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Literature review on appropriate health-based standards for direct and indirect potable reuse as well as various non-potable reuse scenarios

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Literature review on appropriate health-based standards for direct and indirect potable reuse as well as various non-potable reuse scenarios

Literature review on appropriate health-based standards for direct and indirect potable reuse as well as various non-potable reuse scenarios

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BACKGROUND

This document is part of a larger study funded by the U.S. Environmental Protection Agency (EPA) working to accelerate community readiness for potable and non-potable reuse of rainwater, stormwater, agricultural runoff/return flow and municipal wastewater:

Funding Opportunity Title: National Priorities: Water Innovation, Science, and Engagement to Advance Water Reuse

Grant Number: 84046101-0

Project Title: Accelerating technical and community readiness for water reuse in small systems

Project Summary

Objectives: Water reuse is an increasingly important response to water stress; however, major advancements in water reuse have neglected small, rural communities that comprise most public water systems. The objective of this project is to accelerate water reuse adoption in rural communities by increasing technical and community readiness. The general hypothesis is that community readiness for water reuse in small systems can be accelerated by a convergence of technical, informational, social, and institutional innovation. Also, we hypothesize that severe water scarcity need not be a prerequisite for water reuse implementation, given careful attention to windows of opportunity that integrate multiple community concerns.

Approach: Barriers to water reuse adoption are intertwined and complex. Therefore, our proposed work will be an integrated research and engagement program in which we: (1) address knowledge gaps and generate frameworks for overcoming these barriers, and (2) use research outputs to evaluate and accelerate community readiness for reuse in five case studies. Both general activities will be executed in parallel such that knowledge can be co-produced with decision-makers. Specific methods to address knowledge gaps include community surveys, the use of a prototype calculation engine, and desktop, bench-scale and pilot-scale evaluations of treatment technologies. Specific methods to accelerate community readiness include legal and policy analyses and case-study evaluations of five small water systems.

Expected results: This project is expected to produce outputs and outcomes that lead to acceleration of community readiness for reuse in small systems. Specifically, key results include modular, decision support tools such as water inventories, technology databases, and cost and demand curves for reuse. These outputs will be integrated into institutional and regulatory decision-making processes in small, rural, underserved communities with results made available to communities through workshops, outreach events, and publications. We will go through many iterative processes throughout the project in which feedback from small community members and stakeholders will inform the modifications of tools and outputs so that they are indeed meaningful and useful to small communities facing unique challenges.

INTRODUCTION

The water quality required for various sources waters and end uses is typically determined by regulatory standards. Standards for water reuse, however, are largely unclear and not well-defined in many regions. Thus, a literature review was completed on appropriate health-based standards for direct and indirect potable reuse as well as non-potable reuse scenarios. The review scanned existing water quality standards for water reuse around the world including but not limited to California Title 22, relevant Texas administrative codes, European standards, and World Health Organization guidance.

Below is a summary of conclusions drawn from our scan of current water reuse guidelines and regulations in California, Rhode Island, Texas, Iowa, Massachusetts, European Union, Canada, Australia, Israel, and Japan. The focus is on the *most common* specifications for each water quality parameter, drawn from all existing regulatory standards that were researched.

Guidelines and regulations from Canada include federal guidelines as well as British Columbia regulations. Australia includes federal guidelines as well as guidelines from Victoria.

Guidelines and regulations from Canada, Israel, Australia, and Japan are categorized by end use in a way different from those of the U.S. states. Please note that, for the purpose of this document, assumptions were made to best categorize the aforementioned regulations into their appropriate end uses as used in this study. Some data was omitted from the scan.

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Turbidity

When using domestic wastewater for agriculture, specifically *food crops where the recycled water has direct contact with the edible portion*, the most common specifications fall in a range of **2-3 NTU**.

When using domestic wastewater for agriculture, specifically *non-food crops or crops where the water is not likely to have direct contact with the edible portion of the crop*, the most common specification is **2 NTU**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, the most common specifications fall in a range of **2-3 NTU**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specifications fall in a range of **2-3 NTU**.

The only regulation for using harvested rainwater for onsite non-potable reuse is in California, thus there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection, commercial laundries, car washes, snow making, or commercial cooling or air conditioning where mist is created*, the most common specifications fall in a range of **2-3 NTU**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, or street cleaning*, is from Texas, thus there is **no common specification**.

When using domestic wastewater for impoundment, specifically *unrestricted impoundments*, the most common specifications fall in a range of **2-3 NTU**.

The only regulation for using domestic wastewater for impoundment, specifically *restricted impoundments*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for potable reuse, specifically *indirect potable reuse*, is from Canada, thus there is **no common specification**.

The only regulation for using domestic wastewater for environmental restoration applications is from Massachusetts, thus there is **no common specification**.

The only regulation for using domestic wastewater for onsite non-potable reuse is from Colorado, thus there is **no common specification**.

Total Coliform*

The only regulation for using domestic wastewater for agriculture, specifically *food crops where the recycled water has direct contact with the edible portion*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for agriculture, specifically *non-food crops or crops where the water is not likely to have direct contact with the edible portion of the crop*, is from California, thus there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection, commercial laundries, car washes, snow making, or commercial cooling or air conditioning where mist is created*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, or street cleaning*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *restricted impoundments*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from California, thus there is **no common specification**.

Nitrogen

The only regulation for using domestic wastewater for agriculture, specifically *food crops where the recycled water has direct contact with the edible portion*, is from Massachusetts, thus there is **no common specification**.

When using domestic wastewater for agriculture, specifically *non-food crops or crops where the water is not likely to have direct contact with the edible portion of the crop*, the most common specification is **10 mg/L**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, is from Rhode Island, thus there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specification is **10 mg/L**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Massachusetts, thus there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection, commercial laundries, car washes, snow making, or commercial cooling or air conditioning where mist is created*, the most common specification is **10 mg/L**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, or street cleaning*, the most common specification is **10 mg/L**.

The only regulation for using domestic wastewater for environmental restoration applications is from Massachusetts, thus there is **no common regulation**.

The only regulation for using domestic wastewater for potable reuse, specifically *indirect potable reuse*, is from California, thus there is **no common specification**.

Phosphorus

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from Israel, thus there is **no common specification**.

Dissolved Oxygen

The only regulations for using domestic wastewater for agriculture, specifically *non-food crops or crops where the water is not likely to have direct contact with the edible portion of the crop*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from Israel, thus there is **no common specification**.

*E.Coli**

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, there is **no common specification**.

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible part of the crop and non-food crops*, the most common specifications fall in a range of **100-200 MPN/100 mL or 100-200 CFU/100 mL**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection, commercial laundries, car washes, snow making, or commercial cooling or air conditioning where mist is created*, there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, or street cleaning*, there is **no common specification**.

When using domestic wastewater for impoundment, specifically *restricted impoundments*, there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Texas, thus there is **no common specification**.

The only regulation for using harvested rainwater for onsite non-potable reuse is from California, thus there is **no common specification**.

The only regulations for using onsite collected waters for onsite non-potable reuse are from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for onsite non-potable reuse is from Colorado, thus there is **no common specification**.

Total Suspended Solids (TSS)

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water may have direct contact with the edible portion of the crop*, there is **no common specification**.

When using domestic wastewater for agriculture, specifically *non-food crops or crops where the water is not likely to have direct contact with the edible portion of the crop*, there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, the most common specification is **30 mg/L**.

When using domestic wastewater for landscape, *specifically irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specifications fall in a range of **5-10 mg/L**.

The only regulation for using onsite collected waters for onsite non-potable reuse is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Massachusetts, thus there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection, commercial laundries, car washes, snow making, or commercial cooling or air conditioning where mist is created*, there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, or street cleaning*, the most common specifications fall in a range of **10-30 mg/L**.

The only regulation for using domestic wastewater or potable reuse, specifically *indirect potable reuse*, is from Canada, thus there is **no common specification**.

The only regulation for using domestic wastewater for onsite non-potable water reuse is from Colorado, thus there is **no common specification**.

The only regulation for using domestic wastewater for environmental restoration applications is from Colorado, thus there is **no common specification**.

BOD₅

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water may have direct contact with the edible portion of the crop*, the most common specifications fall in a range of **5-20 mg/L**.

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, the most common specifications fall in a range of **10-30 mg/L**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, the most common specifications fall in a range of **10-30 mg/L**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specification is **10 mg/L**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, the most common specifications fall in a range of **10-20 mg/L**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, washing aggregate, street cleaning*, the most common specifications fall in a range of **20-30 mg/L**.

When using domestic wastewater for impoundment, specifically *unrestricted impoundments*, there is **no common specification**.

The only regulations for using domestic wastewater for impoundment, specifically *restricted impoundments* are from Texas, thus there is **no common specification**.

The only regulation of using domestic wastewater for potable reuse, specifically *indirect potable reuse* is from Canada, thus there is **no common specification**.

The only regulation for using domestic wastewater for environmental restoration applications is from Massachusetts, thus there is **no common specification**.

Total Chlorine Residual

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, is from Rhode Island, thus there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, the most common specification is **0.5 mg/L**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specification is **1 mg/L**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, the most common specifications fall in a range of **0.2-0.5 mg/L**.

pH

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water may have direct contact with the edible portion of the crop*, the most common specifications fall in a range of **6.5-8.5**.

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, the most common specifications fall in a range of **6.5-8.5**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, the most common specifications fall in a range of **6.5-9**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specifications fall in a range of **6.5-8.5**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Massachusetts, thus there is **no common specification**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, the most common specifications fall in a range of **6.5-8.5**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, washing aggregate, street cleaning*, the most common specifications fall in a range of **6.5-9**.

The only regulation for using domestic wastewater for environmental restoration applications is from Massachusetts, thus there is **no common specification**.

CTa

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from California, thus there is **no common specification**.

F-specific bacteriophage MS-2 or poliovirus

When using domestic wastewater for agriculture, specifically *food crops where the edible portion is in direct contact with the recycled water*, the most common specifications fall in a range of **5- to 6-log reduction**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from California, thus there is **no common specification**.

Enteric Viruses

When using domestic wastewater for agriculture, specifically *food crops where the edible portion is in direct contact with the recycled water*, the most common specifications fall in a range of **5- to 6-log reduction**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundment*, is from California, thus there is **no common specification**.

Giardia lamblia

The only regulations for using domestic wastewater for potable reuse, specifically *indirect potable reuse*, are from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for potable reuse, specifically *direct potable reuse*, is from Texas, thus there is **no common specification**.

Cryptosporidium

The only regulations for using domestic wastewater for potable reuse, specifically *indirect potable reuse*, are from California, thus there is **no common specification**.

The only regulation for using domestic wastewater for potable reuse, specifically *direct potable reuse*, is from Texas, thus there is **no common specification**.

Fecal Coliform*

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, there is **no common specification**.

When using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, the most common specifications fall in a range of **0-2.2 MPN/100 mL or CFU/100 mL**.

When using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, the most common specification is **0 MPN/100 mL or CFU/100 mL**.

When using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, washing aggregate, street cleaning*, the most common specifications fall in a range of **100-200 MPN/100 mL or CFU/100 mL**.

The only regulation for using domestic wastewater for impoundment, specifically *restricted impoundments*, is from Texas, thus there is **no common specification**.

When using domestic wastewater for impoundment, specifically *unrestricted impoundments* there is **no common specification**.

The only regulation for using domestic wastewater for potable reuse, specifically *indirect potable reuse* is from Canada, thus there is **no common specification**.

The only regulation for using domestic wastewater for environmental restoration applications is from Massachusetts, thus there is **no common specification**.

Enterococci*

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, is from Texas, thus there is **no common regulation**.

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, is from Texas, thus there is **no common regulation**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of areas where human access is restricted*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, washing aggregate, street cleaning*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *restricted impoundments*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Texas, thus there is **no common specification**.

CBOD₅

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the applied reclaimed water is not likely to have direct contact with the edible portion of the crop and non-food crops*, is from Texas, thus there is **no common specification**.

When using domestic wastewater for landscape, specifically *irrigation or areas where public exposure is controlled such as golf courses or parks that have controlled times of operation*, there is **no common specification**.

The only regulation for using domestic wastewater for landscape, specifically *irrigation of landscapes that members of the public are likely to come into contact with or where public access is unrestricted*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from Texas, thus there is **no common specifications**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *commercial cooling or air conditioning where mist is not created, dust control, soil compaction, mixing concrete, washing aggregate, street cleaning*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *restricted impoundments*, is from Texas, thus there is **no common specification**.

The only regulation for using domestic wastewater for impoundment, specifically *unrestricted impoundments*, is from Texas, thus there is **no common specification**.

UV Dose

The only regulation for using domestic wastewater for agriculture, specifically *irrigation of food crops where the reclaimed water may have direct contact with the edible portion of the crop*, is from Colorado, thus there is **no common specification**.

The only regulation for using domestic wastewater for other centralized non-potable reuse, specifically *toilet and urinal flushing, fire protection in internal sprinkler systems or external fire hydrants, commercial laundries and car washes, snowmaking, commercial cooling or air conditioning where mist is created*, is from Colorado, thus there is **no common specification**.

* Among microbial specifications, there is a disagreement between reporting units. The commonalities in this document are made upon an assumption equating 1 MPN/100 mL and 1 CFU/100 mL. Because of this assumption, there are limited common specifications drawn from the microbial parameters.

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