CONTROL CHARTING OF WATER QUALITY PARAMETERS

SOP #422

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SOP VERSION CONTROL

Revision No	Revision Date	Page No(s)	Description	Approved by

STAFF ACKNOWLEDGEMENT

I certify that the requirements of this SOP have been communicated to me and that I am trained in its use. A copy of this page will be distributed to the employee training record file.

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APPROVAL SIGNATURES

Prepared by: Arcadis U.S., Inc. & Cornwell Engineering Group Date: 01/31/2018

Approved by: _____ Date: _____

1 DEFINITIONS AND ACRONYMS

CSII	Control Station 2
LCL	lower control limit
RTCR	Revised Total Coliform Rule
UCL	upper control limit
WEWQPM	weekly enhanced water quality parameter monitoring
WQP	water quality parameter

2 KEY PERSONNEL AND RESPONSIBILITIES

- Water Quality Laboratory Supervisor:
  - Enter data into control chart spreadsheets
  - Review control charts to identify if there are any observed variances that may have an attributable cause
  - If variances are observed that may have an attributable cause, convey that information to the Operations Supervisor so that actions to resolve the variance can be implemented.
- Water Plant Superintendent:
  - Based on information provided by the Water Quality Laboratory Supervisor, take appropriate actions to increase or decrease the system pH, chlorine residual, or orthophosphate residual as needed to bring the system back into control.

3 SCOPE/PURPOSE

The purpose of this SOP is to outline the procedures for using the control chart tools developed by the Cornwell Engineering Group to generate control charts of water system data. These tools consist of three Microsoft Excel-based spreadsheets:

- Flint Distribution System WQP Control Charts v1.2
- Flint Distribution System Chlorine Residual Control Charts v1.2
- Flint CSII and Tap WQP Control Charts v1.2

The first tool generates monthly median control charts for orthophosphate residual, pH, and alkalinity at the ten Enhanced Water Quality Parameter Monitoring Sites that the City of Flint maintains in the distribution system. The second tool generates monthly median control charts for chlorine residual at the twenty-five Revised Total Coliform Rule (RTCR) Monitoring Sites that the City of Flint maintains in the distribution system. The last tool generates weekly median

control charts for orthophosphate residual and pH at Control Station 2 (CSII) and tap sampling locations at the Flint Water Treatment Plant.

The charts generated by these tools are Shewhart control charts, which are statistical tools originally developed to manage manufacturing processes by monitoring parameter variability. Control charts use subgroups (aka "binning") to reduce the inherent variability of each sampled parameter. Because these tools are designed to assess data recorded on a weekly or daily basis, these data have been sub-grouped by month (for weekly data) or by week (for daily data). Each chart displays the median of the monthly or weekly subgroup, as well as an upper control limit (UCL) and a lower control limit (LCL) based on the historical trends of the entire data set.

Control charts reduce the variability inherent in monitoring water quality parameter (WQP) data and instead display the monthly trend relative to historical performance. If the monthly median is plotted above the UCL or below the LCL, it suggests that the observed change in that WQP is not due to natural variability. Therefore, it is likely that there is an attributable cause (e.g. chemical feed pump is not dosing accurately, change in treatment chemical used, etc.) for the observed change in the WQP.

The distance between the UCL and LCL will narrow as more data are available in a subgroup (e.g. more than four samples per month) and will increase as fewer data are available. Therefore, the UCL/LCLs may appear "wavy" because more data were collected in some months than in others. The locations of the UCL and LCL will also change over time as more data are added to the historical record. As the treatment processes become more stable, the UCL and LCL will converge towards one another.

Control charts are most useful when compared to corrosion control treatment goals. If the goal is to maintain a minimum orthophosphate residual, the LCL should be maintained above that value. If the goal is to stay within a desired pH range, the UCL and LCL should fall within that range.

For more information on control charts and how they can be applied to evaluate data for the Lead and Copper Rule please see: "Controlling Lead and Copper Rule Water Quality Parameters" (Cornwell, Brown, and McTigue 2015).

4 HEALTH AND SAFETY

There are no inherent health or safety risks from using the control chart tools to analyze data. Water system staff implementing treatment or operations changes in response to observed variances that may have an attributable cause should follow the SOPs for those operations.

5 PROCEDURE

The following procedures outline how data are to be entered into the control chart tools.

Flint Distribution System WQP Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for WQP data (pH, alkalinity, and orthophosphate residual) recorded in the Weekly Enhanced Water Quality Parameter Monitoring (WEWQPM) spreadsheets. The Data Entry form is arranged similarly to the WEWQPM spreadsheets to allow data to be copied directly from the WEWQPM spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell C2 to navigate to the first empty column.
3. Copy the sample date data from Column C of the WEWQPM spreadsheet and paste into the empty Sample Date column for pH (Rows 5 - 15), orthophosphate residual (Rows 19 - 29), and alkalinity (Rows 33 - 43).
4. Copy the pH data from Column G in the WEWQPM spreadsheet and paste into the empty pH column on the Data Entry worksheet (Rows 5 - 15).
5. Copy the Phosphate data from Column N in the WEWQPM spreadsheet and paste into the empty Phosphate column on the Data Entry worksheet (Rows 19 - 29).
6. Copy the Total Alkalinity data from Column H in the WEWQPM spreadsheet and paste into the empty Total Alkalinity column on the Data Entry worksheet (Rows 33 - 43).
7. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell B2.
8. At the Dashboard, select the WQP to be charted using the upper left dropdown.
9. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or last one year of data, or select a custom range start and end date by using the left-right scroll buttons.
10. The tool can allow for side-to-side comparisons between two WQP monitoring locations. Use the drop down menus for WQP Site I and WQP Site II to select the sites for comparison.
11. The tool also allows comparison of median values for the three parameters (pH, Orthophosphate and Alkalinity) between two WQP monitoring locations and all locations to evaluate the whole system. For a selected WQP (from the dropdown) and selected time period (from the dropdown), the tool generates a single (third) chart showing the data for all of the WQP locations.

Flint Distribution System Chlorine Residual Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for MOR data (chlorine residual) recorded in the Monthly Operating Report (MOR) spreadsheets. The Data Entry form is arranged similarly to the MOR spreadsheets to allow data to be copied directly from the MOR spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell C2 to navigate to the first empty row.
3. Copy the Free Chlorine Residual data from Column BL to CJ in the MOR spreadsheet and paste into the empty columns on the Data Entry worksheet (Columns E to AC) with the corresponding dates.

4. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell B2.
5. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or the last one year of data, or select a custom range start and end date by using the left-right scroll buttons. Data prior to 1/01/2016 have not been entered into this tool so start dates prior to 1/31/2016 cannot be selected.
6. The tool can allow for side-to-side comparisons between two WQP monitoring locations. Use the drop down menus for WQP Site I and WQP Site II to select the sites for comparison.

Flint CSII and Tap WQP Control Charts:

1. This tool is designed to allow for easy generation of monthly control charts for WQP data (pH, orthophosphate residual, and chlorine residual) recorded in the Monthly Operating Report (MOR) spreadsheets. The Data Entry form is arranged similarly to the MOR spreadsheets to allow data to be copied directly from the MOR spreadsheets into this tool.
2. On the Data Entry worksheet, click the hyperlink in Cell B1 to navigate to the first empty row.
3. Using the MOR monthly spreadsheet, copy pH data for the CSII and Tap locations from Columns AE and AF, respectively, from the MOR monthly spreadsheet and paste into Columns E and F on the Data Entry worksheet. Copy orthophosphate data for the CSII and Tap locations from Columns C and E, respectively, and paste into Columns G and H in the Data Entry worksheet. Copy chlorine residual data for the CSII and Tap locations from Columns W and AB, respectively, and paste into Columns I and J in the Data Entry worksheet.
4. After all data have been entered into the Data Entry worksheet, return to the Dashboard using the hyperlink in Cell A1.
5. Select the time period for charting the WQP data. Buttons are provided to quickly display the last six months or last one year of data, or select a custom range start and end date by using the left-right scroll buttons.
6. The tool allows for charting of pH, orthophosphate residual or chlorine residual data at the two WQP sites (CSII and Tap). Select the WQP from the dropdown to choose which WQP to evaluate.

6 DATA RECORDING AND MANAGEMENT

After the control charts have been generated, they should be reviewed to identify points that are above the UCL or below the LCL. Such points are outside the natural variation to be expected, so the Water Treatment Superintendent may need to make process adjustments to bring the system back into control. Such adjustments might be increasing or decreasing chemical feed targets, calibrating chemical feed pumps or flow meters, verifying proper operation of equipment, etc.

7 REFERENCES

Cornwell, D., Brown, R., & McTigue, N. (2015). *Controlling Lead and Copper Rule Water Quality Parameters.* Journal-American Water Works Association, 107(2), E86-E96.