

Turbidity Decision Tree

Process Evaluation and Survey Results

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1 Goal

To create a standard for issuing turbidity advisories that is consistent across the province.

2 Background

The Provincial Ombudsman released a report in June 2008 on the investigation into the Province's regulation of drinking water. This report found that there is inconsistency in how the Regional Health Authorities assess when a Water Quality Advisory is required due to turbidity. The recommendation was to create a standard for issuing turbidity advisories that is consistent across the province.

Turbidity in water is caused by suspended and colloidal matter, such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms. Turbidity plays a direct role in risk to health due to the potential disruption to or overloading of the chlorination process. Turbidity caused by increased silt and clay particles in the water, as would be the case in glacial melt-water, is likely low risk, as chlorine does not chemically bind to mineral content. The concern comes through introduction of higher than normal levels of organic matter and/or microbiological load to the water. This can be from many sources, such as a landslide or heavy rainfall event increasing surface runoff supplying higher levels of decomposed plant matter or fecal contamination to the source water. In the case of organic matter increase, the chlorine binds to the organic particles, exhausting them so they are no longer available to attack harmful agents such as e-coli. With increased microbiological loading, there may be insufficient chlorine available to fully treat the contaminants in the water.

3 Legislation

Section 12 of the Drinking Water Protection Act requires a water supplier to immediately notify the DWO if a water supply system fails to meet an established immediate reporting standard for that system. There are many ways that the water supplier can meet this section of the act, and the Turbidity Decision Tree guideline is designed to facilitate this process and add credibility to support decisions.

4 Turbidity Decision Tree Trial

The April 2009 DRAFT Turbidity Decision Tree (TDT) has created a process for water purveyors and Drinking Water Officers (DWO) across the province to assess health risks related to turbidity. It outlines a consistent approach to issuing Water Quality Advisories (WQA), Boil Water Notices (BWN) and Public Water Communications (PWC). All Health Authorities (HA) were given the Draft TDT in April 2009 to implement over the year and to note any problems that arose. It was intended to be a trial period to ensure the process was effective.

5 TDT Process Evaluation

The TDT process was evaluated to improve the model by incorporating the experience of water suppliers and Health Authorities who have used the TDT. Ultimately the goal is to generate feedback from the HAs and the water suppliers that are familiar with the TDT to ensure all stakeholders are adequately served by this document. The evaluation included a survey of all five HAs, including DWOs and 14 water suppliers.

6 Survey Results

The survey was well received and participants were happy to share their thoughts and experiences. The HA survey was a questionnaire (Appendix A) distributed through Drinking Water Leadership Council (DWLC). Each HA submitted one response that summarized the input from staff. Water suppliers were contacted individually and interviewed over the phone. The interviews followed a questionnaire format (Appendix B), and encouraged any other points the water suppliers wished to bring up. Results for HAs and water suppliers are summarized separately below.

6.1 Health Authority Survey Results

The survey of HAs requested information about specific usage data and also requested specific comments or suggestions to improve the process.

6.1.1 Usage data

The uptake of the TDT was lower than anticipated with approximately 46 of 812 potential water suppliers (6%) participating in the process. The uptake was higher in the Interior HA, where 40 of the 46 participants were located; however this still only represents 9% of the potential water suppliers. It should be noted that the overall number of water suppliers accounted for in the survey was 25% lower than that stated in the Provincial Health Officer (PHO) report, so the survey data may only represent 75% of the population.

The survey requested data about the communication between water suppliers and the DWO relating to turbidity events. During the period of April 2009 to November 2010 water suppliers contacted the DWO 77 times about turbidity related events. Two of these notifications (3%) were the result of the water supplier and the DWO working through the TDT. (This estimate is likely low since the HA's do not consistently record this level of detail for water notifications.)

The survey also explored the resulting advisories and notices issued, as compared to those related to TDT usage. 60 BWN, 40 WQA and 1 PWC was issued during the period of April 2009 to November 2010. None of can be attributed to the TDT process due to lack of tracking.

6.1.2 HA Comments and Suggestions

Comments

1. Water suppliers have interpreted the decision tree without Drinking Water Officer (DWO) consultation. Delays in issuing public notification may have exposed the public to risk.
2. Water suppliers have approached DWOs with last minute requests for assessments despite our having asked for plans months in advance.
3. Friction has developed between DWOs and some water suppliers regarding interpretation of the decision tree.
4. Box 6 of the decision tree has shifted responsibility for demonstrating risk to the DWO from the water suppliers. Some suppliers have chosen not to develop plans but engage with DWOs with the expectation of a prescribed approach.
5. The value of enhanced monitoring suggested under Box 6 is unclear as it delays action to provide public notification. Investigation (e.g. source assessment, sampling) needs to happen before the event occurs.
6. Box 8 has been problematic, assessment results tend towards a moderate or high risk.
7. The explanatory note for Box 10 results in a great deal of subjectivity. The TDT should provide direction to support greater consistency.
8. The TDT remains inconsistent with practices in other jurisdictions. This makes communicating our approach in terms of international and national expectations of water safety difficult.

Suggestions for improvement

1. The debate around and implementation of the decision tree paralleled the role of the health authority and DWO's responsibilities for administering the DWPA. While the decision tree provides value it needs to be clearly aligned with the DWPA and legislation. When conducting the evaluation we suggest you seek out not only gaps with the decision tree itself but issues caused by the process by which it has been implemented.
2. The decision tree should clearly state that water suppliers are to apply this tool in consultation with their DWO.
3. The decision tree should reflect an evidence-based approach that is protective of public health. Where there is a lack of evidence the tree should prescribe appropriate notification be provided to the public. Any event exceeding 1NTU should be considered to pose an elevated risk unless an existing response plan that clearly articulates the rationale for the system being considered at low risk is in place.
4. Eliminating the WQA for turbidity should be considered. It's ambiguous to most of the population and fails to account for risks inherent to these water systems. Populations at increased risk should be encouraged to use boiled water or water from alternate sources at all times. If the WQA is used the considerations for assessing risk during periods of turbidity between 1 and 5NTU should be elaborated upon including a specific link to the advice for immuno-compromised persons provided in BC HealthLink File #56.
5. The definition and intent of "normal operating conditions" under Box 1 needs to be expanded upon. Systems often have seasonal reoccurring conditions that may pose an elevated risk. Non-freshet events (e.g. landslide) should be treated as high-risk until evidence is provided to suggest otherwise. The concept of acceptable water system operating parameters should be included in

the definition.

6. Boxes 2, 3 & 4 do not specify whether the given ranges (<1, 1-5, >5) are to be considered over a specified time period (i.e. 24 average) or a single event. Further elaboration is needed on this and what information is needed when considering if a notice should be lifted.
7. Additional detail regarding the risks associated with systems that blend water to decrease turbidity (e.g. District of Summerland) and those that use sedimentation without filtration (e.g. Greater Vernon Water, Black Mountain Irrigation District) is needed. Neither of these scenarios meets Canadian drinking water guidelines and the risk is difficult to quantify.
8. The turbidity advisory is meant to address the immediate health concerns associated with turbidity levels that can compromise disinfection. My question is does it not make sense to get into the THM discussion and include it in this document. With the persistence of low turbidity levels in the absence of effective filtration, should there not be an advocacy to reduce the levels of turbidity and mitigate the long-term health effects associated with the formation of THM's (CDWQ Guidelines MAC = 100 mg/L). Because there is a relationship between turbidity and formation of THM's (TOC's contribute to turbidity levels and chlorinating TOC's results in the formation of THM's) there is a public education element to this. Advocating turbidity management to reduce the effects of THM would not have any application in the decision making process of public notification for WQA and BWN's, but it might in the Public Water Communications which is about improving water quality. If this is the only provincial document on turbidity management would this not fit in with the TOR.

6.2 Water Supplier Survey Results

Request for interviews were sent to 17 water suppliers along with the material for the survey. 14 were interviewed, 1 declined to participate and 2 were unavailable.

6.2.1 Water Supplier Background

All water supplier data and comments were given based on the portion of their water supply that originated from surface water (60% river and 40% lake sourced) and the portion of water distributed that was not filtered. Four suppliers also have some filtration supply and 6 have some groundwater sources.

The population served by respondents ranged greatly from 1000 up to 2.3 million people. Agriculture connections were primarily in the Okanagan, but ranged as far west as Chilliwack and as far north as McBride. Annual volumes of supplied drinking water were as low as 135 ML up to over 400,000 ML. Treatments were all chlorination, and 35% of respondents had dual filtration (UV 28%; Ozonation 7%).

The main cause of turbidity affecting systems interviewed was freshet, but extended to lakeshore and creek bank erosion (wind events and windfall), lake turn-over and calcite precipitation, glacial sediment and animal disturbance.

6.2.2 Usage Data

The sophistication of the systems interviewed varied with respect to turbidity monitoring and usage of the decision tree. 71% are regularly sampling for turbidity with 64% collecting data from in-line

monitoring equipment. The remaining 29% did not give sufficient details or are not collecting turbidity data. Most water suppliers that are sampling for turbidity have data that covers over 5 years.

Awareness and use of the Decision tree also varied. 50% were aware of the tree and these suppliers are either using the MoH supplied TDT or a similar HA version of the tree. Of those using the TDT, there were 26 reports to the DWO related to turbidity since the inception of the tree, averaging 3.25 per water supplier. Of these 26 turbidity related reports to the DWO, 6 (23%) resulted in a notice to the public due to water quality. This number is not consistent with the data from the HAs, but is likely due to the fact that the HA's do not consistently record this level of detail for water notifications.

6.2.3 Water Supplier Comments and Suggestions

Suggestions summary:

1. Expand the tree to include a similar trigger of 100 total-coliforms before treatment if there is not crypto treatment (UV). Over 20 e-coli consider WQA and/or over 1NTU.
2. The TDT needs some consideration of the source water quality. If the source water quality is very good then minor fluctuations in NTU levels are not a concern and PWC are unnecessary.
3. The tree doesn't have a way of taking into account system history or trends that they have recorded in their system, such as normal colour, usual turbidity levels, etc. Maybe a way of judging things from the historical standard (i.e. 10%, 50% off of the standard) rather than arbitrary NTU levels?
4. Suppliers often deal with fluctuations in turbidity through modification of treatment, so public communication is felt to be unnecessary when they are mitigating the risk. However, they would communicate with the DWO regarding a change in treatment regimes as they adapt to increased turbidity and maintain a record of this in case of public concern.
5. The weakness is messaging fatigue. If there is no risk but there is a change in the water appearance what is the message?
6. Create a guide to effective public notification.
7. Make the digital version more user friendly by adding pop-up comments to the boxes to integrate Appendix A.
8. Clarify that a higher NTU means a trigger for communicating with the DWO and not always public notice. It is unfair to direct them based on turbidity only. It seems DWOs do not value the extra effort they put into ensuring the water is safe, just focus on the NTUS.
9. Clarify that action and communication with the DWO is based on diversion from 'normal operating' turbidity levels, so if 1.5 NTUs is normal for the spring then no communication should be expected.
10. Box 9, increased risk needs more guidance. The issue with the tree is the interpretation of whether the risk level is raised or not. How to define there is no increased risk.
11. Add Trihalomethanes (THM) to Appendix B and Appendix A as a risk factor.
12. Add potential to close-off turbid source from the system.
13. Make font and arrow clear for photocopying.
14. With lack of a better option, the "other risk factors to consider" need to be clarified. Also I am not sure how in Appendix B turbidity increasing is a risk of turbidity increasing.
15. Felt that the appendices were probably fine for the DWO but that it may need to be adjusted to be understood by the "guy in the coveralls" who is operating the system.

Box specific comments:

1. As the chart is designed, box 6 works for Boxes 3 and 5, but it doesn't work for box 7 because risk assessment is already an inherent part of box 7 – the No arrow from Box 7 should go directly to Box 12. Also the text in Box 12 should be re-worded to say "If the appearance of the water

changes or is expected to change issue public health communication and provide the reason for the communication.”

2. Box 6 – Enhanced monitoring likely wouldn’t be relevant here because of the time involved. The decision on whether or not there is increased risk will be immediate in most cases.
Box 10 – this part of Appendix A is shown as “Uncertain Risk” on the chart but the title (in the text) Issue Water Quality Advisory which means the box and text are out of synchronization. It appears that this lack of synchronization is carried through the rest of Appendix A.
3. Comment on Appendix B: Agree with points 2, 3, 5 and 6 but not points 1 and 4. Point 1 really doesn’t say anything and point 4 is too long-term in nature. Under “Other Risk Factors” generally do not agree with them, especially points 1 and 3. Regarding point #2, if there is evidence of pathogens in the system wouldn’t it already be under a BWN?
Another risk factor that might be considered as part of the decision process is the reliability of water treatment – eg. a higher risk of losing treatment due to a power outage associated with heavy rainfall.

7 Suggested Revisions to the TDT

There have been many great suggestions covered during the evaluation. Some are directed at the delivery of the concept, some at the way the TDT is implemented, and some are specific to the TDT and its appendices. These specific comments were used to revise the TDT, and as a result several options are displayed in Appendix C.

Option 1: The concept of integrating raw water e-coli and total coliform testing into the decision tree is displayed in this version. This concept has a few key limitations, including that only some water suppliers are set up to take raw water sample and analyze for coliforms (e.g. colilert) and the delayed nature of the testing results. Even presence absence testing done in-house will take no less than 18 hours to complete, which is too long to wait to avoid risk of illness. It could be considered as evidence to rescind a notice before lab testing is returned where time is of the essence (e.g. the day before a long weekend where waiting for the lab results will mean the BWN would be extended until the following working day, inconveniencing the public unnecessarily).

Option 2: This option is similar to the original TDT, and so will be easiest to integrate. However, this version does not adequately address the issues raised with respect to the ability to clarify the meaning or interpretation of increased/decreased or high/medium/low risk.

Option 3: Here the concept of proving there is a certain risk level has been removed and replaced with the determination of the past history of similar turbidity events. So the supplier would come to the DWO with notice of a turbidity level above normal, but will also need to have data showing that similar turbidity events under similar conditions in the past have proven safe based on testing. Otherwise some sort of notice will be required.

As per agreement at DWLC the Public Water Communication option has been removed from the tree options. The definition of a Water Quality Advisory and a Boil Water Notice needs revision and

clarification. How do we interpret the difference consistently between a BWN and a WQA? In order to make this work there would need to be some quantitative factors or at least defined qualitative risk rankings based on tangible data that can be derived in the short time-window available. We also need to revisit the definitions in the DWO guide of these terms, as they are overly subjective.

Suggestions pertaining to the appendices:

Need to add information to the appendix for box 1 to clarify that a freshet that normally happens each spring and results in X NTU is not normal operating conditions and thus needs to be communicated to the DWO. This does not mean that it will result in a BWN if there is historic information showing testing does not show increased pathogens at this level during this season fluctuation. But this argument would not hold for a case where an unexpected turbidity event was encountered.

Box 6 follows the same logic as the added explanation for box 1 above, wherein the only reasonable explanation to justify that there is no increased risk would be based on historic information. All other evidence would take at least a day.

Summary:

Unless we can sufficiently answer the health risk question, then the tree needs to be revised to reflect only if there is sufficient historic data to suggest that the risk of elevated path levels associated with the turbidity event are very low (i.e. Option 3).

Upon revision of the TDT diagram, work will commence on revising the Appendix A and B portions. This will not be started until then since any change to the tree will have an associated impact on the Appendix.

8 Next steps

In order to proceed with the TDT revision and implementation there are several action that should be completed:

1. Revise the tree to reflect any changes suggested by MoH, DWLC and IHA.
2. Revise the definitions of WQA and BWN to reflect a quantifiable distinction.
3. Re-write Appendix A based on new format.
4. Consider the needs for Appendix B and re-write or delete.

Additionally

8.1 Changes to the TDT

Option 3 should be considered the model going forward. This is based on discussion at DWLC and a subsequent conversation with MoH and IHA. The tree should be re-titled to reflect it's primary function as a model for an SOP to be pre-approved between the DWO and the water supplier. This would include using historic data and information to create pre-determined scenarios that would result in low risk (e.g. spring freshet in June resulted in no elevated path for the past 5 years, and the additional turbidity is mainly inorganic). The secondary function would be use during an event that is not expected. In this

case the example would be related to the organic content potential and likely result in a BWN if the event cannot be related to historic unexpected events such as landslides of inorganic material.

Create a new numbering system on the TDT for reference to Appendix A. This will need to be done in Visio, and Steve Baumber has the software and experience in the program.

8.2 WQA, BWN Definitions

The definitions in the DWO guide are ambiguous, and thus are not particularly useful to the water supplier and DWO when deciding the level of severity that would distinguish between the two. (e.g. WQA could be revised to state “The DWO agrees there is a low level of risk, but a need to notify the public exists”). The new definitions should be quantifiable or at least qualifiable, such as “Historic evidence supports a low risk in the situation, but the appearance and risk level is altered from normal operating conditions.

8.3 Re-write Appendix A

Appendix A is now outdated since many of the boxes have changed and the purpose is modified. The new wording needs to be very clear and specific to the point made in the associated box. Include as attachment is some earlier revisions of the old wording.

8.4 Reconsider Appendix B

Appendix B has some comments in the water supplier suggestions. This document should be re-written completely or removed. The original reason to offer this clarification may no longer be of benefit.

9 Appendix A, Health Authority Question

Questions for Health Authorities:

Please answer the following questions directly within this Word document and resave with the HA name in the file name.

1. The following questions draw information about the current utilization of the TDT within each HA:
 - a. Were water suppliers notified of the TDT and encouraged to participate in the process? If so, how many participate with the DWO in the TDT process?
 - b. Approximately how many water suppliers are in your Region that **could** make use of the TDT, but do not participate with the DWO in the process? Please explain the reasons (e.g. not aware, unwilling, following alternate process...).
 - c. Approximately how many water suppliers are in your Region that **could not** make use of the TDT? Please explain the reasons (e.g. fully filtered system, deep well water source...).
 - d. How many known water suppliers are in your HA? Note: this number should equal the total of the answers given in questions a, b and c.

2. The following questions outline the current and potential effectiveness of the TDT:
 - a. How many turbidity notifications were received by your office since April 2009? How many of the turbidity notifications were the result of water suppliers and the DWO participating in the TDT process (please estimate if this data is not recorded).
 - b. Since April 2009 in the HA, please provide the number of incidences for the following. If data is available, please specify how many originated with a turbidity notification:
 - i. Boil Water Notice
 - ii. Water Quality Advisory
 - iii. Public Water Communication

3. The final questions investigate the satisfaction with the TDT and generate feedback to improve the process:
 - c. Please provide a contact list of water suppliers who have participated in the TDT process and detail any feedback received.
 - d. Please offer detailed comments about the usefulness and clarity of the TDT, specifically:
 - i. Any strengths and weaknesses you perceive in the stepwise process.
 - ii. Specific areas in the TDT that would benefit from improvement/clarification. Please suggest alternate flow or wording.
 - iii. Do you find Appendix A: Explanatory Notes to the Decision Tree for Turbidity useful and easy to follow? To help improve, please specify the box number and any suggested wording change.
 - iv. Do you find Appendix B: Factors That May Increase the Risk of Human Disease with Rising Turbidity useful guidance? If not, please explain and offer alternate suggestions if applicable.

4. Please provide any other comments/concerns not covered by the questions above.

10 Appendix B, Water Supplier Questions

Questions for Water Suppliers:

Pre screen Questions

1. Does your system include full filtration as a treatment? If yes for all water supplied, the TDT is not applicable.
2. Is your water source surface water?
3. If not surface water is your water source a well under direct influence of surface water (GWUDI)? If the answer to questions 2 and 3 are no (i.e. protected well source), the TDT is not applicable.
4. Do you have turbidity monitoring equipment? Only 1 "no" of 3 per Health Authority (HA)

Water Supplier Background

1. Where are you located?
2. What is/are your water source(s) (Lake, river, spring, shallow well, deep well)?
3. How many homes or people do you supply? Industries? Agricultural operations?
4. What volume do you supply annually? Daily?
5. What treatment(s) is (are) done to the water supply?
6. What are the causes of turbidity in your source area?
7. Are your turbidity levels tracked and recorded? If so, how many years of data do you have?

Turbidity Decision Tree

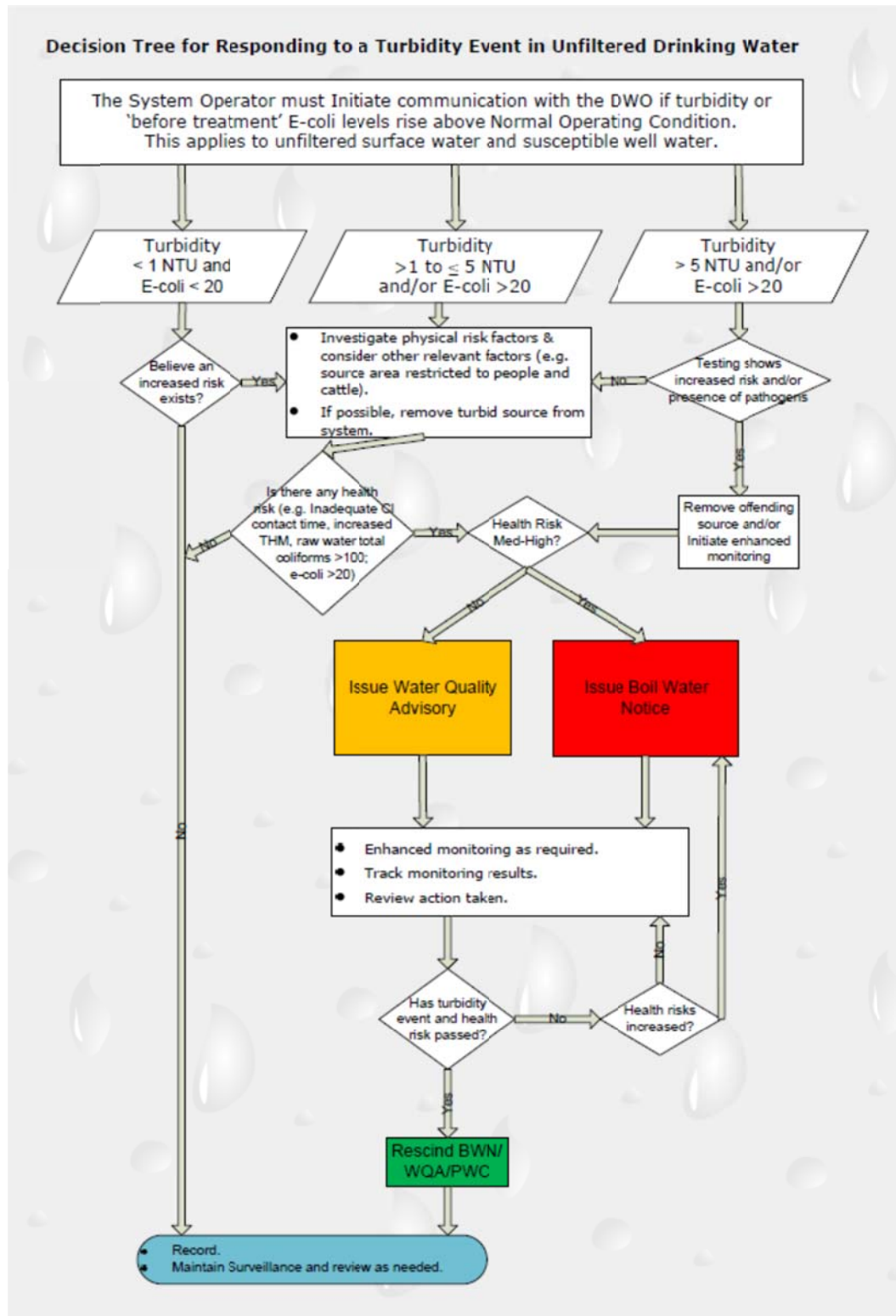
8. Are you aware of the Turbidity Decision Tree (TDT) and its function as a tool for responding to a turbidity event?
9. If yes, are you participating in the TDT process with the Drinking Water Officer (DWO)?
10. If you are not using the TDT, please review the tree and appendices and proceed to question 18.

Turbidity Decision Tree Improvement Ideas

11. How many events, related to turbidity, were reported to the Drinking Water Officer (DWO) since April 2009?
12. How many of the turbidity related notifications since April 2009 resulted in Boil Water Notice (BWN)? Water Quality Advisory (WQA)? Public Water Communication (PWC)?
13. If you have had turbidity events that contributed to the issuance of a BWN, WQA or PWC, was the TDT helpful to rationalize this decision? Please explain.
14. Have there been cases where turbidity less than 1.0 NTU contributed to the issuance of a BWN, WQA or PWC? Please explain.
15. Was the TDT helpful in this case? If the TDT was not used, please indicate if you feel using the TDT would have been helpful.
16. Please offer detailed comments about the usefulness and clarity of the TDT, specifically:
 - a. Any strengths and weaknesses you perceive in the stepwise process.

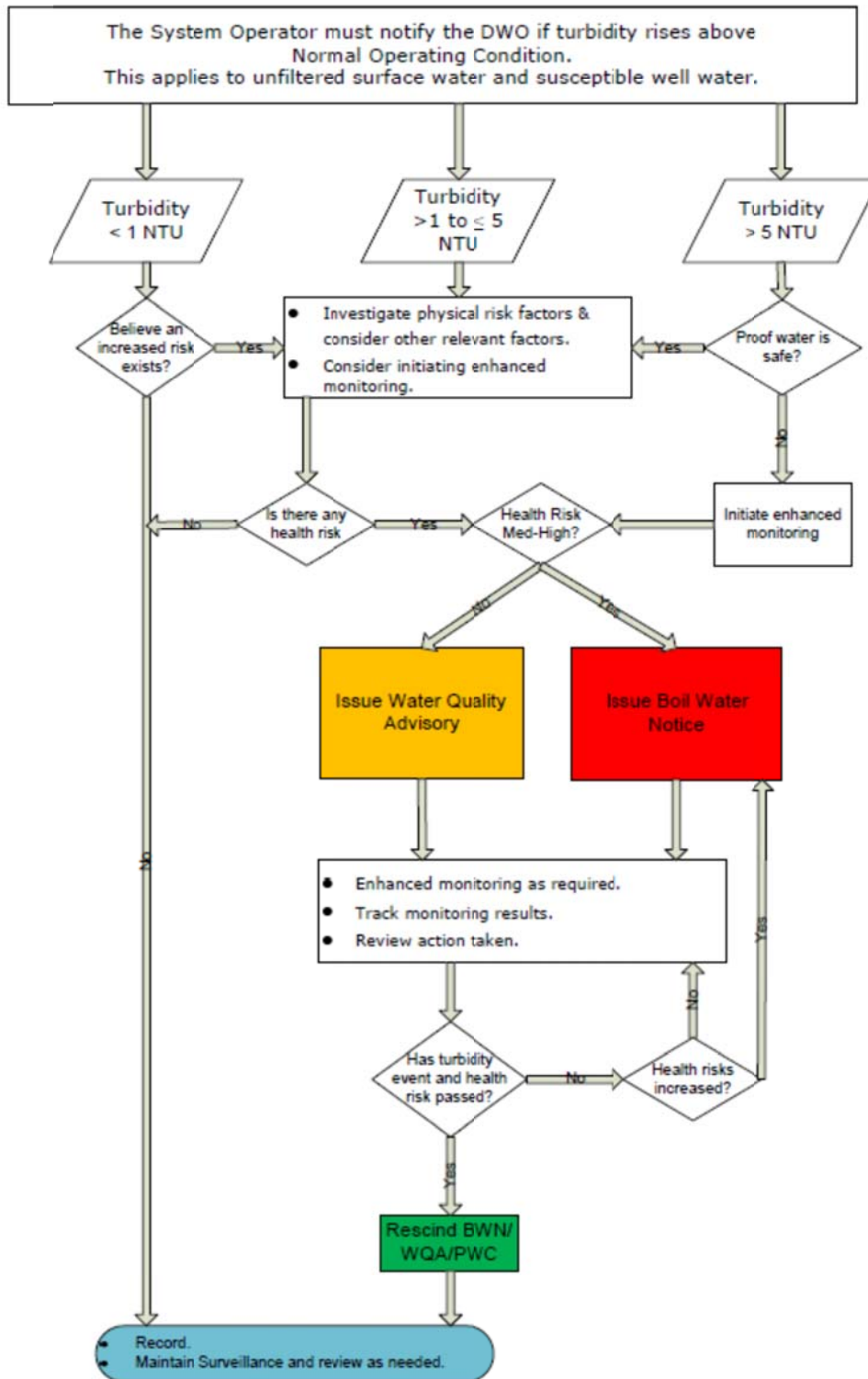
- b. Specific areas in the TDT that would benefit from improvement/clarification. Please suggest alternate flow or wording.
- c. Do you find Appendix A: *Explanatory Notes to the Decision Tree for Turbidity* useful and easy to follow? To help improve, please specify the box number and any suggested wording change.
- d. Do you find Appendix B: *Factors That May Increase the Risk of Human Disease with Rising Turbidity* useful guidance? If not, please explain and offer alternate suggestions if applicable.
- e. Please provide any other comments/concerns not covered by the questions above.

11 Appendix C, Option 1:

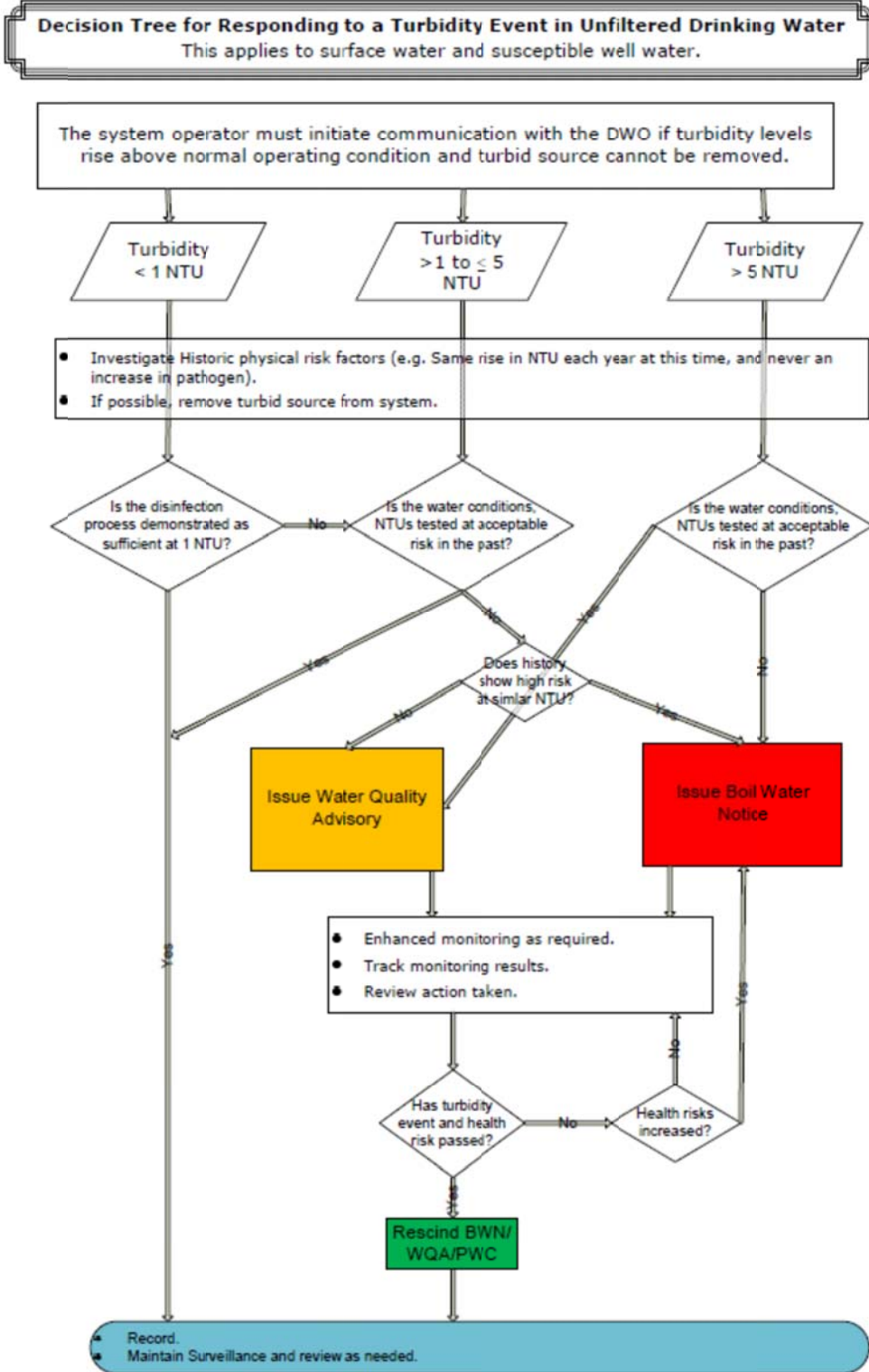


12 Appendix D, Option 2:

Decision Tree for Responding to a Turbidity Event in Unfiltered Drinking Water



13 Appendix E, Option 3:



14 Appendix F, Survey Data

Please refer to the Excel document “TDT Survey Data Final” including one worksheet for the Health Authority survey data and a second worksheet with the water supplier survey data.