Water Quality Considerations for Diving in the Zoo and Aquarium Industry:

Chemical Treatments of Water Systems

Obvious goals of the zoo and aquarium industry include ensuring healthy animal collections and maintaining visually pleasing exhibits, but a main function of these facilities is also to ensure the safety of staff, volunteers, and guests. Divers routinely dive to maintain the aesthetic of the exhibits, make repairs, provide and participate in visitor experiences, or work with the animals that occupy the habitats. Concurrently, medical or systemic treatments critical to animal health goals are often performed in these same exhibits. The purpose of this document is to address the issue of diver safety in water that has undergone medical or systemic treatments. It is important to note that this document focuses on exposure to water treatments by chemical addition but does not assess medical or physiological effects of chemicals on human health. Institutions must remain aware of the inherent risks of diving within a zoo or aquarium setting and should perform applicable risk management assessments for all diving programs.

Considerations Regarding Chemicals in Water:

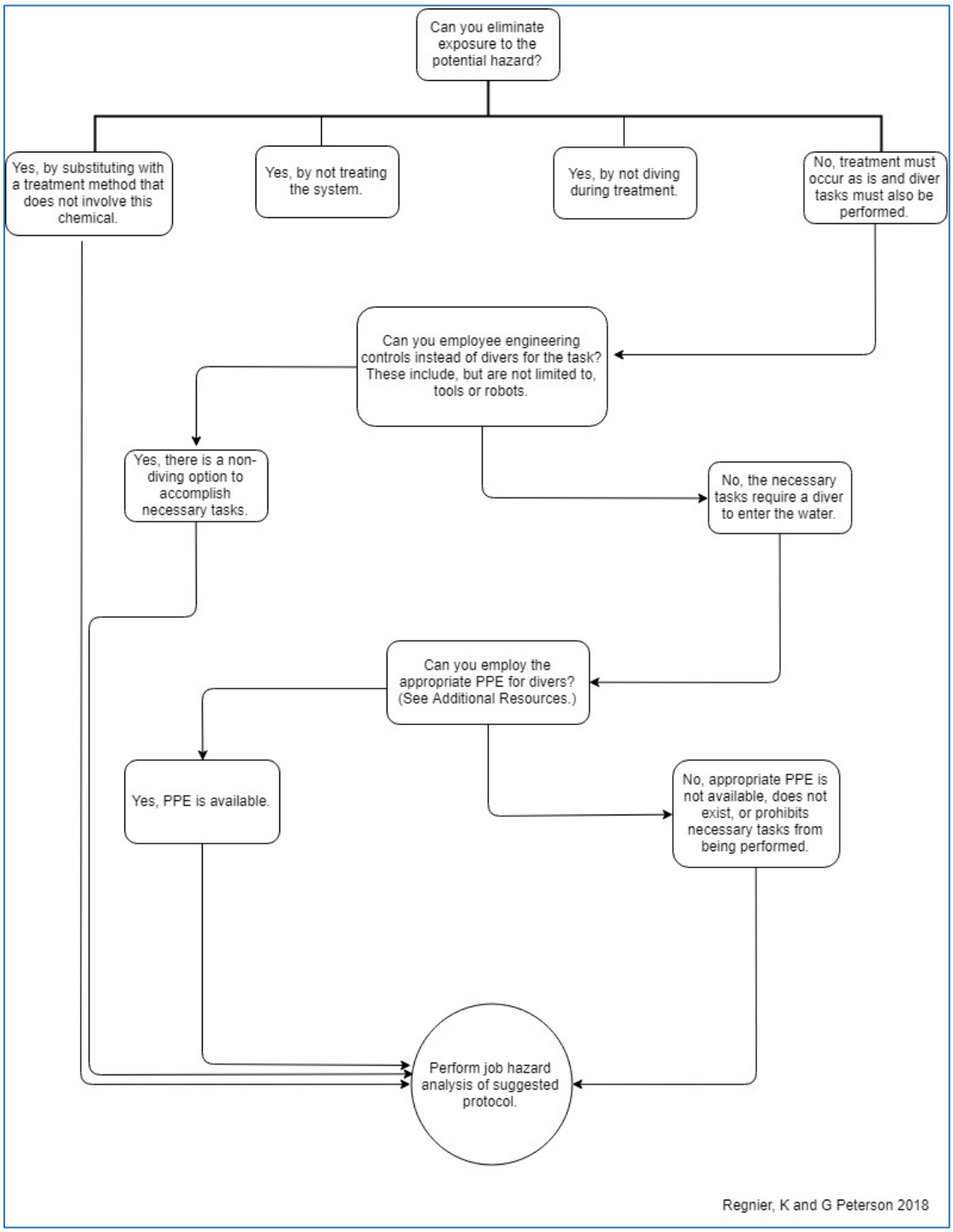
Many of the chemical treatments and medications commonly applied to seawater and freshwater exhibits or holding systems are untested for the effects of human immersive exposure typically experienced by a diver. Additionally the behavior and fate of many chemical treatments after they have been applied to water is also unknown or varies widely based on system conditions. The breakdown or removal process and residence time of a chemical can depend heavily on the water chemistry, the exhibit substrate, the plants and animals present, the microbiota, filtration, water flow, temperature, age of exhibit, and other variables. In addition, the end components or byproducts after a chemical is broken down are sometimes not fully understood, and these byproducts themselves may have not been assessed for safety of human exposure via immersion. In addition, many chemicals are unable to be readily analyzed on site for concentration, making the point at which a chemical is no longer present in the water difficult to accurately determine. Consequently, it is challenging to establish effective protocols for immersion safety that are consistent and ubiquitous across treatment protocols and facilities.

Therefore, it is recommended that institutions perform a risk assessment before each occurrence of human entry into a body of water that has been treated with a chemical or medication. Institutional protocols should then be established to appropriately assess and address diver exposure to each chemical treatment present in water.

Risk Analyses:

A comprehensive risk analysis process should be established by an institution in order to address the exposure of divers to chemicals present in a body of water. When undertaking a risk analysis, identify and evaluate the potential risk(s), then analyze the potential hazard(s) involved in the risk to determine all possible ways to accomplish the task while controlling said risk to an acceptable level. OSHA defines a hazard as “the potential for harm.” In practical terms, a hazard is a condition, practice, or activity that, if left uncontrolled, could potentially result in an injury or illness. Identifying hazards and eliminating or mitigating them as early as possible can help prevent both acute and chronic injuries and illnesses, will lead to more efficient and effective operating procedures, will assist with training employees to a more standardized and uniform process, and can ultimately reduce lost work time and workers’ compensation costs.

Below is an example employment of the Hierarchy of Controls to assess a chemical treatment in water as a potential hazard to divers. The Hierarchy of Controls is a tool used widely in industry to minimize hazard exposure. Please note that Administrative Controls, which include written protocols, training requirements, scheduling, communication, and documentation, are an integral part of the entire analysis and should be employed throughout this process. More information about the Hierarchy of Controls can be found in Additional Resources.



Job Hazard Analysis:

Once a protocol has been decided upon after an initial risk analysis, the protocol itself should be analyzed utilizing a **job hazard analysis** (JHA). A JHA is a process that focuses on specific job tasks to identify and evaluate hazards before they occur. The table below illustrates a sample JHA form for a task associated with a repair dive in a saltwater exhibit. Please see Additional Resources for more information on conducting a JHA.

***Job Location*:** Tropical Paradise	***Analyst*:** Joe Safety	***Date:***
***Task Description*:** Divers scuba dive to enter Tropical Paradise for 30 minutes in 75 degree water in order to repair a misplaced drain cover.		
Hazard Description: Water contains 5.0ppm praziquantel. Task requires full diver immersion.		
Hazard Controls: 1. Appropriately trained divers wear positive pressure full face masks mated to a dry hood with dry gloves, and a decon compatible "slick" exterior and/or helmet with a latex neck dam. 2. Trained divers wear Hazmat drysuit. 3. Trained divers wear attached protective gloves and hood. 4. Employ appropriate de-con procedures post dive.		

Conclusion:

In conclusion, it is important to remember that it is difficult to establish a ubiquitous safety protocol for the diverse zoo and aquarium industry. Therefore, is imperative that each institution, and its divers, be aware of the chemical treatments performed on its exhibits, the potential human exposure to each of these chemicals, and the potential hazards associated with such exposure in their particular institution. Institutional risk analyses for diving protocols are not only best practice, but are crucial to pragmatic and thorough risk management models.

NOTE: No type of diving full face mask and/or helmet, exposure protection or post dive de-con procedures can guarantee complete protection from exposure to contaminants underwater, but they can reduce the likelihood or severity of illness.** ***G McFall et al [2017] NOAA Diving Manual, 6th Edition Best Publications, Solano Beach, CA

***Divers should employ procedures consistent with the OSHA standard 29 CFR 1910.120 (HAZWOPER) or equivalent program as well as the U.S. Environmental Protection Agency Diving Safety Program's minimum PPE and standard decontamination procedures.**

Additional Resources:

Hierarchy of Controls: Recommended Practices for Safety and Health Programs
https://www.osha.gov/shpguidelines/hazard-prevention.html
https://www.osha.gov/dte/grant_materials/fy10/sh-20839-10/hierarchy_of_controls.pdf

Job Hazard Analysis Formulation
https://www.osha.gov/pls/publications/publication.athruz?pType=Industry&pID=116

US EPA Dive Program: Dive PPE and Decontamination Procedures
https://www.epa.gov/diving/epas-diving-safety-program

Appendix O Standard Decontamination Procedures

Appendix L Biohazards of Diving Operations and Aquatic Environments

Also see: **https://www.epa.gov/diving/diving-publications**

To purchase the NOAA Diving Manual
https://www.omao.noaa.gov/connect/faq/noaa-diving-manual

OSHA Standard 1910.120 - Hazardous waste operations and emergency response
https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=9765

AZA Zoo and Aquarium Safety Example Practices; list of common chemical treatments used in aquariums
https://www.speakcdn.com/assets/2332/safety-example-practices-for-aquariums-zoos-2015-.pdf

Association of Dive Program Administrators: Risk Management
https://adpa.org/adpawp-47/wp-content/uploads/ADPA-Risk-Management-101.pdf
Diving Best Practices for the Zoo and Aquarium Industry