or quality assurance organization.

2.5 **Sample Apparatus Preparation and Handling** - Do not touch the polywound filter with bare hands; use sanitary latex gloves or the plastic cover the filter is wrapped in. Before each sample is collected, the hose and filter housing should be washed with hot water containing a mild detergent and bleach solution; rinse with hot water followed by particle free water (deionized, distilled or reverse osmosis water, passed through a 0.22 um filter and containing less than 100 particles/ml (2um or larger). If this cannot be done, run a minimum of 50 gallons of sample water through the sampling equipment prior to inserting a new filter. While the wash and rinse method is preferred, sometimes field conditions warrant field preparation by rinsing with sample water as described above. There is no requirement to notify the Department or the laboratory if the field procedure is used.

3.0 **Sample Collection Procedure**

3.1 **Source water measurements**

3.1.1 Run sample tap to clear in-line debris and allow turbidity to become uniform (at least for 2-3 minutes).

3.1.2 Measure and record turbidity, temperature and pH of sample source (optional but preferred) on Analysis Request Form.

3.2 **Flush equipment**

3.2.1 Assemble clean sampling apparatus as shown in Figures 1 or 2; **however, do not install filter or limiting flow orifice yet.**

- 3.2.2 Use the additional equipment (Appendix II, Figure 2) if sampling chlorinated water.
- 3.2.3 Ensure proper flow direction by checking arrows on meter and in/out indications on pressure regulator and filter housing.
- 3.2.4 Flush sampling apparatus with the water being sampled for 3-5 minutes. Allow water to flow through entire sampling apparatus (except for filter and limiting flow orifice).
- 3.3 **Adjust pressure**
 - 3.3.1 Attach the limiting flow orifice.
 - 3.3.2 Use pressure regulator to adjust water pressure to **10 psi** for unchlorinated samples (**25 psi** in the first gauge for samples requiring dechlorination).
 - 3.3.3 If sampling a chlorinated source, follow directions at 3.6 below.
- 3.4 **Install filter**
 - 3.4.1 Turn off water, open and drain filter housing.
 - 3.4.2 Put on new latex gloves.
 - 3.4.3 Open filter packaging and aseptically place filter into filter housing.
 - 3.4.4 Reassemble filter housing.
- 3.5 **Begin Sampling (See Paragraph 4 Below for Sample Volume)**
 - 3.5.1 Record date, time and initial meter reading.
 - 3.5.2 Turn water on slowly with unit in upright position.
 - 3.5.3 Invert unit to expel all air from filter housing. When housing is full of water, return to upright position.
 - 3.5.4 Increase water flow to no more than one gpm (0.5 gpm for raw waters with higher turbidity levels) and maintain this rate for entire sampling period (limiting flow orifice will prevent flow over 1 gpm (3.785 L/min)).
 - 3.5.5 Monitor pressure gauge: 10 psi maximum for unchlorinated samples (25 psi (read from the first gauge) for samples requiring dechlorination).
- 3.6 **Additional Instructions for Sampling Chlorinated Sources**
 - 3.6.1 Prepare 2% Sodium Thiosulfate Solution (make prior to sampling): Dissolve 3.14 grams sodium thiosulfate pentahydrate per 100 mL distilled water or sample water in a large sanitary container.
 - 3.6.2 10 mL of 2% sodium thiosulfate solution is needed for each gallon of chlorinated water that is sampled.
 - 3.6.3 Injector Adjustments (make while adjusting pressure in 3.5.5).
 - 3.6.3.1 Sample tap must supply water with at least 25 psi. If not, install 1-5 gpm gas or electric pump after sample filter housing. Pump must be capable of producing at least 25 psi.
 - 3.6.3.2 Adjust injector during 50 gallon flush period by placing injector tubing with injector filter and weight into a large sanitary container filled with distilled water or sample water.

- 3.6.3.3 Use ejector water bypass screw to adjust pressure on second pressure gauge to 10 psi, while pressure is at least 25 psi on first pressure gauge.
- 3.6.3.4 Check that injector is slowly and consistently drawing up the water. Coarse adjustments may be made with water bypass screw. Use the fine metering adjustment screw to fine tune injection rate.
- 3.6.3.5 If there is no suction visibly drawing up the water, or if too much is flowing, make sure the first gauge has at least 25 psi and adjust the water bypass screw further to increase or decrease the pressure differential between the two gauges. Greater differential between the first and second gauges increases the flow rate; a smaller differential decreases the flow rate.
- 3.6.3.6 When the adjustments are complete, replace the water with the 2% sodium thiosulfate solution and run it to waste until the water in the line is replaced with the thiosulfate solution.
- 3.6.3.6 During sampling and after injector adjustments have been made, monitor level of sodium thiosulfate solution which should go down slowly and consistently at about 10 mL per minute.

IF IT IS NOT POSSIBLE TO DECLORINATE WHILE SAMPLING:

- This situation should generally be known in advance or should be anticipated so that a sodium thiosulfate solution of proper concentration is available to dechlorinate the sample.
- Prepare 100 milliliters of a 10% solution of sodium thiosulfate by weight.
- Immediately upon completion of step 3.7.5, add the 100 ml of sodium thiosulfate solution to the zip-loc bag containing the filter and water or directly into the Envirochek HV capsule if applicable.
- Close the zip-loc bag securely and roll the filter back and forth gently for at least a minute
- Continue with step 3.7.6
- Advise analytical laboratory of this procedure on the MPA Analysis Request Form

3.7 End sampling

- 3.7.1 Shut off water.
- 3.7.2 Record stop date and time, final meter reading, turbidity (optional but preferred) and total volume sampled.
- 3.7.3 Disconnect the lower section of filter housing while maintaining housing in upright position.
- 3.7.4 With new latex gloves, aseptically remove the polywound filter from housing and immediately place in plastic zip-loc bag.
- 3.7.5 Immediately pour the remaining water from filter housing into the same bag and seal the bag.
- 3.7.6 Without allowing bag to touch any environmental surface, record sample name on bag with a permanent marker.
- 3.7.7 Without allowing bag to touch any environmental surface, place it inside a second new bag.

- 3.7.8 Refrigerate sample at 2-5°C prior to shipping. **DO NOT FREEZE.**
- 3.8 **Ship sample** NOTE: Sample must be received at laboratory within 24 hours of sample collection.
 - 3.8.1 WRAP SAMPLE IN SOME FORM OF INSULATION (e.g. bubble wrap).
 - 3.8.2 Wrap ice packs around filters (outside of bubble wrap) so that ice is **NOT IN DIRECT CONTACT** with filters (frozen filters may compromise test results).
 - 3.8.3 Place into insulated shipping container. **DO NOT USE DRY ICE** and avoid using wet ice whenever possible.
 - 3.8.4 Supply appropriate sample meta-data and Indicate the type of analysis to be performed on the Analysis Request Form.
 - 3.8.5 Place completed Analysis Request Form in zip-loc bag then in cooler with sample.
 - 3.8.6 Deliver or ship by **priority overnight** courier to laboratory.
- 3.9 **Clean up**
 - 3.9.1. If using the same equipment for more than one sample, clean equipment as described in paragraph 2.5.
 - 3.9.2 Return equipment borrowed from analytical laboratory within time period specified by the analytical laboratory and shipped separately from the sample by the means specified by the laboratory (generally, surface ground).
- 4.0 **Sample Volumes and Water Quality Parameters**
 - 4.1 **Raw water** - Ideally, the sampling device should be allowed to run for a 12 to 24 hour period in which time a minimum volume of 100 liters (26.4 gallons) should be filtered, but the optimum amount is 5450 liters (1440 gallons). If the filter becomes clogged or plugged due to highly turbid waters, terminate sampling and record the volume collected to this point. If the raw water source is known to have high turbidity, the sampling flow rate may be lowered to 0.5 gpm which will increase the sampling period thus obtaining a sample more representative of the raw water quality during a treatment day. Pressure over the filter should not be increased above 10 psi in an effort to collect greater sample volumes.
 - 4.2 **Filtered water** - Ideally, a minimum of 1000 liters (264 gallons) is collected, but the optimum sample volume is 5450 liters (1440 gallons). The collection period should encompass a full treatment cycle run, or for 24 hours, including at least one backwash cycle and one solids recycle episode at any time during the collection period.
 - 4.3 **Water Quality Parameters** - Measurement of certain water quality parameters is recommended and should be included in the sample data form for both raw and filtered water samples. Among these are: total and free chlorine residual, temperature, pH, and turbidity. Additionally, the source of the sample and the treatment plant unit processes in use for both disinfection and particulate removal should be recorded on the Analysis Request Form. Information on any microbiological testing, such as total and fecal coliform and heterotrophic plate count, conducted at the time of the MPA sample collection are valuable, but are not likely to be available when the Analysis Request Form is prepared so they are generally not submitted with the Analysis Request Form.
 - 4.4 **Chlorinated Samples** – If possible, obtain water samples prior to any chlorination. If chlorinated water must be sampled, an injector system will need to be installed to add sodium thiosulfate solution to neutralize the chlorine. Add sodium thiosulfate solution

via the injector system to produce a final concentration of 50 mg/L. In lieu of the ejector system described herein, a peristaltic pump or electric pump can be used to inject the sodium thiosulfate. In any case, use a chlorine residual test kit to ensure that there is no chlorine residual detected at the inlet to the filter housing. In those rare situations where it is not possible to de-chlorinate while sampling, de-chlorinate the sample filter after sample collection following the procedure provided in the text box of paragraph 3.6.

NOTE: These sampling procedures are applicable to public water systems using surface water or ground water under the direct influence of surface water that are required to perform routine MPA monitoring as directed by the Drinking Water Program of the Colorado Department of Public Health and Environment.

Figure 1 – MPA Sampling Apparatus for Un-chlorinated Sources

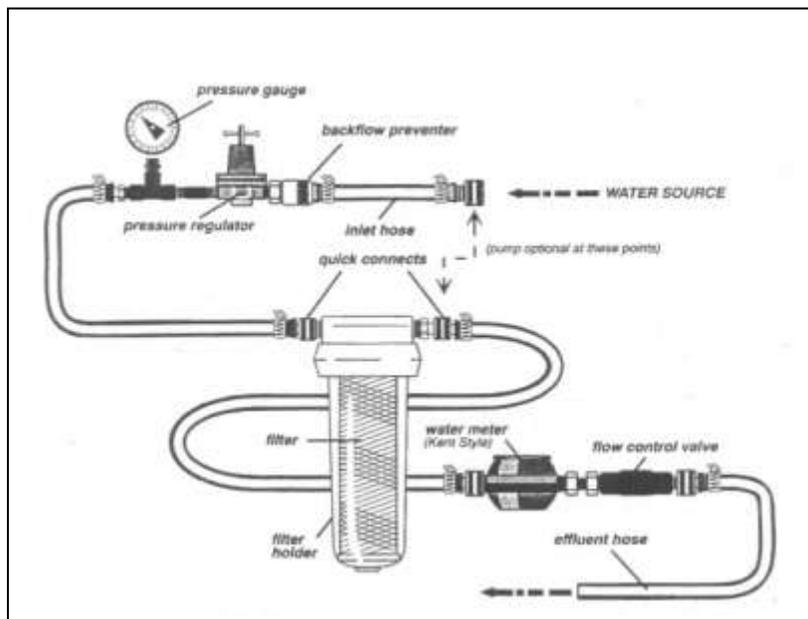
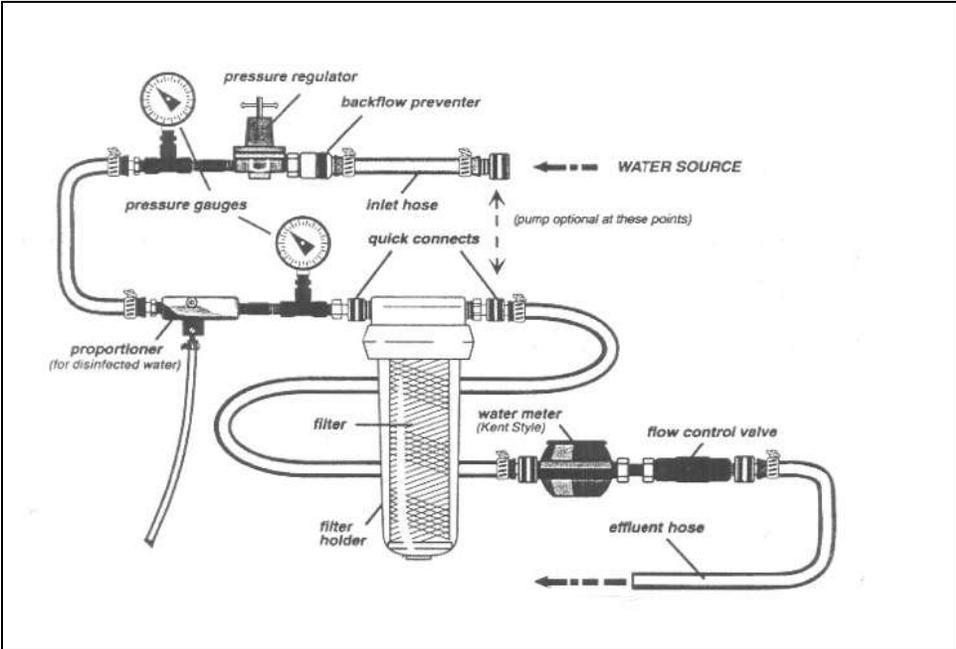


Figure 2 – MPA Sampling Apparatus for Chlorinated Sources



APPENDIX III – Microscopic Particulate Analysis (MPA) Form: Request and Utility Report and Laboratory Results Reporting

(Note: An example Microscopic Particulate Analysis (MPA) Form: Request and Utility Report is provided below. It contains color-coding that is linked to the corresponding narrative explanation of terms and instructions for completing the form. Actual working copies of the form are not color coded)

| | | | | | | | | | | | | | | | |
|--|--|---|------------------|----------------------------|--|--|-------|---------------------------|-----------------------------|---------------------------|-------|--------------|--------------|-----------------------|-----------------|
| Logo | Colorado Department of Public Health and Environment | | | | | | | | | | Logo | | | | |
| | Water Quality Control Division | | | | | | | | | | | | | | |
| | Safe Drinking Water Program | | | | | | | | | | | | | | |
| | Compliance Assurance Section | | | | | | | | | | | | | | |
| Microscopic Particulate Analysis (MPA) Form: Request & Utility Report | | | | | | | | | | | | | | | |
| Client Information | | | | | | Utility Information | | | | | | | | | |
| Client | | | | | | System/Utility | | | | | | PWSID # | | | |
| Contact/Collector | | | | | | Address | | | | | | | | | |
| Address | | | | | | State | | | | | | Zip | | | |
| Phone | | | | | | Contact | | | | | | Title | | | |
| e-Mail | | | | | | e-Mail | | | | | | | | | |
| Project | | | | | | Signature | | | | | | Date | | | |
| Source Water Information | | | | | | Analysis Request Information (check all applicable) | | | | | | | | | |
| Spring | | Well depth | Lake/Reservoir | | MPA only (groundwater or surface water) | | | | | | | | | | |
| Dug well | | | Irrigation canal | | MPA w/ Giardia & Cryptosporidium (1623 or ICR Method) | | | | | | | | | | |
| Horizontal well | | Distance From Surface Water | Stream/River | | Giardia & Cryptosporidium only (1623 or ICR Method) | | | | | | | | | | |
| Drilled Well - Shallow | | | Wastewater | | Matrix Spike | | | | | | | | | | |
| Drilled Well - Deep/Conf | | | Other | | Add'l pellet analysis? (Y/N) | | | | Quant. Chlorella, etc (Y/N) | | | | | | |
| Infiltration Gallery | | | | | Initial Sample (Y/N) | | | | Repeat Sample (Y/N) | | | | | | |
| Water Sample Treatment Information (check all treatment provided prior to point of sample collection, if none - check "No Treatment" Box) | | | | | | Treatment Plant Filter Conditions | | | | | | | | | |
| Pre-chlorine | | No Disinfection | | | | Membrane Filtration | | | | Filter loading (gpm/ft2): | | | | | |
| Post-chlorine | | Disinfection Only | | | | Pressure Filtration | | | | Backwashed filter? (Y/N) | | | | | |
| Post-chloramine | | Conventional filtration | | | | Slow sand Filtration | | | | Filter to Waste? (Y/N) | | | | | |
| Ozone | | Direct Filtration | | | | No Treatment | | | | Other | | | | | |
| Chlorine dioxide | | Diatomaceous Earth Filtration | | | | Other | | | | | | | | | |
| Sample Collection Information | | | | | | | | | | | | | | | |
| Sample Purpose: | | Assess Direct Influence of Surface Water: | | | Assess Microbiological Particle Removal Effectiveness: | | | | | | | | | | |
| Sample Location ID: | | | | Start Sampling (Date/Time) | | | | Stop Sampling (Date/Time) | | | | Volume (Gal) | Filter Clog? | Exposed to Chlorine ? | De-Chlorinated? |
| | | | | Temp | pH | NTU | Meter | Temp | pH | NTU | Meter | | | | |
| Sample ID: | | | | | | | | | | | | | | | |
| Sampling Conditions: | | | | | | | | | | | | | | | |
| Sample Notes/Add'l Requests | | | | | | | | | | | | | | | |

| | | |
|---|--------------------|------|
| Logo | Lab Name: _____ | Logo |
| | Lab Address: _____ | |
| | Lab Phone: _____ | |
| | Lab e-Mail: _____ | |
| Microscopic Particulate Analysis (MPA) Form: Results | | |

| Sample Receipt Information | | | | | | |
|----------------------------|---------------|------|-----------|-------|------|-------|
| Courier | UPS _____ | Type | Container | _____ | Date | _____ |
| | Fed Exp _____ | | HV | _____ | Time | _____ |
| | HD _____ | | Polywound | _____ | Temp | _____ |
| | Other _____ | | | | By | _____ |
| Receipt Notes | _____ | | | | | |

Laboratory Results

| Microorganisms | Untreated (raw) Sample ID : | Filtered Sample ID: |
|-------------------------|------------------------------|------------------------------|
| | Lab Sample ID: | Lab Sample ID: |
| | Filter Color: | Filter Color: |
| | Date/Time Eluted: | Date/Time Eluted: |
| | Centrifugate Vol. (mL/100L): | Centrifugate Vol. (mL/100L): |
| | Date/Time Analyzed: | Date/Time Analyzed |
| | TotalCount per 100L | TotalCount per 100L |
| Cryptosporidium (IFA) | | |
| Giardia (IFA) | | |
| Algae (non-diatom) | | |
| Diatoms | | |
| Plant Debris | | |
| Rotifers | | |
| Nematodes | | |
| Pollen | | |
| Amoeba | | |
| Ciliates | | |
| Flagellates (colorless) | | |
| Insects/Larvae | | |
| Other Arthropods | | |
| Select Algae | | |
| Other | | |
| Analysis Notes | _____ | |

Example MPA Form Side 2

Evaluation

| | Percent Reduction | Log Reduction |
|--|-------------------|---------------|
| Centrifugate Removal | | |
| Microorganism Removal | | |
| Removal W/O Select Algae | | |
| (Surface Water) Significance Model Result: | | |
| (Ground Water) Risk Level: | | |
| Notes | | |
| _____ | | |

| | | |
|------------------------------|-------------|------------|
| Reviewed & Approved by _____ | Title _____ | Date _____ |
|------------------------------|-------------|------------|

Explanation of Terms and Instructions for Completing Microscopic Particulate Analysis (MPA) Form: Request and Utility Report

General

The microscopic particulate analysis is generally used for two different purposes: (1) to assess particle removal effectiveness of surface water treatment processes, and (2) to estimate the risk that an ostensible ground water source is under the direct influence of surface water. However, only one two sided form is used to request and report the results of the MPA regardless of the purpose of the test. Each MPA sample submitted to the laboratory for analysis should be accompanied by one copy of the form (both sides). Thus a ground water system using MPA for assessing direct influence of surface water would use one copy of the form (both sides) for each sample, and a surface water system using MPA to assess microbiological particulate removal effectiveness would use two copies of the two sided form: one copy for the sample of the untreated water, and one copy for the sample of the treated water.

The instructions that follow are for entities requesting an MPA for assessing particle removal effectiveness of surface water treatment processes. Side 1 of the form (Microscopic Particulate Analysis (MPA) Form: Request and Utility Report) is used by a water system to communicate vital information to their analytical laboratory with each sample for which a MPA analysis is requested. When the analytical laboratory completes the analysis, it reports the results back to the water system using Side 2 (Microscopic Particulate Analysis (MPA) Form: Results). Then the “Utility Information” on Side 1 is completed and signed by the water system. The completed, signed form is used as the vehicle to report the results of the analysis to the Colorado Safe Drinking Water Program.

Instructions for Side 1 - Microscopic Particulate Analysis (MPA) Form: Request and Utility Report

Side 1 of the MPA Form: Request and Utility Report, contains 8 major parts as depicted in the example color coded form and as listed below:

1. Client Information,
2. Source Water Information,
3. Analysis Request Information,
4. Water Sample Treatment Information,
5. Treatment Plant Filter Conditions,
6. Sample Collection Information,
7. Sample Notes/Add'l Requests, and
8. Utility Information

Parts 1 through 7 of Side 1 are designed to be completed by the person who collects the sample on behalf of the public water system for which the sample was collected and for which the analysis is being requested. Part 7, Sample Notes/Add'l Requests is designed to be completed either by the person

collecting the sample or the person reporting analytical results to the Colorado Safe Drinking Water Program. When completed by the sampler, this part of the form is generally used to convey additional information to, or requests of the laboratory. When completed by the utility representative, it is generally used to convey additional information or clarification of results to the Colorado Safe Drinking Water Program.

Finally, Part 8, Utility Information, is designed to be completed by the utility representative officially responsible for reporting to the Program. Information in Part 8 is completed by a water system representative after the MPA results have been received from the laboratory and reviewed. When signed, it becomes the water system's vehicle to officially transmit the test results to the Colorado Safe Drinking Water Program.

The following paragraphs provide an explanation of the terms used on the form and instructions for properly completing and submitting the form (narrative color coding is keyed to the example form color coding for clarity – actual working copies of the form are not color-coded).

Client Information

Client – Provide name of the party that is originating the request for analysis. For large water systems it may be a person in the water quality monitoring function, while at a small system, it may be the operator in responsible charge.

Contact/Collector – Provide the name of the person that collected the sample for the client or other person most knowledgeable about exactly how and when the sample was collected.

Address - Enter where the sample collector or most knowledgeable contact can be located. For contract operators this is their business address. For a sampler employed by the water system, this would be their work mailing address.

Phone/Fax – Enter the telephone and fax number that will most directly provide a means to directly contact the person who performed the sampling.

Email – Enter the email address for the person who performed the sampling

Project – May be a simple routine sample (if so, insert “routine sample”) or a unique named event such as a particular special investigation. Enter the name of the project, for example: “Plant x, Filter y startup investigation”.

PO # - If the analysis is being procured from the laboratory under the terms of a purchase order, insert the purchase order number.

Source Water Information

Indicate with a check mark in the appropriate box, the type of source being sampled. If none of the listed sources adequately describe the source, check "Other" and enter an appropriate description in the space next to and under the "Other" box.

Spring – A spring occurs where water flows to the surface of the earth from underground. More specifically, a spring is a site where a water-bearing aquifer meets the ground surface. For use as a potable source, the point where the water emerges from the ground is protected from surface contamination by a properly constructed spring box.

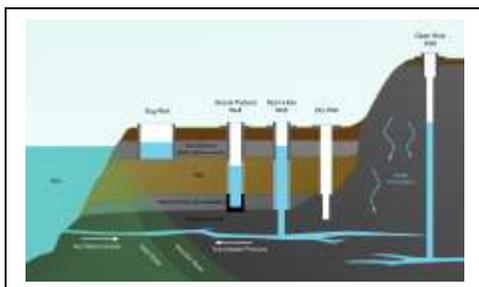
Dug Well - Hand-dug wells are excavations with diameters large enough to accommodate one or more men with shovels digging down to below the water table. Dug wells can be lined with laid stones or brick; extending this lining upwards above the ground surface into a wall around the well serves to reduce both contamination and injuries by falling into the well. A more modern method called caissoning uses reinforced concrete or plain concrete pre-cast well rings that are lowered into the hole. A well-digging team digs under a cutting ring and the well column slowly sinks into the aquifer, while protecting the team from collapse of the well bore.

Horizontal Well – Is a well cased and screened approximately horizontally into a water-bearing stratum, or under the bed of a lake or stream.

Drilled Well - Drilled wells are typically vertical and created using either top-head rotary style, table rotary, or cable tool drilling machines, all of which use drilling stems that are turned to create a cutting action in the formation. Drilled wells are usually cased with a factory-made pipe, typically steel (in air rotary or cable tool drilling) or plastic/PVC (in mud rotary wells, also present in wells drilled into solid rock). The casing is constructed by welding, either chemically or thermodynamically, segments of casing together.

There are two broad classes of drilled-well types, based on the type of aquifer the well is in:

- *Shallow or unconfined wells* are completed in the uppermost saturated aquifer at that location (the upper unconfined aquifer).



- *Deep or confined wells* are sunk through an impermeable stratum into an aquifer that is sandwiched between two impermeable strata. The majority of deep aquifers are classified as artesian because the hydraulic head in a confined well is higher than the level of the top of the aquifer. If the hydraulic head in a confined well is higher than the land surface it is a "flowing" artesian well.

Infiltration Gallery - A structure including perforated conduits in gravel to expedite transfer of water to or from an aquifer or surface water source. They may be vertical, for example along the banks of a river or lake, or horizontal where they may underlie a stream or lake.

Well Depth – The vertical distance, measured in feet, from the surface of a well downward to the depth where the first zone of water production contributes to the flow from the well. Note that this may, or may not be, the depth from the surface to the well’s screened interval.

Distance From Surface Water – The horizontal distance, measured in feet, from the water source being tested to the nearest surface water source, such as lake, river or irrigation canal. When taking a sample from a known surface water source, this distance will be zero.

Lake/Reservoir – Refers to a natural or manmade basin or hollow on the Earth’s surface in which water collects or is stored that may or may not have a current or single direction of flow. Lakes can be contrasted with rivers or streams, which are usually flowing. However most lakes are fed and drained by rivers and streams. A reservoir is generally a man-made impoundment that results in a relatively still body of water of considerable size.

Irrigation Canal – Is generally an open conduit used for transporting river, stream, reservoir, lake or pond water from one location to another.

Stream/River – A surface water source that is flowing as opposed to quiescent such as a lake or reservoir.

Wastewater – Water that has been discharged following some domestic or industrial use.

Other – If source being sampled does not fit into one of the defined categories, above, check the “Other” box and write in an appropriate short description of the source.

Analysis Request Information

(The MPA sample being submitted may be analyzed for different purposes using different laboratory analytical procedures. Indicate with a check mark, which analysis you are requesting the laboratory to perform. The cost will vary depending on the analysis requested)

MPA Only – Checking this box asks the laboratory to analyze the submitted sample only for MPA as described in one of the following EPA documents: Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water using Microscopic Particulate Analysis, EPA 910/9-92-029; Microscopic Particulate Analysis for Filter Plant Optimization, EPA-R-96-001.

MPA w/*Giardia* & *Cryptosporidium* – Checking this box requests the laboratory to enumerate *Giardia* and *Cryptosporidium* in addition to performing the above MPA analysis. Water treatment plants sampling to meet the routine MPA analysis of the Safe Drinking Water Program are not required to have this additional analysis performed. Enumerating *Giardia* and *Cryptosporidium* is more time-consuming

for the laboratory, so generally incurs additional cost, but does yield important risk information to the water system.

Giardia & Cryptosporidium Only – Checking this box requests only the enumeration of *Giardia* and *Cryptosporidium* only (using either EPA Method 1623, or the EPA ICR Method) and not a MPA test.

Matrix Spike – When *Giardia* and *Cryptosporidium* are being analyzed, a minimum number of water samples must be spiked with known concentrations of target organisms. These samples are referred to as matrix spike samples. If the sample being submitted is a matrix spike, indicate such by entering a check in the associated box.

Add'l Pellet Analysis (Y/N)- When the requester desires that cryptosporidium be quantified, additional laboratory analysis (at additional cost) is required if the packed pellet volume of the eluted and centrifuged sample is greater than 0.5 mL. Indicating “Y” (yes) authorizes the laboratory to conduct the additional analysis and bill the requester for the associated additional cost.

Quant. Chlorella, etc (Y/N) – If it is desired to have the laboratory quantify and eliminate counts of chlorella (as explained in paragraph 2 of Table 1 (MPA Results Interpretation Summary)), circle Y, if not, circle N.

Initial Sample (Y/N) – If this is an original sample and not a repeat sample (as explained in the paragraph of this guidance titled: “Opportunity to Resample”) circle Y; if not, circle N.

Repeat Sample (Y/N) – If this is a repeat sample (as explained in the paragraph of this guidance titled: “Opportunity to Resample”) circle Y; if not, circle N.

Water Sample Treatment Information

If the sample being submitted to the analytical laboratory with this form was subjected to treatment, indicate all treatment processes employed in such treatment by checking the appropriate boxes. If no treatment was provided, check the “No Treatment” box.

Laboratories are able to better assist their clients interpret MPA results or analyze sampling difficulties if they have an understanding of the treatment processes that a sample was subjected to prior to sample collection. **Indicate with a check mark, all treatment processes upstream from the sample collection location in use at the plant at the time that the sample was collected.**

Pre-chlorine – Check indicates that the plant adds chlorine upstream from the combined filtered effluent including: at the plant intake, within the flocculation process, or upstream from the filter media and sample was collected downstream from such treatment.

Post-chlorine – Indicates that the plant adds chlorine following their filtration process, usually at a clear well downstream of the combined filtered effluent and sample was collected downstream from such treatment.

Post-chloramine - Indicates that the plant chloraminates following their filtration process, usually at a clear well downstream of the combined filtered effluent and sample was collected downstream from such treatment.

Ozone – A check indicates that the plant disinfects or oxidizes contaminants using ozone in their treatment train and sample was collected downstream from such treatment.

Chlorine Dioxide - A check indicates that the plant disinfects or oxidizes contaminants using chlorine dioxide in their treatment train and sample was collected downstream from such treatment.

No Disinfection – A check indicates that the plant does not provide any disinfection anywhere in their treatment train upstream from the sample location and hence the sample was not subjected to any disinfection process (including UV).

Disinfection only – A check indicates that the only treatment process in use at the plant being sampled is disinfection and sample was collected downstream from such treatment.

Conventional filtration – A check means the plant uses conventional filtration as defined by the CPDWR, i.e., a series of processes including coagulation, flocculation, sedimentation and filtration resulting in substantial particulate removal, and sample was collected downstream from such treatment.

Direct filtration – A check means the plant uses direct filtration as defined by the CPDWR, i.e., a series of processes including coagulation and filtration but excluding sedimentation resulting in substantial particulate removal and sample was collected downstream from such treatment.

Diatomaceous earth filtration – A check means the plant uses diatomaceous earth filtration as defined by the CPDWR, i.e., a process resulting in substantial particulate removal in which (1) a pre-coat cake of diatomaceous earth filter media is deposited on a support membrane (septum), and (2) while the water is filtered by passing through the cake on the septum, additional filter media known as body feed is continuously added to the feed water to maintain the permeability of the filter cake; and sample was collected downstream from such treatment.

Membrane filtration – A check means the plant uses membrane filtration as defined by the CPDWR, i.e., a pressure or vacuum driven separation process in which particulate matter larger than 1 micrometer is rejected by an engineered barrier, primarily through a size-exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test. This definition includes the common membrane technologies of microfiltration, ultrafiltration, nanofiltration, and reverse osmosis; and sample was collected downstream from such treatment.

Pressure filtration – A check means that the filter in use at the plant meets the criteria of a rapid rate vertical pressure filter as described in section 5.11 of the Design Criteria for Potable Water Systems (Reference 7) and sample was collected downstream from such treatment.

Slow sand filtration – A check means that the plant uses slow sand filtration as defined in the CPDWR, i.e., a process involving passage of raw water through a bed of sand at low velocity (generally less than 0.4 meters per hour (m/h)) resulting in substantial particulate removal by physical and biological mechanisms and sample was collected downstream from such treatment..

No Treatment – A check means the plant provides no treatment and the sample was not subjected to any treatment.

Other – If the plant uses a treatment process not listed and the sample was collected downstream from the application of such treatment, check the box and write in the treatment applied.

Treatment Plant Filter Conditions

This information should be provided whenever the sampled water was treated using filtration processes. Operational conditions within the plant have a significant effect on the degree of particle removal achieved, therefore, it is important that the major operational variables listed below be known and recorded to better interpret the results of the test.

Filter loading (gpm/ft²) – Filter loading rate is a measure of the volume of water passing per square foot of filter surface area. If the filter loading rate gets too high, filter performance usually decreases. The rate to be reported is the highest loading rate that occurred during the sampling period, taking into account the change in flow rate experienced by a filter when other filters are taken off line or recirculation occurs. Generally, it is desirable to obtain the filtered sample from the effluent of the filter that is suspected of being the worst performing. This helps provide a margin of comfort in the results, i.e., if the filter that has the worst performance is achieving good removal as measured by the MPA test, all remaining filters should be performing at a higher level. If the filtered water sample is taken from the combined filter effluent, the highest loading rate of all filters in use during the sampling period should be recorded, again accounting for changes in loading rater that occur as a result of plant flow, filters off line, recirculation or other significant events.

Backwashed filter? – It is recommended that the sampling period of the finished water MPA sample (for surface water plants) include at least one solids recycle event. If the finished water sampling period included a solids re-cycle event, indicate by circling “y” or entering a “Y” to indicate yes or circling or entering “N” for no.

Filter to waste? Some, but not all plants have the ability to filter to waste following a filter backwash cycle. Generally, filter performance improves rapidly after about 15 minutes of filtration. The optimum period can be estimated for a particular filter by developing a filter profile, i.e., a plot of filter effluent turbidity versus time that will visually show when performance improvement has stabilized. If the plant was not able to or did not filter to waste following the filter backwash cycle, so indicate by circling or

entering “N” for no. If filter to waste was practiced, circle or enter “Y” for yes and enter the number of minutes or the number of gallons that passed during the filter to waste period.

Sample Collection Information

Sample Purpose – Since the MPA test can be used for two different purposes, this part of the form is used to specify the purpose of the test: Check the appropriate box to indicate whether the purpose of the test is to determine direct influence of surface water or to assess filter plant microbiological particulate removal effectiveness.

Sampling Location ID – It is important to accurately identify the exact location from which the sample has been obtained. For systems using surface water, MPA sampling locations should be identical with, and named the same as the sampling locations identified on the system’s monitoring plan for Surface Water Treatment Rule requirements (for systems that are nominally supplied by groundwater but are sampling to gather information about possible direct influence of surface water, the sampling location should be at the wellhead, prior to any treatment).

Water System Sample ID – This is a code or number assigned by the water system (or person collecting the sample) that is used to identify one particular MPA sample.

Start Sampling (Date/Time) – Enter the date (mm/dd/yyyy format) and time to the nearest minute (hh:mm format, indicate am or pm) that sample collection began.

Stop Sampling (Date/Time) - Enter the date (mm/dd/yyyy format) and time to the nearest minute (hh:mm format, indicate am or pm) that sample collection ended.

Start or Stop Temp – In the appropriate box below the word “Temp” enter respectively, the temperature in degrees F of the water when sampling was started and when sampling ended.

Start or Stop pH - In the appropriate box below the word “pH” enter respectively, the hydrogen ion concentration (in standard pH units) of the water when sampling was started and when sampling ended.

Start or Stop NTU - In the appropriate box below the word “NTU” enter respectively, the turbidity (in standard nephelometric units) of the water when sampling was started and when sampling ended.

Start or Stop Meter - In the appropriate box below the word “Meter” enter respectively, the meter reading (in appropriate units of gallons or liters depending on how the meter reads) of the water when sampling was started and when sampling ended.

Volume (gal) – In the box below the word “Volume” enter the total number of gallons that were sampled. This entry is obtained by subtracting the “Start meter” reading, from the “Stop meter” reading. If the meter reads in Liters, divide the difference (“Start meter” – “Stop meter”) by 3.78 to determine the volume in gallons and enter this result in the box.

Filter Clog? – During the sampling period, sources with high concentrations of particulates may cause the filter to clog, especially when the Envirochek HV filter is used. This will be indicated by a drop in the flow rate and an increase in the pressure drop across the filter housing. If there is evidence that the filter has clogged, enter “Y” for yes in the space (also, stop sampling and record the time and meter reading). If there is no evidence that the filter clogged, enter “N” for No.

Exposed to Chlorine? – It is sometimes important for the laboratory analyst to know whether or not the organisms in the sample were exposed to chlorine. If the sample was exposed to chlorine, enter “Y” for yes even if the sample was de-chlorinated during or after the sampling period. If there was no chlorine in the water sampled, enter “N” for no.

De-Chlorinated? – If the sample was de-chlorinated, either during sample collection (recommended for chlorinated samples) or following sample collection, enter the word “yes”, if not, enter the word “no”. If the filter was de-chlorinated after sample collection also advise the laboratory of this situation by means of a note in the “Sample Notes/Add'l Requests” section of the request form.

Sample Notes/Add'l Requests

Enter in the space provided any additional information that may be useful to the analyst or client or to document any unusual conditions observed that may have an effect on the sample results.

Utility Information

System/Utility – Enter the name of the public water system or utility for which the analysis was completed.

PWSID # - For analysis results being provided by the water system to the Colorado Department of Public Health and Environment, enter the unique public water system identification (PWSID) number assigned to the system by the Department.

Address – Enter the mailing address of the water system/utility.

Contact – Enter the name and title of the person who is authorized to and responsible for submitting the report to the Colorado Department of Public Health and Environment or other entity who will receive the analysis report.

E-mail – Provide the email address of the water system contact

Signature – The signature block of the form is reserved for use of the utility monitoring and reporting representative and is generally the last entry made prior to submitting the analytical results to the Colorado Safe Drinking Water Program. The signature represents the official verification by the system/utility that the sample was collected in accordance with the method requirements, the client

and utility-provided information is correct and the results provided are true and accurate as received from the laboratory. The person signing the form should be certain that the system's internal controls are sufficiently robust to ensure that no incorrect information is reported.

Instructions for Side 2 - Microscopic Particulate Analysis (MPA) Form: Results

Aside from the laboratory identification information at the top of the MPA Form, Side 2 of the Form contains 3 major parts as depicted in the color-coded Example Form and as listed below:

1. Sample Receipt Information,
2. Laboratory Results, and
3. Evaluation.

All three parts of Side two are designed to be completed by the analytical laboratory. Information provided by the laboratory begins with "Sample Receipt Information" which may serve as part of the laboratory's chain-of-custody and internal tracking process. The "Laboratory Results" section will be completed with the detailed outcome of the laboratory's analysis. The "Evaluation" section, again completed by the laboratory, will provide particulate removal effectiveness information for surface water plants (or risk estimates for ground water systems using the MPA to help determine the direct influence of surface water).

Sample Receipt Information

The analytical laboratory will use this section of the form as part of their chain of custody process and/or their internal sample tracking process. From the client standpoint, possibly the most important information that will be recorded in this section is the date and time of arrival and the temperature of the sample. These fields should be reviewed to be sure that the samples arrived within the allowable sample holding time and temperature.

Laboratory Results

This form is designed to provide results of two different uses of the MPA test:

- Surface water particulate removal where results of two MPA sample counts will be reported: the untreated (or raw) sample counts and the treated (filtered) sample counts. Additionally, the laboratory will calculate and report the particulate percent removal between the untreated and filtered samples (see part 3, Evaluation).

- Ground water being evaluated for direct influence of surface water where the results of only one MPA will be reported

Untreated (raw) Sample ID – This is the same identification number as entered on side one of the Form in the box titled: “Water System Sample ID”. When the purpose of the MPA is to assess plant particulate removal effectiveness, the ID of the filtered water sample that is associated with the raw water sample will be entered in the column titled: “**Filtered Sample ID**”. Likewise, the analysis results of the filtered water sample will be entered into the appropriate lines under this entry.

Lab Sample ID – This is a tracking number the laboratory may assign to facilitate internal tracking and automated data reporting. Some laboratories may rely on the client’s sampling ID and not assign a lab sample ID.

Filter Color – The analyst will provide this information based on a subjective evaluation of filter color. According to the method description, the filter cartridge changes color during sampling depending on the water's particulate composition and color as well as the amount of water sampled. The cartridge color can provide useful information about the general quality of water and can be used to make some process control decisions. For example: an efficient water treatment plant will often have a brown raw water sampling cartridge and a white finished water sampling cartridge. The presence of a green tinge on only the finished filter cartridge may indicate the presence of algae growth within the filter beds.

Date/Time Eluted – The laboratory analyst will enter the date and time the sample was eluted at the laboratory. The elapsed time between initiation of sample collection and laboratory elution should not exceed the maximum sample holding time of 96 hours specified in the MPA method.

Centrifugate Vol. (ml/100L) – The centrifugate pellet volume in ml per 100 liters is a direct measurement of the final pellet of particulate matter recovered from the sampling cartridge after particulate elution and centrifugation. The percent reduction or log removal between raw and finished centrifugate pellet volume can be useful in interpretation of overall filtration plant efficiency. However, it is important to realize that the volume of pellet can be strongly influenced by sampling technique and other factors and therefore should not be used as the sole factor in determining filtration efficiency. Treatment problems may be identified when finished sediment is greater in volume than the raw sediment. Situations such as this may occur when excess treatment chemicals are used.

Date/Time Analyzed – Will be provided by analyst and indicates the date and time that final microscopic analysis was completed.

Microorganisms

The microorganisms listed on the laboratory report form are defined under the heading of “Standards of Identity” within the MPA method (Reference 3), with the exception of “Insects/Larvae” and “Select algae” which are defined below.

Insects/Larvae – Means the same as “crustaceans” as defined under the heading of “Standards of Identity” within the MPA method (Reference 3).

Select Algae - Means *Chlorella sp*, *Dictyosphaerium minutum* or other non-pathogenic algae recognized and approved by the Safe Drinking Water Program to be eliminated from the MPA particulate removal calculation (see discussion in section of Guidance titled: Growth of Microorganisms in Treatment Plant).

Evaluation

Centrifugate Removal (Percent Reduction) - Is a measure of the % reduction in centrifugate pellet volume in ml/100L determined as follows:

$$\% \text{ Reduction} = ((\text{Raw Sample Centrifugate Vol} - \text{Filtered Sample Centrifugate Vol}) \div \text{Raw Sample Centrifugate Vol}) \times 100$$

Centrifugate Removal (Log Reduction) – Is a measure of the reduction in centrifugate volume measured on a log scale and calculated as follows:

$$\text{Log reduction} = \text{Log raw sample centrifugate vol} - \text{Log finished sample centrifugate vol}$$

Removal w/o select algae – The MPA interpretation algorithm makes it possible to account for the growth of certain non-pathogenic algae within the treatment plant. If authorized by the requesting utility, the laboratory will adjust results and report this measure of adjusted microorganism removal. The result will be expressed as a percent or log reduction (as calculated above respectively) with counts of selected non-pathogenic algae (such as chlorella) excluded from the microorganism counts in both the untreated and filtered water samples.

(Surface Water) Significance Model Result - If the purpose of the MPA was for evaluation of surface water treatment, the analytical laboratory will enter individual organism counts into the significance model (Appendix V) to determine a significance score. The significance score (a number with value of from 1 to 5) will be reported in this space.

(Ground Water) Risk Level – If the purpose of the MPA was to evaluate whether an ostensibly groundwater source is under the direct influence of surface water, the laboratory will conduct the analysis using the protocol outlined in the document titled: Consensus Method for Determining Groundwater Under the Direct Influence of Surface Water Using the Microscopic Particulate Analysis (MPA) (Reference 4). The result of this process will be a finding of “High”, “Moderate” or “Low” Risk level which will be reported in this space of the Form.

Notes - The space provides an opportunity for the laboratory to record and report any additional information that may be useful to the analyst or client or to document any unusual conditions observed that may have an effect on the sample results.

Reviewed & Approved By – Provides space for the name, title and date of laboratory official that is certifying that the laboratory processed the sample in accordance with the appropriate method and associated quality assurance requirements.

APPENDIX IV – Significance Model Background Information

Organism Group and Significance to Water Treatment

Many organisms and materials can impact water treatment operations. It is difficult to create groups of organisms that reflect all effects of water treatment plant operations. However, the descriptions below attempt to give certain weight to groups of organisms according to the expected impact of plant operations on each group. The groups and scores are based on the size class of organism as well as the potential health risks associated with the size class and the organisms themselves. The scale ranges are based on the *Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water using Microscopic Particulate Analysis (MPA)* EPA 910/9-92-029 method. Some modifications have been made to account for surface water ecologies.

Group 1 contains Rotifers, Nematodes, Insects and Larvae. These organisms are considered large when compared to the other groups (>75 um). These organisms are also higher level feeders, requiring a food source and time for establishment. They do not create ‘blooms’ like algae, but will increase in numbers under certain conditions. Rotifers are free-living or attached and more common in lake/reservoir sources. Nematodes are mostly associated with soil and substrates. Both feed on algae, bacteria, debris and other particulate matter. This group does not contain specific pathogens, but due to their larger size, if they are present in finished waters, they can indicate poor filter performance, particularly if these organisms are present in significant numbers in the raw water. The significance model scaling indicates the number of organisms which may be a concern for conventional treatment.

Group 2 contains Amoebas, Ciliates, and Flagellates. These organisms are generally smaller than group 1, and could contain organisms that are potential pathogens. These organisms mostly feed on bacteria, algae, other protozoa and extraneous debris. Flagellates are mostly photosynthetic, but some species can grow without light in the presence of sufficient dissolved nutrients. Because this group could contain pathogenic organisms and they are large, their presence in finished waters indicates poor filter performance. The significance model scaling indicates the amount of organisms if present in finished waters, to be of concern to filter performance.

Group 3 contains Diatoms and Nondiatomaceous Algae (all other algae such as green and cyanobacteria). This group is a very diverse size class and represents the majority of organisms found in source waters. This group does not contain pathogenic organisms, though some may produce toxins which can pose a health risk. Diatoms are very resistant to chemical and mechanical process and therefore are frequently found in finished waters. Some green algae like *Chlorella* can actually colonize water treatment plant filter beds, and while not a health risk, do reduce the water quality. Complete removal of these organisms is not expected with conventional treatment due to their prevalence, reproduction rate, size and structure. Their presence in finished water does indicate poor filter performance, especially when present in large quantities. The scaling reflects the prevalence of these

organisms in finished waters. The overall microscopic log removal in conjunction with the quantity and type of diatoms and non-diatomaceous algae is the key to interpreting the MPA.

Group 4 contains plant debris, pollen, crustacean parts, arthropods, and any other organisms. This group is variable in size and not detected in large numbers. Pollen is common during certain times of the year and is typically airborne, therefore its presence is not significant to filter performance. Plant debris, Crustaceans and Arthropods are nonpathogenic and are easily removed during conventional water treatment. The scaling reflects the impact of water treatment processes.

APPENDIX V – MPA Significance Model

The Significance Model automatically enters the weighting value based on the count of each microorganism as shown in the table below. The final significance model score is calculated by the model as the average of the individual weightings for each microorganism. A working version of the significance model is available in the “Drinking Water Regulatory Guidance” section of the Department’s Safe Drinking Water Program [web page](#).

| Grouping | Microorganisms | Model Weighting |
|----------------------------|-----------------------|---|
| 1 | Rotifers | =IF(E9<1,5,IF(E9<21,0,IF(E9<61,-5,IF(E9<150,-10,IF(E9>149,-15)))))) |
| 1 | Nematodes | =IF(E10<1,5,IF(E10<21,0,IF(E10<61,-5,IF(E10<150,-10,IF(E10>149,-15)))))) |
| 1 | Insects/larvae | =IF(E11<1,5,IF(E11<21,0,IF(E11<61,-5,IF(E11<150,-10,IF(E11>149,-15)))))) |
| 2 | Amoeba | =IF(E12<1,5,IF(E12<16,2,IF(E12<31,0,IF(E12<100,-2,IF(E12>99,-5)))))) |
| 2 | Ciliates | =IF(E13<1,5,IF(E13<16,2,IF(E13<31,0,IF(E13<100,-2,IF(E13>99,-5)))))) |
| 2 | Colorless Flagellates | =IF(E14<1,5,IF(E14<16,2,IF(E14<31,0,IF(E14<100,-2,IF(E14>99,-5)))))) |
| 3 | Diatoms | =IF(E15<100,5,IF(E15<1001,2,IF(E15<10001,0,IF(E15<100001,-2,IF(E15<500001,-5,IF(E15<2000001,-7,IF(E15>1999999,-10)))))))) |
| 3 | Nondiatomaceous Algae | =IF(E16<100,5,IF(E16<1001,2,IF(E16<10001,0,IF(E16<100001,-2,IF(E16<500001,-5,IF(E16<2000001,-7,IF(E16>1999999,-10)))))))) |
| 4 | Plant Debris | =IF(E17<1,5,IF(E17<26,3,IF(E17<71,2,IF(E17<201,1,IF(E17>199,0)))))) |
| 4 | Pollen | =IF(E18<1000,5,IF(E18>999,3,)) |
| 4 | Crustacean parts | =IF(E19<1,5,IF(E19<26,3,IF(E19<71,2,IF(E19<201,1,IF(E19>199,0)))))) |
| 4 | Other Arthropods | =IF(E20<1,5,IF(E20<26,3,IF(E20<71,2,IF(E20<201,1,IF(E20>199,0)))))) |
| 4 | Other | =IF(E21<1,5,IF(E21<26,3,IF(E21<71,2,IF(E21<201,1,IF(E21>199,0)))))) |
| Significance Rating | | =AVERAGE(F9:F21) |

MPA Significance Model

Sample Information

| | | |
|--------------------|--------------------------------------|--------------------|
| Sample Site: _____ | Microorganism Log Removal: _____ | Other Notes: _____ |
| Sample ID: _____ | Total Organisms/100L Influent: _____ | _____ |
| Sample Date: _____ | Total Organisms/100L Effluent: _____ | _____ |
| Sample Time: _____ | | _____ |

Significance Model

| Grouping | Microorganisms | #/100L | Scale Value |
|----------------------------|-----------------------|--------|-------------|
| 1 | Rotifers | 0 | 5 |
| 1 | Nematodes | 0 | 5 |
| 1 | Insects/larvae | 0 | 5 |
| 2 | Amoeba | 0 | 5 |
| 2 | Ciliates | 0 | 5 |
| 2 | Colorless Flagellates | 0 | 5 |
| 3 | Diatoms | 0 | 5 |
| 3 | Nondiatomaceous Algae | 0 | 5 |
| 4 | Plant Debris | 0 | 5 |
| 4 | Pollen | 0 | 5 |
| 4 | Crustacean parts | 0 | 5 |
| 4 | Other Arthropods | 0 | 5 |
| 4 | Other | 0 | 5 |
| Significance Rating | | | 5.00 |

General Significance Model Background:

The model helps weigh the significance of specified microorganisms potentially found in finished water MPA samples. The model translates these microorganism counts into a single number keyed to a sliding scale ranging from less than 1 to 5. The Significance Model is applied to all MPA results to aid in results interpretation as discussed in the Guidance. *A significance model rating of 3 or more generally indicates effective microbiological removal performance while a result less than 3 may indicate an impaired ability to remove particles.* However, a significance model rating of 3 or more must be tempered with knowledge of the plant's untreated (raw) water total particulate counts in conjunction with removal levels as explained in the text of this Guidance.

Instructions:

- Enter the **effluent** microorganism result into the #/100L column.
- The model will determine what range and grouping that value falls within. For Groupings, see next page.
- The Significance model result is submitted with the Microscopic Analysis and Request Form.

- A significance model rating of 3 or more generally indicates effective microbiological removal performance while a result less than 3 indicates an impaired ability to remove particles.

Organism Grouping Key

| Grouping 1 | | | |
|------------|-----------|----------------|-------|
| Rotifers | Nematodes | Insects/Larvae | Scale |
| <1 | <1 | <1 | 5 |
| 1-20 | 1-20 | 1-20 | 0 |
| 21-60 | 21-60 | 21-60 | -5 |
| 61-149 | 61-149 | 61-149 | -10 |
| >150 | >150 | >150 | -15 |

| Grouping 2 | | | |
|------------|----------|-----------------------|-------|
| Amoeba | Ciliates | Colorless Flagellates | Scale |
| <1 | <1 | <1 | 5 |
| 1-15 | 1-15 | 1-15 | 2 |
| 16-30 | 16-30 | 16-30 | 0 |
| 31-99 | 31-99 | 31-99 | -2 |
| >100 | >100 | >100 | -5 |

| Grouping 3 | | |
|-------------------|-----------------------|-------|
| Diatoms | Nondiatomaceous Algae | Scale |
| <100 | <100 | 5 |
| 100-1,000 | 100-1,000 | 2 |
| 1,001-10,000 | 1,001-10,000 | 0 |
| 10,001-100,000 | 10,001-100,000 | -2 |
| 100,001-500,000 | 100,001-500,000 | -5 |
| 500,001-2,000,000 | 500,001-2,000,000 | -7 |
| >2,000,000 | >2,000,000 | -10 |

| Grouping 4 | | | | | |
|--------------|--------|------------------|------------------|--------|-------|
| Plant Debris | Pollen | Crustacean Parts | Other Arthropods | Other | Scale |
| <1 | <1,000 | <1 | <1 | <1 | 5 |
| 1-25 | >1,000 | 1-25 | 1-25 | 1-25 | 3 |
| 26-70 | | 26-70 | 26-70 | 26-70 | 2 |
| 71-200 | | 71-200 | 71-200 | 71-200 | 1 |
| >200 | | >200 | >200 | >200 | 0 |

Organism Grouping Background Information:

Many organisms and materials can impact water treatment operations. It is difficult to create groups of organisms that reflect all effects of water treatment plant operations. However, the descriptions in Appendix IV of this Guidance attempt to give certain weight to groups of organisms according to the expected impact of plant operations on each group. The groups and scores are based on the size class of organism as well as the potential health risks associated with the size class and the organisms themselves. The scale ranges are based on the *Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water using Microscopic Particulate Analysis (MPA)* EPA 910/9-92-029 method. Some modifications have been made to account for surface water ecologies.

See Appendix IV for more information on specific groups.

APPENDIX VI – Operational Review Checklist

Solids Recycle

Are solids re-cycle streams metered into plant flow at less than 10% of plant flow?

Are re-cycle streams included in the raw water sample collected for the MPA?

Coagulation

Is optimal coagulant feed rate determined for current water quality conditions?

Is coagulant feed rate at the optimal level?

Does the mixing device have integrity and is it revolving at design rate?

Is pH optimized for coagulant and flocculant being used?

Flocculation

Is there evidence of short-circuiting in the floc basins?

Is the floc mixing mechanism properly operating?

Is there evidence that floc is not properly forming or is being sheared?

Is floc basin detention time consistent with design levels?

Sedimentation

Is sludge removed with minimal turbulence?

Is sedimentation detention time consistent with design assumptions?

Is settled water turbidity within established goals?

Is there any evidence of short-circuiting within the sedimentation basin?

Is there even effluent flow across the weirs?

Is there evidence of floc shearing in the effluent launders?

Filters

Do operators develop and analyze filter profiles?

Does plant filter to waste until filter is stabilized or otherwise condition the filter following backwash?

Is filter media depth and size periodically analyzed versus design specifications?

Is there evidence of filter-bed inconsistencies such as mud balls or boils during backwash?

Is filter backwashed at first sign of turbidity breakthrough?

Is hydraulic loading across filter controlled within design conditions and are surges controlled?

Does filter backwash procedure provide sufficient bed expansion and solids removal?

Is backwash recycle included in MPA sample if it is not wasted under normal operating conditions?