SUMMARY NOTES OF THE APRIL 17, 2024, MEETING OF THE TECHNICAL ADVISORY COMMITTEE FOR *A CHLORIDE IMPACT STUDY FOR THE SOUTHEASTERN WISCONSIN REGION*

INTRODUCTION

The April 17, 2024, meeting of the Technical Advisory Committee (TAC) for *A Chloride Impact Study for the Southeastern Wisconsin Region* (Study) was convened online at 10:03 a.m. The meeting was called to order by Committee Chairman Thomas M. Grisa, Director of Public Works, City of Brookfield. Mr. Grisa welcomed the attendees to the meeting. Attendance was taken using the online software.

Members Present

Thomas M. Grisa, Chairman.....Director, Department of Public Works, City of Brookfield
Laura K. Herrick, Secretary ..... Chief Environmental Engineer, SEWRPC
Karl E. Buck.....Community Planner, FHWA Wisconsin Division
Brian Cater.....Interim Director of Public Works/City Engineer, City of Kenosha
Steven R. Corsi ..... Research Hydrologist, Chemistry, U.S. Geological Survey
Craig Helker..... Water Resources Biologist, WDNR
Samantha J. Katt .....Urban Stormwater Specialist, Wisconsin Department of Natural Resources
Scott Kroeger .....Director, Public Works and Development, City of Muskego
Matthew T. Magruder .....Environmental Research Manager, Milwaukee Metropolitan Sewerage District
Cheryl Nenn..... Riverkeeper, Milwaukee Riverkeeper
Neal T. O'Reilly.....Director, Conservation and Environmental Science Program, UWM
Charles J. Paradis..... Assistant Professor, Department of Geosciences UWM
Kurt Sprangers ..... Engineer in Charge, Environmental Engineering Section, Department of Public Works, City of Milwaukee
David Strifling..... Director, Water Law and Policy Initiative, Marquette University Law School

Guests and Staff Present

Joseph E. Boxhorn .....Principal Planner, SEWRPC
Eric N. Hettler.....Water Resources Management Specialist, WDNR
Karin M. Hollister..... Principal Engineer, SEWRPC
James M. Mahoney .....Engineer, SEWRPC
Nicklaus J. Neureuther.....Specialist, SEWRPC
Mitchell T. Olds..... Water Resources Specialist, Milwaukee Metropolitan Sewerage District
Aaron W. Owens.....Senior Planner, SEWRPC
Justin P. Poinsatte ..... Principal Specialist, SEWRPC
Thomas M. Slawski .....Chief Biologist, SEWRPC

Ms. Herrick introduced the presenters and the agenda for the meeting to review SEWRPC Technical Report No. 64, *Regression Analysis of Specific Conductance and Chloride Concentrations.*

[Secretary's Note: The agenda for this meeting is attached herein as Exhibit A.]

REVIEW OF THE SUMMARY NOTES FROM THE JANUARY 31, 2024, TECHNICAL ADVISORY COMMITTEE MEETING

At Ms. Herrick's request, Mr. Boxhorn reviewed the summary notes from the January 31, 2024, TAC meeting. He stated that Commission staff received written comments on draft Chapter 3 of Technical Report No. 62 from Craig Helker of the Wisconsin Department of Natural Resources. Mr. Boxhorn noted that the

edits that were made to the chapter in response to Mr. Helker's comments are documented on pages 5 and 6 of the summary notes. He thanked Mr. Helker for his comments.

Mr. Boxhorn stated that in response to comments by members of the TAC made at the January 31, 2024, meeting, Commission staff added a section to Chapter 5 describing the benefits that are provided to people by the use of chloride salts. He noted that an email was sent to TAC members soliciting comments on the draft section. Mr. Boxhorn indicated that one comment was received from a TAC member who stated that he liked the new section.

TAC members offered no questions or comments on the review of the Summary Notes.

REVIEW OF PRELIMINARY DRAFT CHAPTER 1, "INTRODUCTION," OF SEWRPC TECHNICAL REPORT NO. 64, *REGRESSION ANALYSIS OF SPECIFIC CONDUCTANCE AND CHLORIDE CONCENTRATIONS*

At Ms. Herrick's request, Mr. Boxhorn reviewed draft Chapter 1 of TR-64. Mr. Boxhorn and Mr. Poinsatte thanked the members of the Data Analysis Working Group, a subcommittee of the TAC, for the advice and comments that they offered Commission staff during the development of the regression models.

Mr. Boxhorn stated that Commission staff developed regression models to estimate the chloride concentration in streams of the Southeastern Wisconsin Region from measurements of specific conductance. He explained that specific conductance was monitored as a surrogate for chloride as part of the Chloride Impact Study because it could be done more cheaply and safely and at a finer temporal scale than collecting water samples for chemical analysis. Mr. O'Reilly commented that the presence of other ions in waters can affect levels of specific conductivity, complicating the relationship between specific conductance and chloride. TAC members offered no other questions or comments for draft Chapter 1.

REVIEW OF PRELIMINARY DRAFT CHAPTER 2, "METHODS" AND DRAFT CHAPTER 3, "RESULTS" OF SEWRPC TECHNICAL REPORT NO. 64, *REGRESSION ANALYSIS OF SPECIFIC CONDUCTANCE AND CHLORIDE CONCENTRATIONS*

Mr. Boxhorn stated that he would present a combined review of preliminary draft Chapters 2 and 3 of TR-64. He explained that doing this makes more sense for presentation purposes than reviewing the chapters in sequence.

Mr. Boxhorn gave a short definition and description of the statistical technique of regression focusing on linear regression. He noted that regression techniques make several assumptions regarding the data and that the quality of the analysis depends, in part, on how well the data satisfy these assumptions. Mr. Boxhorn added that for the purposes of estimating values of one variable from those of another using linear regression, the data need to meet only two assumptions: 1) that they are representative of the population of interest and 2) that the relationship between the two variables is linear. He noted that other uses of regression require that the data satisfy additional assumptions.

Mr. O'Reilly asked whether the software used to generate the graphs in the chapters would add error bars to the data. Mr. Boxhorn replied that the R software could do this, but that for these analyses error bars would not have been appropriate. He explained that confidence bands are often calculated and drawn around regression lines. Mr. Boxhorn added that such bands would not be valid for the analysis of this dataset because the variability of the data around the regression line increases as specific conductance increases.

He noted that this violates one of the assumptions of linear regression that must be satisfied to draw such bands.

Mr. Boxhorn briefly described the data used to develop the regression models. He stated that the models were developed from 1,104 paired specific conductance/chloride samples that were collected at 41 stream sites throughout the Southeastern Wisconsin Region. He added that the collection and processing of these data are described in SEWRPC Technical Report No. 61, which the TAC reviewed at its June 28, 2023, meeting.

Mr. Boxhorn stated that a scatterplot of chloride versus specific conductance showed that the relationship between these two water quality indicators was slightly curvilinear. He noted that the relationship flattens out at low values of specific conductance, which he attributed to the influence of other ions on specific conductance. Mr. Boxhorn also noted that the variability of chloride at different levels of specific conductance was not constant.

Mr. Boxhorn described the results of an attempt to model the relationship between specific conductance and chloride using simple linear regression for the entire dataset. He noted that this model gave a poor representation of the data at low values of these two water quality constituents. He added that this model also tended to overestimate chloride concentrations over a large portion of the data range and concluded that this model did not produce a good fit of the data. Mr. Boxhorn added that applying mathematical transformations to the data worsened the fit of the model to the data.

Mr. Boxhorn stated that Commission staff attempted to model the relationship between specific conductance and chloride using piecewise regression. He explained that this is a technique that divides the independent variable, in this instance specific conductance, into segments and develops a separate linear regression equation for each segment. Mr. Boxhorn added that this method is useful when data show that the relationship has slight departures from being linear. He noted that it is important to use as few segments as possible to avoid overfitting the data.

Mr. Boxhorn described the results of an attempt to model the relationship between specific conductance and chloride using two-segment piecewise regression. He stated that while this model gave a better representation of the data at low values of the variables, it still tended to overestimate chloride concentrations over much of the range of the data.

Mr. Boxhorn stated that Commission staff conducted a thorough evaluation of the two-segment piecewise regression model. He explained that this evaluation included developing site-specific simple linear regression models of specific conductance and chloride for each sample site and comparing the results to those of the two-segment piecewise regression. Mr. Boxhorn noted that these comparisons showed that the two-segment piecewise regression systematically overestimated chloride concentrations at 10 sites. From this evaluation the team concluded that it would not be possible to develop a single model that would be usable for all the sites.

Mr. Boxhorn stated that based on the evaluation of the two-segment piecewise regression it was decided to divide the data into three groups. He explained that a “high group” consisting of 30 sites with 818 samples was modeled using piecewise regression. He noted that a “low group” consisting of 10 sites with 253 samples was modeled using a linear mixed effects regression model. Mr. Boxhorn added that there was one site with 25 samples for which the site-specific regression was not statistically significant. He explained that a model could not be developed for this site.

Mr. O’Reilly asked whether the meters used to measure specific conductance performed temperature compensation. Mr. Boxhorn replied that the CTD units measured both specific conductance and water

temperature and compensated for temperature. He added that the sensors that were used to collect the data are fully described in TR-61.

Mr. Boxhorn described the three-segment piecewise regression that was used to model data from the "high group" sites. He noted that this model fits the data much better than either the simple linear regression or the two-segment piecewise regression models. Mr. Boxhorn stated that this model consists of four equations rather than three. He explained that the equation for the lowest segment of the model crosses the x-axis at 103 microSiemens per centimeter (µS/cm), suggesting that below this value chloride concentration would have a negative value. He continued that since this make no physical sense, the estimate of chloride concentration for specific conductance values at and below 103 µS/cm was set at 0 mg/l. He noted that specific conductance values this low were very rarely observed in the data collected by Commission staff.

Mr. Boxhorn stated that Commission staff conducted a thorough evaluation of the three-segment piecewise regression model. He noted that the R^2 value for this model showed that variation in specific conductance accounted for over 98 percent of the variability in chloride concentration. Mr. Boxhorn stated that the evaluation of the three-segment piecewise regression model included a cross-validation of the model. He explained that this is a method used to determine whether a model overfits the data and added that the cross-validation showed that this model was stable to random removal of portions of the data.

Mr. Boxhorn discussed that the evaluation of the three-segment piecewise regression model also included a comparison of estimates of chloride concentrations generated by the model to measured concentrations in over 23,000 paired samples from data in four watersheds in the Region. He noted that these watersheds all had moderate to high levels of urban development. Mr. Boxhorn explained that the team was unable to find any datasets with sufficient numbers of paired samples from more rural areas within the Region.

Mr. Boxhorn stated that comparison of estimates from the three-segment piecewise regression to measured concentrations for data over the period 1964-2022 showed that this model tended to overestimate chloride concentrations more often than it underestimated them. He noted that this model showed better performance when compared to data from 2011-2022; however, it still had a tendency to overestimate chloride concentrations. Mr. Boxhorn suggested that it may be more appropriate to use the piecewise regression model with recent data than with older data.

Mr. Boxhorn stated that Commission staff also evaluated the ability of the three-segment piecewise regression model to correctly assess whether regulatory criteria were exceeded using paired samples from the same four watersheds. He explained that three criteria from Wisconsin waters quality standards were examined: the acute toxicity criterion for chloride of 757 milligrams per liter (mg/l), the chronic toxicity criterion for chloride of 395 mg/l, and the drinking water maximum contaminant limit of 250 mg/l. Mr. Boxhorn stated that for each criterion estimates generated by the model correctly identified whether or not an exceedance had occurred in over 90 percent of samples. He added that the estimates also showed low rates of false positives and false negatives.

Ms. Nenn asked what values of specific conductance in the three-segment regression model corresponded to each of the regulatory thresholds. Mr. Boxhorn replied that he did not have those values readily available, but that he would provide them.

[Secretary's Note: The three-segment model indicates that a specific conductance of 2,813 µS/cm corresponds to the chloride acute toxicity criterion of 757 mg/l; a specific conductance of 1,773 µS/cm corresponds to the chloride chronic toxicity criterion of 395 mg/l; a specific conductance of 1,303 µS/cm corresponds to the drinking water maximum contaminant limit of 250 mg/l. Commission staff provided these values to Ms. Nenn via email.]

Mr. Boxhorn stated that Commission staff developed a linear mixed effects regression model to use to estimate specific conductance from chloride at the 10 sites in the "low group." He explained that this type of model structures the data and considers variation among samples at an individual site and between sites. He noted that in constructing this model it was assumed that the relationship between specific conductance and chloride concentration was the same at all ten sites and that differences among the sites reflected differences in water chemistry at those locations. Mr. Boxhorn explained that this was equivalent to assuming that the slope of the relationship between specific conductance and chloride would be the same at all 10 site but the y-intercepts might be different.

Mr. Boxhorn next described the linear mixed effects regression model. He noted that the model produced a separate set of equations for each site and a consensus equation that could be used for similar sites. He explained that some sets consisted of two equations because the equation generated by the model crossed the x-axis at a positive value of specific conductance, implying that chloride concentrations were less than 0 for very low specific conductance values. Mr. Boxhorn noted that the estimates for chloride concentration were set at 0 mg/l for values of specific conductance at or below the x-intercept. He stated that specific conductance values this low were rarely observed in the data collected by Commission staff.

Mr. Boxhorn stated that Commission staff evaluated the linear mixed effects model. He noted that both the marginal and conditional R^2 values for the model were lower than that of the 3-segment piecewise regression model. He attributed this to the fact that the dataset used to develop the linear mixed effects model was smaller than the one used for developing the piecewise regression model.

Mr. Boxhorn stated that a cross-validation was performed on the linear mixed effects regression model. He indicated that the results showed that the model was stable to removal of data. Mr. Boxhorn noted that he was unable to compare estimates generated by this model to measured data because no data sets from rural areas in the Region with a sufficient number of samples were available.

Mr. Corsi commented that while the R^2 values for the linear mixed effects regression model were lower than that from the piecewise regression model, they were still very good for environmental data. He added that the two models that were presented are both good models.

Mr. Boxhorn discussed the application of the two regression models. He stated that they are not intended for use in lakes or in streams outside of the Southeastern Wisconsin Region. He noted that the piecewise regression model is preferred for most streams in the Region. He explained that the linear mixed effects regression model was developed for sites on streams with very low specific conductance values and chloride concentrations that were poorly modeled by the piecewise regression model.

Mr. Boxhorn discussed some considerations related to the use of the piecewise regression model. He noted that it tends to overestimate chloride concentrations more often than it underestimates them. He added that it may give poor results immediately downstream from lakes. He explained that the large volume of water in a lake buffers chloride concentrations and may dampen fluctuations of chloride in the stream system. Mr. Boxhorn suggested that when the piecewise regression model is used to estimate chloride concentrations in a stream that was not sampled for its development, it would be prudent to collect paired samples of specific conductance and chloride and compare the measured chloride concentrations to those estimated from the model to ensure that the model is producing reasonable estimates.

Mr. Boxhorn stated that there may be some limited instances in which the linear mixed effects regression model might be used to estimate chloride concentrations. He noted that it may be used only under the following conditions:

- The piecewise regression model consistently overestimates chloride concentrations at the site
- Previous sampling shows that specific conductance at the site never exceeds 1,000 µS/cm
- The drainage area to the site has less than 20 percent urban land use
- There is no major transportation infrastructure draining to the site

Mr. Boxhorn emphasized that the linear mixed effects regression model should never be used to assess whether water quality criteria have been exceeded. He explained that the model was developed for situations with low values of specific conductance and chloride concentration. Mr. Boxhorn suggested that it would also be prudent to collect paired samples and compare them to estimates generated by the model to ensure that the model is producing reasonable estimates.

Ms. Nenn noted that seiche activity in the Milwaukee Harbor Estuary may have an effect on estimates similar to the dampening effect downstream of a lake. No other comments or questions for draft Chapters 2 and 3 were provided by the TAC.

REVIEW OF PRELIMINARY DRAFT APPENDIX B, "LAKE-SPECIFIC REGRESSIONS FOR LAKES SAMPLED AS PART OF THE CHLORIDE IMPACT STUDY" OF SEWRPC TECHNICAL REPORT NO. 64, *REGRESSION ANALYSIS OF SPECIFIC CONDUCTANCE AND CHLORIDE CONCENTRATIONS*

Mr. Boxhorn reviewed preliminary draft Appendix B of TR-64. He stated that the piecewise regression model performed poorly at estimating chloride concentrations in lakes. He noted that Commission staff attempted to develop simple linear regression models for estimating chloride concentrations in the six lakes that were sampled as part of the Chloride Impact Study.

Mr. Boxhorn stated that the models developed for Big Cedar Lake and Geneva Lake were not statistically significant. He attributed this to the relatively long average residence times of water and the low amounts of variation in chloride concentration and specific conductance levels in these lakes. He noted that significant simple linear regression models were developed for Little Muskego Lake, Voltz Lake, Silver Lake, and Moose Lake. Mr. Boxhorn noted that the models in the regression models developed for Little Muskego Lake and Voltz Lake specific conductance accounted for over half the variability in chloride concentration; however, in the regression models developed for Silver Lake and Moose Lake, specific conductance accounted for less than half of the variability in chloride concentration.

Mr. Boxhorn provided suggestions for estimating chloride concentrations in other lakes. He indicated that if paired specific conductance and chloride samples were available, lake-specific simple linear regression models could be developed. He explained that this may require samples collected over several years in order to have data with sufficient variability to develop a model. For lakes with longer water residence times, Mr. Boxhorn suggested collecting chloride samples over the course of a year and using the average concentration as the estimate.

Mr. Corsi commented that most lakes do not show much variability in chloride levels and will not need to have regression models for estimating chloride concentration. He suggested that chloride concentration could be estimated from samples collected throughout the year. He noted that sites that may be an exception to this generalization include lakes with a lot of variability in or high values of specific conductance or chloride, and those that are influenced by urban land use. Mr. Poinsatte pointed out that some lakes might have seasonal effects upon chloride concentrations. He noted that drainage lakes with shorter residence times may behave more like riverine systems and would be better candidates for developing lake-specific regression models.

NEXT STEPS FOR THE PLAN

Mr. Boxhorn stated that staff will take comments on TR-64 until May 17, 2024. He added that comments can be submitted through the Chloride Study webpage at www.sewrpc.org/chloridestudy or directly to him by email at jboxhorn@sewrpc.org.

Ms. Herrick reviewed the next steps for the Study. Work will continue with research and report writing, developing loading analyses, analyzing chloride conditions and trends, and gathering information on state-of-the-art practices. She stated that she anticipates that the next TAC meeting will be in fall 2024 and consist of review of a portion of either TR-63, which documents chloride conditions and trends within southeastern Wisconsin, or TR-66 which reviews the state of the art of chloride management. She indicated that meeting presentations and summary notes along with draft chapters will be posted on the SEWRPC project website at www.sewrpc.org/chloridestudy. She cautioned the TAC that the Commission will soon unveil a new website, so links to these materials may change and the TAC will be notified.

ADJOURNMENT

There being no further business, the meeting was adjourned by unanimous consent at 11:50 a.m.

Respectfully submitted,

Laura Herrick
Recording Secretary

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Southeastern Wisconsin Regional Planning Commission

Notice of Meeting and Agenda

TECHNICAL ADVISORY COMMITTEE FOR
A CHLORIDE IMPACT STUDY FOR THE SOUTHEASTERN WISCONSIN REGION

DATE: Wednesday, April 17, 2024

TIME: 10:00 am to Noon

TEAMS LINK:
Join on your computer, mobile app or room device
Click here to join the meeting
Meeting ID: 282 908 330 460
Passcode: bsU647

AGENDA:

1. Roll call

2. Review of summary notes from the January 31, 2024, TAC meeting

3. Review preliminary draft **SEWRPC Technical Report No. 64, Regression Analysis of Specific Conductance and Chloride Concentrations**
    a. Chapter 1 – Introduction
    b. Chapter 2 – Methods
    c. Chapter 3 – Results
    d. Appendix A – Acronyms and Abbreviations
    e. Appendix B – Lake-Specific Regressions for Lakes Sampled as Part of the Chloride Impact Study

4. Next steps

5. Adjourn

Laura K. Herrick
Chief Environmental Engineer

The summary notes and preliminary draft chapters can be found on the Study webpage at www.sewrpc.org/chloridestudy

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