State Water Resources Control Board

Proposed Hexavalent Chromium MCL Staff Report

In 2001, the California Legislature required the Department of Health Services to develop a primary drinking water standard for hexavalent chromium by 2003.[1] Health and Safety Code (HSC) sections 116365(a) and 116365(b)[2] require the State Water Resources Control Board (State Water Board) to adopt primary drinking water standards at a level as close as feasible to the corresponding public health goal (PHG), placing primary emphasis on the protection of public health, and avoiding, to the extent technologically and economically feasible, any significant risk to public health. In 2011, the Office of Environmental Health Hazard Assessment (OEHHA) published the hexavalent chromium PHG at 0.02 micrograms per liter (µg/L).[3]

State Water Board staff is considering a hexavalent chromium maximum contaminant level (MCL) of 10 µg/L or 0.010 milligrams per liter (mg/L), and an associated detection limit for purposes of reporting (DLR) of 0.05 ug/L or 0.00005 mg/L.[4] In addition, State Water Board staff proposes a compliance schedule based on system size:

- Systems with more than 10,000 service connections would be required to comply with the MCL within two years of rule adoption.
- Systems with 1,000 to 10,000 service connections would be required to comply with the MCL within three years of rule adoption.
- Systems with less than 1,000 service connections would be required to comply with the MCL within four years of rule adoption.

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[1] Health and Saf. Code, § 116365.5. The Department of Health Services became the Department of Public Health (CDPH) in 2007, and its Drinking Water Program was transferred to the State Water Board in 2014. Prior to the transfer, CDPH issued a primary drinking water standard for hexavalent chromium, which was overturned by the Sacramento Superior Court in 2017.

[2] All references are to the Health and Safety Code, unless otherwise indicated.

[3] Pursuant to HSC section 116365(c), OEHHA prepares and publishes an assessment of public health risks posed by each contaminant for which the State Water Board proposes a primary drinking water standard. The risk assessment includes an estimate, the PHG, of the drinking water contaminant level that is not anticipated to cause or contribute to adverse health effects, or that does not pose any significant health risk.

[4] DLRs are the designated minimum levels at or above which any analytical finding of a contaminant in drinking water resulting from monitoring must be reported to the State Water Board.

Consistent with HSC section 116370, State Water Board staff is proposing findings of reduction/coagulation/filtration, ion exchange, and reverse osmosis as best available technologies (BAT) for the removal of hexavalent chromium from drinking water to concentrations at or below the proposed MCL.

Proposal Background

State Water Board staff reviewed analytical method availability, evaluated efficacy of various treatment technologies, and prepared cost estimates using water quality monitoring data in the State Water Board's Water Quality Information Replacement (WQIR) database to evaluate 17 possible MCLs (1 to 15, 20, and 25 µg/L). It was assumed laboratories would use United States Environmental Protection Agency's (U.S. EPA) Methods 218.6 or 218.7 for sample analysis and that public water systems (PWS) would rely on centralized treatment using strong base anion exchange to meet the MCL.

Technological Feasibility

A primary drinking water standard must be set at a level that is technologically feasible. (Health & Saf. Code, § 116365, subd. (a).) Technological feasibility requires an analytical method capable of detecting hexavalent chromium at or below the proposed level and a method of treatment that can produce water at or below that level.

Detection Limit for Purposes of Reporting

Two analytical methods, U.S. EPA Methods 218.6 and 218.7, are capable of reporting concentrations at or below the proposed DLR of 0.05 µg/L. Establishing a DLR of 0.05 µg/L will maximize current technological feasibility.

Treatment Techniques

The following three treatment technologies are proposed as best available technologies for the removal of hexavalent chromium from drinking water to concentrations at or below the proposed MCL of 10 ug/L:

- Reduction coagulation filtration (RCF) treatment reduces hexavalent chromium to trivalent chromium. Trivalent chromium has a very low solubility, which results in the formation of a precipitate that can be removed by filtration to result in hexavalent chromium concentrations less than 5 µg/L in finished water.
- Ion exchange uses strong base resins to which the hexavalent chromium anion can adsorb, decreasing hexavalent chromium concentrations to less than 1 µg/L in finished water.
- Reverse osmosis can filter hexavalent chromium through membranes to less than 1 µg/L.

Treatment technology capabilities may differ in non-ideal circumstances. While RCF has been shown to treat hexavalent chromium down to 5 µg/L, the data is limited to one treatment plant. Source water quality impacts the treatment efficacy of ion exchange and RCF. High sulfates can reduce the efficiency of strong base ion exchange treatment, and pH has a significant impact on RCF's reduction efficiencies. State Water Board staff considers the proposed MCL of 10 µg/L to be technologically feasible because multiple mature, full-scale treatment technologies have been demonstrated capable of treating to concentrations at or below this level.

Estimated Costs

Statutory Requirements

A primary drinking water standard must be set at a level that is economically feasible. (Health & Saf. Code, § 116365, subd. (a).) HSC section 116365(b) requires the State Water Board to consider as part of its economic feasibility determination "the costs of compliance to public water systems, customers, and other affected parties with the proposed primary drinking water standard, including the cost per customer and aggregate cost of compliance, using best available technology."

Estimated Costs

PWS cost estimates were evaluated using the following service connection categories:

1) systems with less than 100 connections[5];
2) systems with at least 100 connections, but less than 200 connections;
3) systems with at least 200 connections, but less than 1,000 connections;
4) systems with at least 1,000 connections, but less than 5,000 connections;
5) systems with at least 5,000 connections, but less than 10,000 connections; and
6) systems with over 10,000 connections.[6]

Estimated costs include statewide costs and not actual cost to a particular water system. Actual costs for any particular water system will vary depending on many site-specific parameters, such as the concentration of hexavalent chromium in the source, the physical and chemical characteristics of the water to be treated, the need to provide treatment for other contaminants, the type and method of resin and brine disposal, the availability of land, the future cost of construction, and the cost of water treatment plant operating staff. [7]

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[5] The general lack of information regarding very small, centralized treatment system costs (less than 10 gpm) makes estimating treatment costs for the small water systems difficult. Therefore, alternate cost estimates for systems with less than 100 connections are included in the form of POU cost estimates in the following section.

[6] Although half of California's community water systems serve fewer than 100 connections, these small systems serve only 6.6% of consumers served by public water systems. By contrast, systems with more than 10,000 service connections serve more than 74.5% of the population served by public water systems.

[7] Although PWS may select from various means of compliance, State Water Board staff is basing costs on strong base anion ion exchange because it is anticipated that this will be the most commonly used treatment for hexavalent chromium.

1. Estimated Total Costs of Monitoring and Treatment

The estimated total annualized monitoring and treatment costs for water sources with concentrations of hexavalent chromium greater than the proposed MCL of 10 µg/L, by water system size, are shown in Tables 6A and 6B in Attachment 1 for community water systems (CWS) and nontransient noncommunity water systems (NTNCWS), respectively. For the proposed MCL of 10 µg/L, the total annualized costs are approximately $157,406,603 and $5,528,796 for CWS and NTNCWS, respectively. Tables 17C and 17D show the total and annualized monitoring and treatment costs for transient noncommunity water systems (TNCWS) and wholesalers, respectively. For the proposed MCL of 10 µg/L, the total annualized costs are approximately $555,166 and $47,596,797 for TNCWS and wholesalers, respectively.

2. Estimated Total Costs Per System

The estimated number of systems requiring treatment can be found in Tables 7.1A and 7.1B for CWS and NTNCWS, respectively. The average estimated annual cost per system, by water system size, is shown in Tables 7.2A and 7.2B for CWS and NTNCWS, respectively. For the proposed MCL of 10 µg/L, the average annual cost per system for CWS ranges from $104,738 (systems with less than 100 service connections) to $4,984,385 (systems with more than 10,000 service connections) depending on the system size. The average annual costs per system for NTNCWS are generally smaller due to their sizes, ranging from $82,711 to $174,941. Larger water system costs are generally greater due to the need to treat greater flows to serve more people.

For the proposed MCL of 10 µg/L, the average annual cost per system is $92,528 for TNCWS and $15,865,599 for wholesalers. The cost is much higher for wholesaler systems than other system types because wholesalers usually produce very large amounts of water.

Note that for systems with less than 200 connections, State Water Board staff looked at the capital and O&M costs for point-of-use (POU) treatment, instead of costs of centralized treatment. Costs were estimated using U.S. EPA's POU cost estimating tool.[8] Costs for residential reverse osmosis (RO) devices registered for sale in California were collected from manufacturer or online retail websites and averaged to determine the RO device, replacement filter, and membrane cartridge costs based on the device's ability to treat hexavalent chromium. As of June 2021, no POU device using RO and registered for sale in California could treat to below 3 µg/L.[9] Based on U.S. EPA case

[8] U.S. EPA. (2007). Cost Evaluation of Point-of-Use and Point-of-Entry Treatment Units for Small Systems: Cost Estimating Tool and User Guide (EPA 815-B-07-001). United States Environmental Protection Agency, Office of Ground Water and Drinking Water.

[9] SWRCB. (2021d). Residential Water Treatment Devices. State Water Resources Control Boards. Accessed June 2021.
https://www.waterboards.ca.gov/drinking_water/certlic/device/watertreatmentdevices.html

studies and vendor information, given regular maintenance (e.g., filter cartridge replacement), the POU devices are expected to continue functioning for 10 years before the entire device needs to be replaced. The estimated POU monthly costs per connection based on MCL level and water system size are shown in Table 1.

Table 1. Monthly cost per connection of POU treatment based on MCL and system size. (Attachment 1, Table 14).

MCL (µg/L)	Less than 100 service connections	Between 101 and 200 service connections
4, 5	$52	$51
6, 7	$47	$47
8	$46	$44
9	$41	$40
10 to 25	$38	$37

3. Estimated Annual Costs per Source

The estimated average annual cost per source, by water system size, is shown in Tables 8A and 8B for CWS and NTNCWS, respectively. For the proposed MCL of 10 µg/L, the average cost per source for CWS ranges from $88,625 (systems with less than 100 service connections) to $842,431 (systems with more than 10,000 service connections). The average annual cost per source for NTNCWS ranges from $81,618 to $147,613. On average, systems with fewer than 100 service connections treat much less water per source (6 million gallons per year) than systems with more than 10,000 service connections (451 million gallons per year), which accounts for the large range of costs. Again, larger water system costs are generally greater due to need to treat greater flows.

For the proposed MCL of 10 µg/L, the average annual cost per source is $92,528 for TNCWS and $3,966,400 for wholesalers. The per source wholesaler costs are higher than other system types because on average, each source produces more water.

4. Estimated Costs per Service Connection

The estimated number of service connections in each water system size category can be found in Tables 9.1A and 9.1B for CWS and NTNCWS, respectively. The estimated average annual cost per service connection, by system size, is shown in Tables 9.2A and 9.2B for CWS and NTNCWS, respectively. For the proposed MCL of 10 µg/L, the average annual cost per service connection for CWS ranges from $133 (systems with more than 10,000 service connections) to $2,440 (for systems with less than 100 service connections). These costs are higher for smaller water systems due to a lack of economies of scale – meaning that there are fewer households (service connections) among which the cost of the treatment can be shared. However, these are cost estimates for centralized treatment, and systems with less than 100 service connections are expected to use POU treatment, which would have annual costs of $456 per service connection.

For the proposed MCL of 10 µg/L, the average annual cost per service connection for NTNCWS ranges from $3,482 (systems with at least 100 but less than 200 people) to $47,610 (systems with less than 50 people). While these costs are large, they are not reflective of costs a family would be asked to pay because NTNCWS do not serve yearlong residents. Instead, these systems consist of agricultural and industrial facilities, schools, churches, prisons, recreational areas, restaurants, and any other public water system that regularly serves 25 or more of the same persons more than 6 months per year. NTNCWS also have very few service connections on average; one third of all NTNCWS in the state have only one service connection. For these reasons, NTNCWS costs are better understood on a per person basis, as discussed in the next section.

For the proposed MCL of 10 µg/L, the average annual cost per service connection is $1,934 for TNCWS. Wholesaler costs cannot be broken down to the service connection level because wholesalers do not directly serve residents and do not consistently report service connections in the SDWIS database (some report the number of connections through which water is delivered to other systems, some report an estimate of the number of service connections that will eventually be served by their water, and some report the total number of service connections of all the systems to which they sell).

5. Estimated Costs Per Person

The estimated number of people served by the systems in each water system size category can be found in Tables 10.1A and 10.1B for CWS and NTNCWS, respectively. The estimated average annual cost per person, by system size, is shown in Tables 10.2A and 10.2B for CWS and NTNCWS, respectively. For the proposed MCL of 10 µg/L, the average annual cost per person for CWS ranges from $34 (systems with more than 10,000 service connections) to $686 (systems with less than 100 service connections) for centralized treatment. For comparison, the annual POU costs are approximately $128 per person. For the proposed MCL of 10 µg/L, the annual average cost per person for NTNCWS ranges from $131 (systems with 1,000 or more people) to $2,657 (systems with less than 51 people). However, NTNCWS are not community systems and do not directly charge households or individuals for the cost of water. Instead, the 51 NTNCWS that were identified as potentially exceeding the MCL of 10 µg/L consist of 29 industrial/agricultural businesses (packing companies, farms, etc.), 10 schools, three restaurants, three “other transit areas” (Christian center, wedding event property, and county hauling), one medical facility, one church, one winery, one regional park, one Cal Fire conservation camp, and one migrant center.

For the proposed MCL of 10 µg/L, the average annual cost per person is approximately $622 for TNCWS and $257 for wholesalers.[10] The six TNCWS are a raceway, a campground, two churches, a spa, and a packing company, none of which charge households or individuals for the cost of water.

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[10] The number of people served by each system is available in the DDW SDWIS data. This information can be accessed at this webpage: https://www.waterboards.ca.gov/resources/data_databases/drinking_water.html.

6. Understanding Cost Trends

Some cost tables in Attachment 1, such as the estimated annual cost per service connection (Tables 9.2A and 9.2B) and the estimated annual cost per person (Tables 10.2A and 10.2B), show costs decreasing for lower potential MCLs or increasing for higher potential MCLs. The purpose of this section is to explain those cost trends.

The average monthly costs per household are shown below in Figure 1 in black for all systems, red for systems with less than 100 service connections, and in green for systems with more than 100 service connections. Treatment costs are very expensive for systems with less than 100 service connections because they have fewer customers to pay for centralized treatment (lack of economies of scale, as previously discussed).

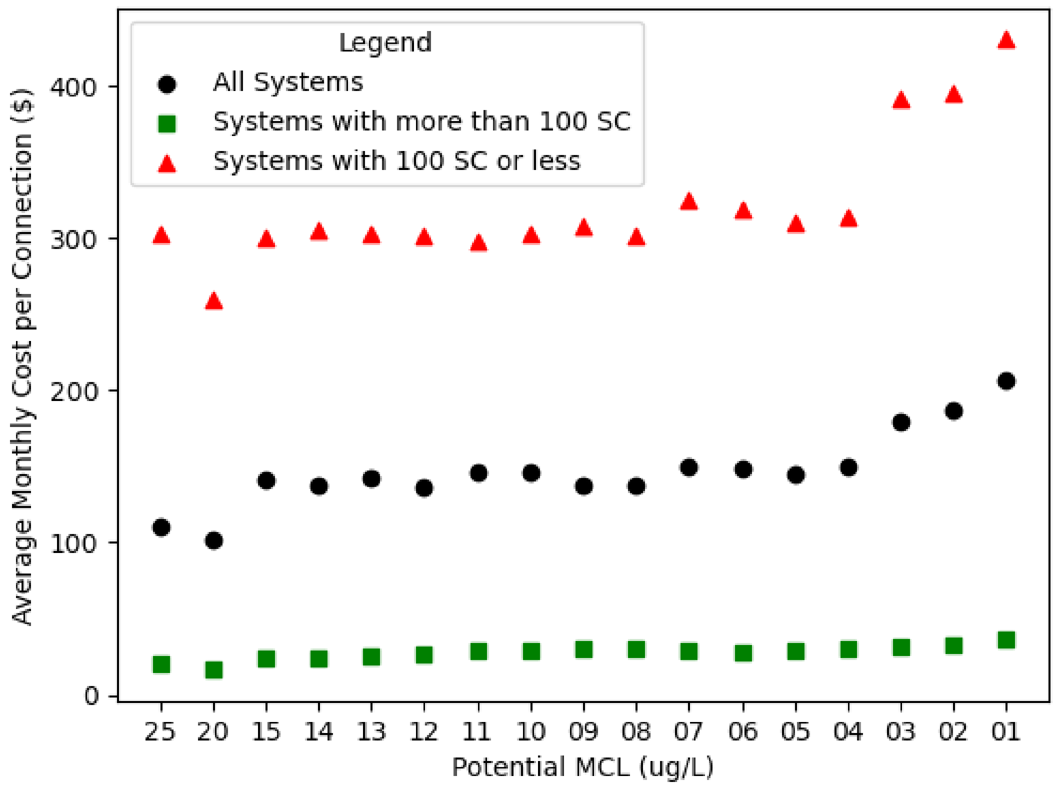

Figure 1. The average monthly cost per service connection

The average monthly costs for systems with more than 100 service connections in Figure 1 do not grow much as the potential MCL decreases (becomes more stringent), and in some cases the average monthly costs even decrease. This phenomenon is a result of new, much less contaminated sources being added at each MCL, such that the average contamination of all water being treated decreases as the potential MCL decreases. Therefore, the average costs stay the same or decrease even as costs are increasing for each individual system that has already been treating.

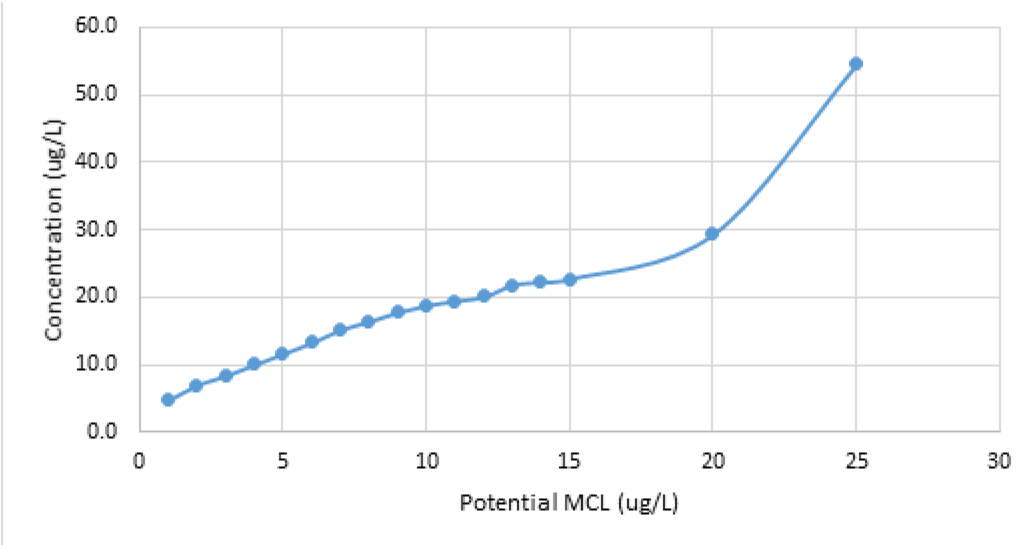

Figure 2. Average Hexavalent Chromium Concentration in Treating Sources

Figure 2 shows the extent to which the average concentration of hexavalent chromium in water sources to be treated changes with each potential MCL. The source concentration of all sources to be treated decreases with decreasing MCLs because added sources are much less contaminated than the previously included sources. These less contaminated sources cost less to treat, which lowers the average cost of treatment, even as individual costs increase for each source already treating.

Economic Feasibility

HSC section 116365 sets forth criteria to consider in determining the economic feasibility of a proposed MCL. State Water Board staff took a multi-faceted approach, considering a number of factors, including the household affordability of the rates public water systems may need to establish to fund compliance and meet ongoing operation and maintenance costs.

To determine economic feasibility, the State Water Board took a conservative approach by estimating centralized treatment costs for all PWS.[11] However, due to the high centralized treatment costs for CWS with less than 100 service connections, it is assumed that this subset of PWS will use POU treatment to comply with the MCL.

As noted above, at the proposed MCL of 10 µg/L, the majority of Californians would pay less than an additional $20 per month. Some of the smallest systems, however, would have rate increases closer to $40 per month.[12] The minimum and maximum monthly household costs for each system size category are shown in Table 16A in Attachment 1. A large cost jump in the maximum costs occurs at MCLs lower than 10 ug/L for

[11] There are additional and likely less expensive ways many systems may use to comply with the MCL, such as blending, drilling new wells, and purchasing uncontaminated water from other system(s).
[12] Note that for systems with fewer than 100 connections, costs are based on installation of POU treatment, as set out in Table 1 above, rather than the costs for centralized treatment set out in Table 9.2, attached.

systems between 100 and 200 service connections. Water systems with less than 100 service connections using POU devices in lieu of centralized treatment would have cost increases of $38 per household per month instead of the costs shown in this table.

Some categories in Table 16A show that the minimum cost decreases with lower MCLs. This is because less contaminated sources are more likely to be included at lower MCLs, some of which would require minimal hexavalent chromium removal, leading to very low minimum costs. It will, however, always cost more for any given system to treat its water to a lower MCL.

Considering water affordability principles from U.S. EPA[13], State Water Board staff estimated the number of customers required to spend more than 2.5% of median household income (MHI) on their water bills. Each of these estimates excludes potential financial and technical assistance that the State Water Board might provide to small systems serving disadvantaged communities through various funding programs. At the proposed MCL of 10 µg/L, 16 systems with more than 100 service connections would potentially have total water bills that exceed that threshold. Fourteen of these systems are severely disadvantaged communities with MHIs below $45,000 (three systems have water bills that already exceed the 2.5% threshold, even before estimated compliance costs for hexavalent chromium are added to their water bill).

Although the State Water Board cannot guarantee funding for any one system, as the individual circumstances of each system would have to be analyzed, the State Water Board has funding programs available to alleviate financial strain experienced by small PWS customers.

As Close as Feasible to PHG, and Avoiding Significant Risk to Public Health

With respect to carcinogens, such as hexavalent chromium, HSC section 116365 requires that to the extent technologically and economically feasible the MCL be set at a level that is not only as close to the PHG as feasible, but also avoids any significant risk to public health.

Ingesting hexavalent chromium has been shown to cause both cancer and kidney toxicity. Although this regulation is expected to reduce the number of cancer and kidney toxicity cases, at the proposed MCL of 10 µg/L, the cancer risk is 500 times greater than at the PHG.[14] This equates to a lifetime risk for individuals that 1 person out of 2,000 exposed to drinking water at 10 µg/L for 70 years may experience cancer. Of the 69 MCLs adopted in California, the proposed MCL of 10 µg/L would place hexavalent chromium as the seventh least protective MCL, with 6 current MCLs less protective and 63 more protective of human health.

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[13] U.S. EPA (1998). Variance Technology Findings for Contaminants Regulated Before 1996. (EPA 815-R-98-003). United States Environmental Protection Agency, Office of Ground Water and Drinking Water.

[14] The PHG of 0.02 µg/L represents a risk that is considered negligible (e.g., one excess cancer case in one million people).