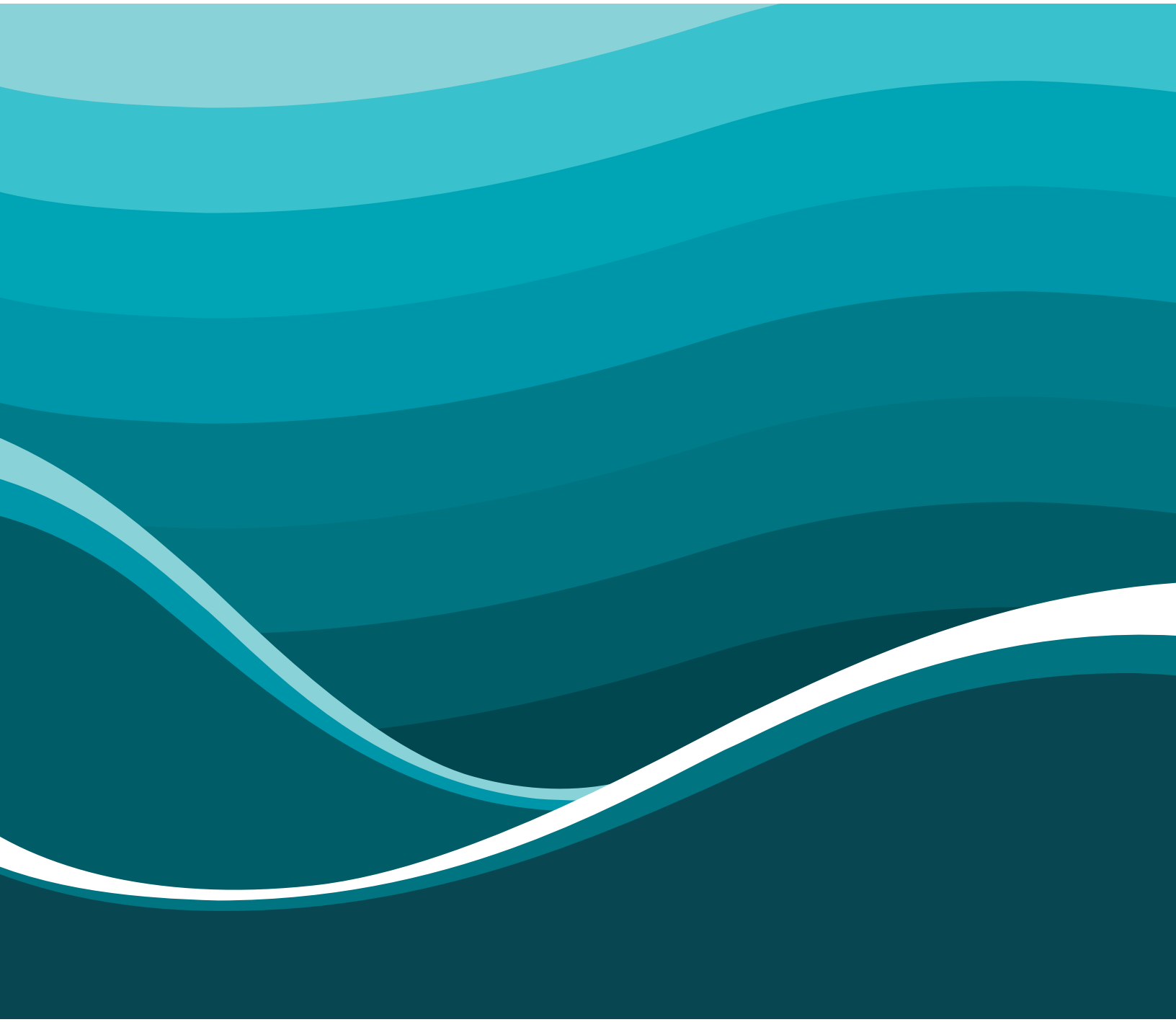
OWP Sacramento State | 50 YEARS



CHARTS

GUIDELINES 2022

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Introduction

If a picture is worth a thousand words, then a good visual representation of data is worth at least that much. Effective visuals allow authors to focus on what the data mean instead of crafting extensive text outlining the data.

This document aims to guide OWP employees in authoring effective charts (the catchall term for visual representations of data) that have a consistent look within each deliverable and across deliverables regardless of end user. By creating clear and consistent charts, authors help readers understand the data and how it relates to the rest of the document.

There are many kinds of charts. Graphs, plots, and maps are among the most common charts. This document discusses common charts used in OWP projects, their applications, and their formatting for OWP style and visual guidelines.

The following sections define some terms that will be used in this document, including the parts of a chart.

Definitions

Chart—Visual representation of data; any method intended to visualize data and communicate ideas about the data

Plot—A specific type of chart that shows individual data points

Graph—A specific type of chart that represents the relationship between at least two variables

Map—A specific type of chart that represents the spatial arrangement or distribution of data over an area (not the focus of these guidelines)

Parts of a chart

These guidelines use many of the same naming conventions as Microsoft Excel when referring to the different elements of a chart.

Chart area—Area that contains all of the parts of a chart

Plot area—Area that graphically displays data in a chart

Axes—Reference lines on a chart that provide the scale or category of the data on the chart

Axis titles—Labels that describe the category of the data shown on the axes

Chart title—Short description of the data the chart is showing; OWP favors figure captions over chart titles

Data labels—Text elements that describe individual data points in a chart

(Data) series—The raw data values displayed on the chart

Error bars—Graphical representations of data variability that show the precision of a measurement

Gridlines—Lines that cross the plot area to show axis divisions, making it easier for viewers to see values of unlabeled data points

Legend—A list of the name and symbol for each data series displayed on the graph

Trendline—A straight or curved line in a chart that shows the general pattern or overall direction of the data

Tick marks—Small marks on chart axes that establish the position of values on a scale

Figure 1 shows most of the commonly used chart elements. Some of the elements, like secondary axes, are not always used.

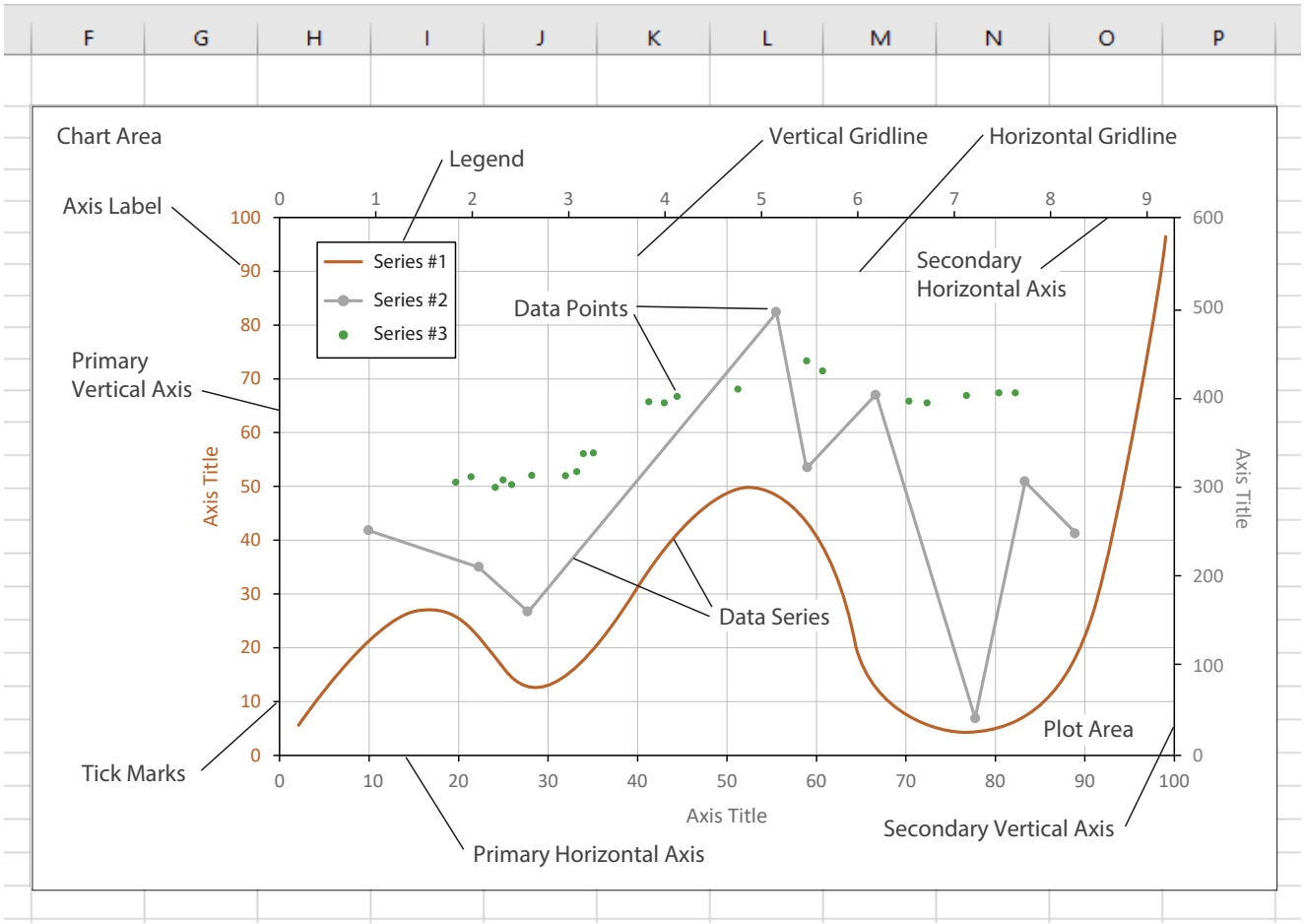


Figure 1: Chart elements

Difference between a chart, a graph, and a plot

Visualization of scientific and engineering data is most often done using plots, graphs, and charts. They provide a very efficient way of visually presenting data, along with trends and relationships within the data that are often difficult to describe in words. All three terms tend to be used interchangeably, and are defined differently based on the source and discipline that they are used within. However, in general:

- Plots display the individual data points, such as a dot plot showing sampling data. Plots are a good way to initially view or present collected data.
- Graphs display data that shows the relationship between two variables (i.e., the x-axis variable and the y-axis variable). Graphs are typically used to show mathematical functions, time series data, or any time when one variable is dependent on another. A good example of this is a hydrograph, which displays discharge over time.
- Charts typically display data using symbology other than a point or a line. Charts typically are used to display groups of data by representing them on the chart as a statistic for each group (mean, median, percentile, percentage, etc.) instead of the individual data points. Examples of charts are a histogram that shows the frequency distribution of a variable and a box and whisker chart that shows the median, lower and upper quartiles, and the lower and upper extremes of a data set.

To eliminate the confusion between graphs, charts, and plots, these guidelines simply refer to all three types as charts. But, the most important thing to recognize is that no matter what type of data visualization technique you use, it must have a purpose and be able to convey a message.

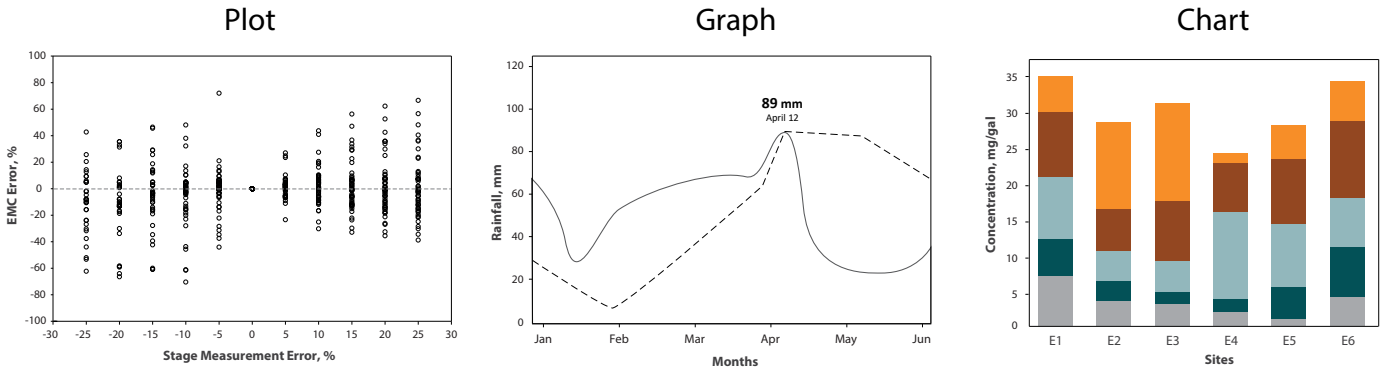


Figure 2: Plot, graph, and chart examples

Chart element design standards

> *"The data on a graph are the reason for the existence of the graph. The data should stand out. It is too easy to forget this. There are many ways to obscure the data, such as allowing other elements of the graph to interfere with the data or not making the graphical elements encoding the data visually prominent. Sometimes different values of the data can obscure each other.*
>
> *We should eliminate superfluity in graphs. Unnecessary parts of a graph add to the clutter and increase the difficulty of making the necessary elements – the data – stand out."*
>
> The Elements of Graphing Data (Cleveland, 1994)

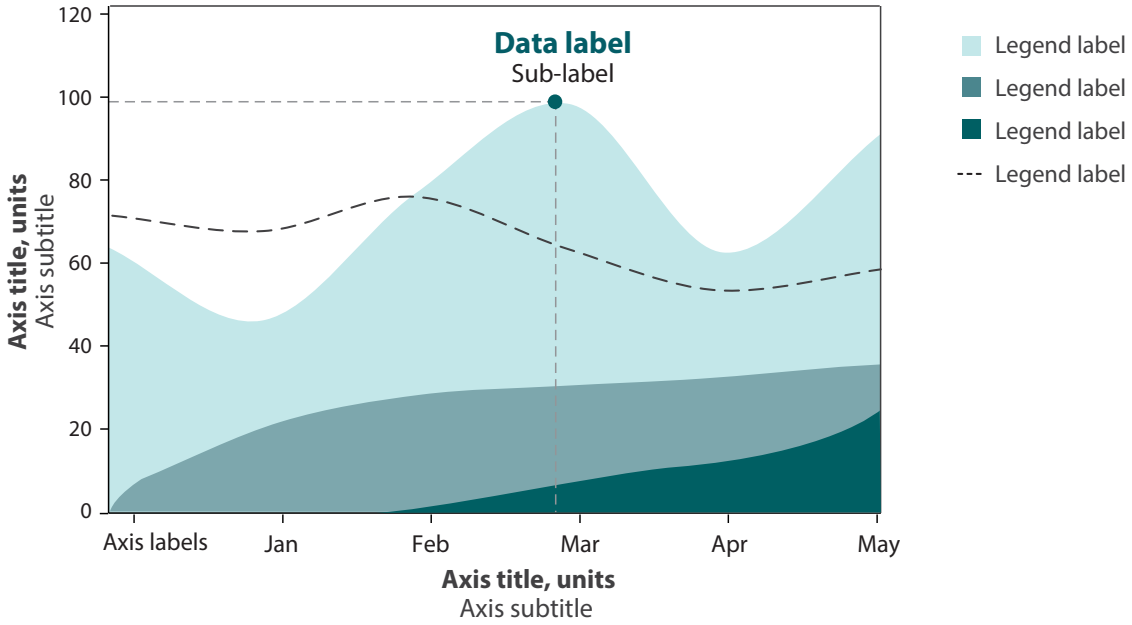
To help OWP authors and editors prepare charts that have a consistent look, Table 1 provides the design standards to be used at OWP for many of the main chart elements. When applying these standards, it is important to remember that the data is the reason for the chart to exist (Cleveland, 1994), but that the purpose of a chart is to convey a message about the data. It is the author's responsibility to recognize when these standards hinder that message or obscure the data. In these situations, the author should deviate from the standards in a way that optimizes the effectiveness of the chart.

For help choosing wording for text in charts (e.g., labels, captions, and legends), contact the publications manager or a technical editor.

Table 1: OWP format for chart elements

Chart Element	OWP Recommended Style
Collected Data (Data Series)	When the data series is of collected data, it should be displayed as discrete points (i.e., plot) and not connected by a line. The points should not be so large that they overwhelm the plot area, but not so small that they disappear into the background. If data points overlap then consider using a plotting symbol without fill to help show multiple points that are clustered together.
Functions (Data Series)	When the data series is of a mathematical function, it should be plotted as a smooth, continuous line without visible data points.
Gridlines	Gridlines should only be used when the graph is intended to have values read off of it.
Origin (Axes)	The graph axes should include the origin whenever possible. This is especially important when comparing differences between data or data sets because not starting from the origin often overexaggerates the difference.
Plot Area	The plot area should have a solid border in a single color.

Chart Element	OWP Recommended Style
Tick Marks	Axes tick marks should be placed outside the plot area to ensure they do not interfere with the data. Categorical axis titles (e.g., Sample #1, Sample #2) do not require tick marks if they are part of a bar or similar graph.
Time Series (Data Series)	When the data series is time series data that show an order through time, the data points should be displayed as dots and connected with straight lines. If the data are smooth and the individual points are not important, then they can be plotted with just a smooth line. If there are a large number of data points and the individual values must be displayed, use either a vertical bar chart or a dot plot. In a vertical bar chart, each value is represented by its own bar and the bars are spaced close together to show that they represent a continuous series. The vertical bar chart is most effective when the bars emanate from a horizontal line. In a dot plot, each dot represents a separate measurement at that time step or the value is represented by an equivalent number of dots.
Units	When needed, units should appear at the end of the axis title and be separated from the axis title by a comma (e.g., "Volume, L" or "Length, m").



Source: Benene and Carleton (2022)

Figure 3: Sample full color chart with chart elements

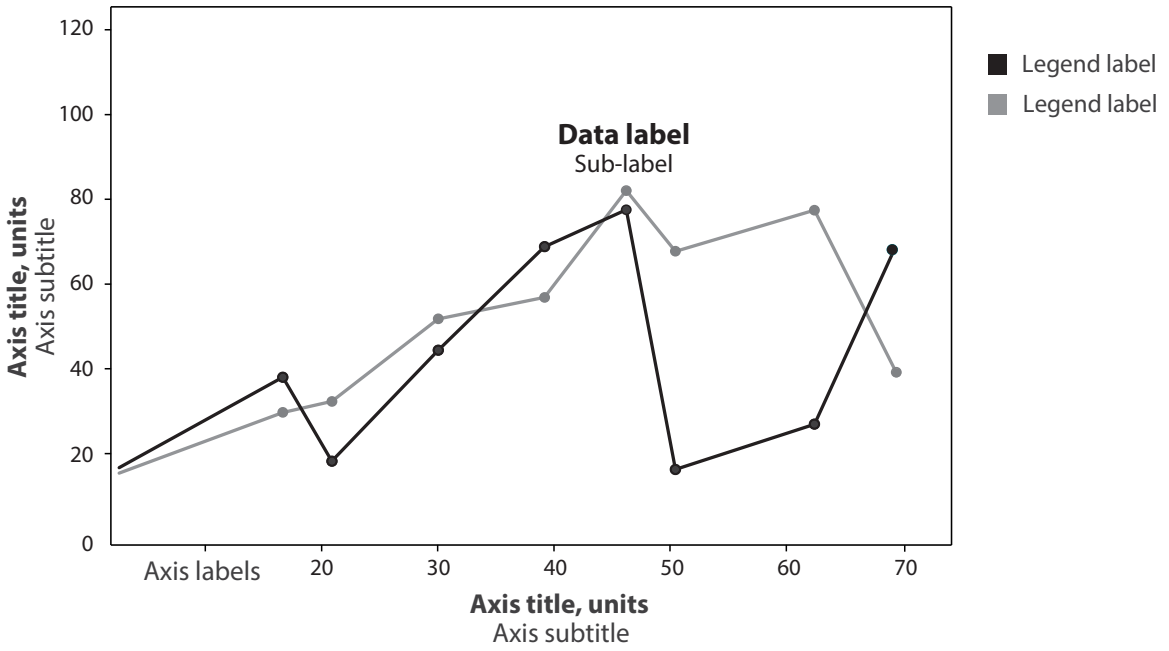


Figure 4: Sample gray scale chart with chart elements

Font selection

OWP uses the Myriad Pro fonts for final published products. It is one of OWP's specified, core typefaces and should be used when developing charts for our training manuals. The system font Calibri should be used when draft files are being shared outside of OWP. It is a common font that typically ships with most PC systems. Use Calibri when sharing documents with clients and colleagues.

Use bold text only for a few key elements. Bold applied to many parts makes important elements difficult to find. Compare the two charts in Figure 5. The shape of the graph is harder to see in the version on the left.

Table 2 provides guidance on when and where to use the different preferred OWP chart fonts.

Table 2: Font selection recommendations

Name	Size	Usage	
Myriad Pro regular Calibri regular	9–12pt	Axis labels, units Data labels Sub-labels	Axis subtitle Legend labels Source
Myriad Pro bold **Calibri bold**	11–14 pt	Data labels Axis titles	
Myriad Pro bold **Calibri bold**	14–22 pt	The most important information that needs to be highlighted in charts. Usually it will be a single data label.	

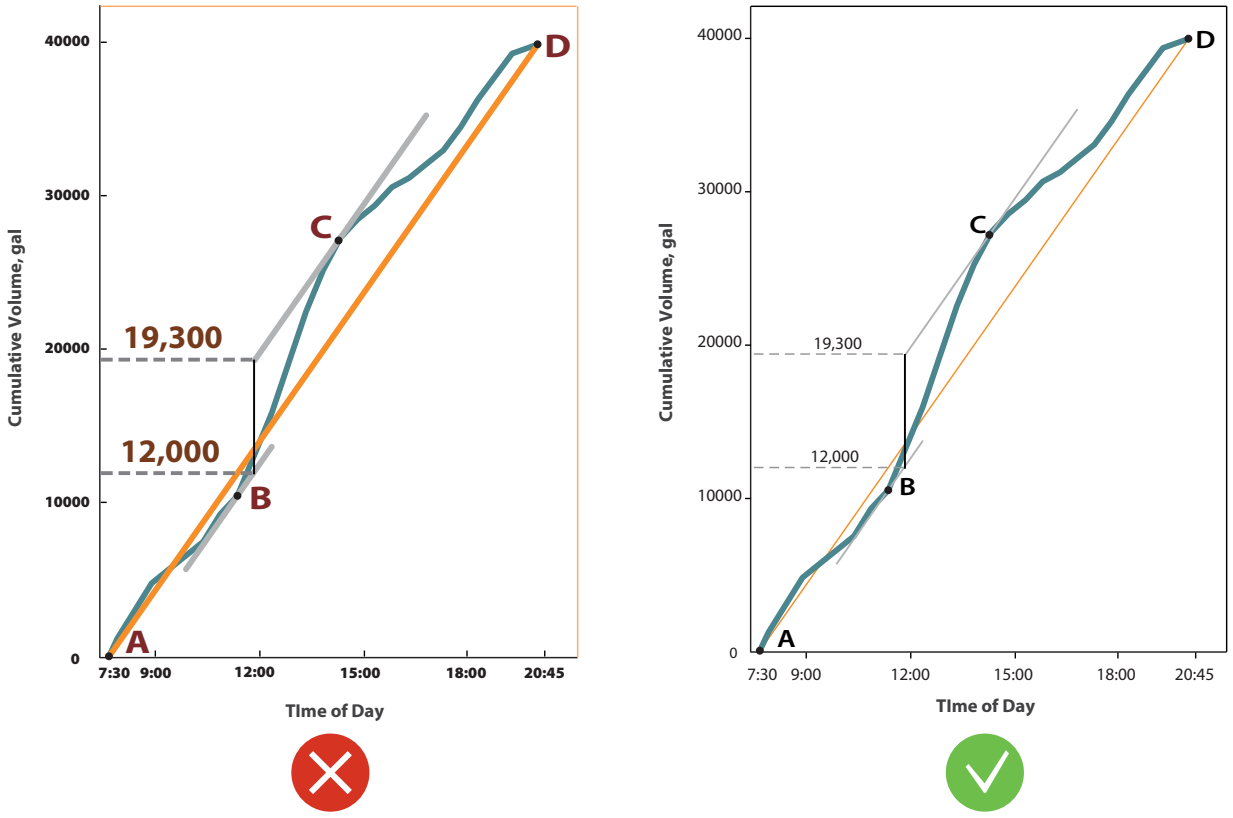


Figure 5: Fonts and colors

Selecting chart elements

Creating graphs and charts might be a challenging process since information is often complex. Try to keep them simple. Include only the essential information. Do not overload charts with superfluous details such as extra data labels.

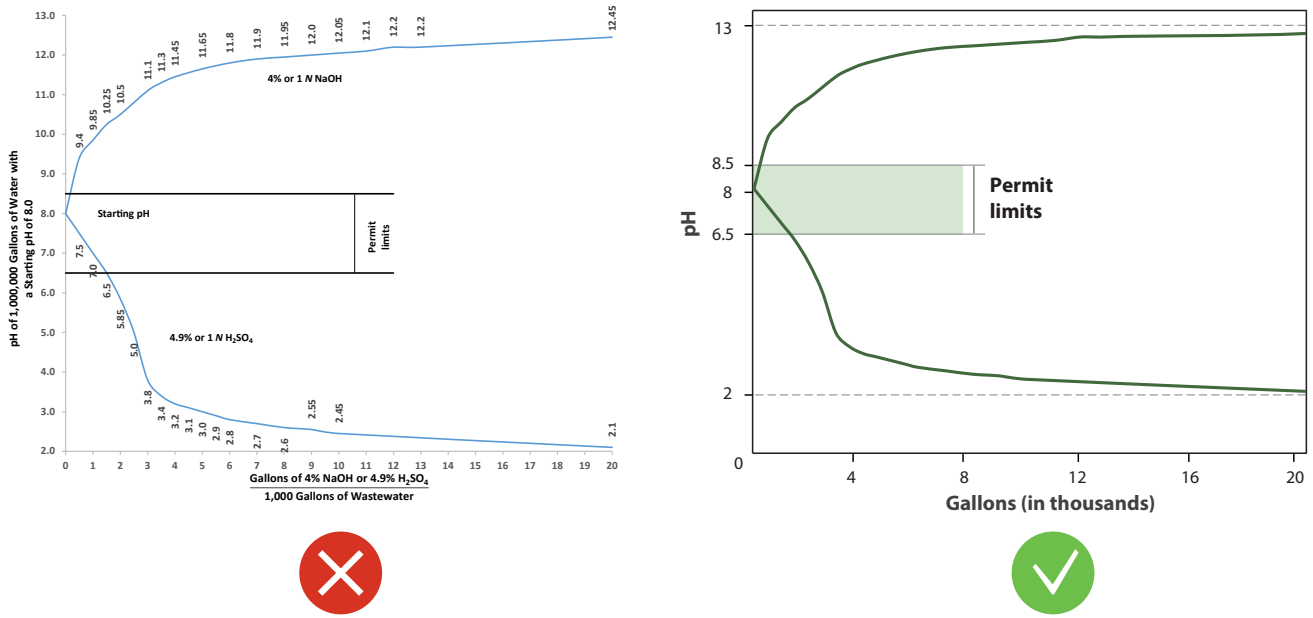


Figure 6: Essential information

Use of color

There are many instances when colors can help a chart convey information:

- speed up the visual search of important elements
- increase object recognition
- convey structure
- show symbolism
- convey mood

Black and shades of gray are always a good starting point. Add colors only if they are needed for the graph or chart to tell its story. Use just 1 or 2 colors if possible. Some colors might be **hard** to read because they are too light. Others might be very **similar** to **black**. When choosing colors for text, select colors with **strong** contrast.

Colors are powerful tools that can help, but they might be harmful if used inappropriately. It is possible to trigger negative associations in viewers without realizing it. There are several recommendations that will help avoid common problems.

Color readability

A large number of people have limited color vision. Look at the pie charts in Figure 7. The right part of the image shows how people with color blindness will see these charts. The top chart will be very hard to read. Avoid this problem by choosing colors with different light values (light and dark contrast). Try to imagine how will your chart look in black and white.

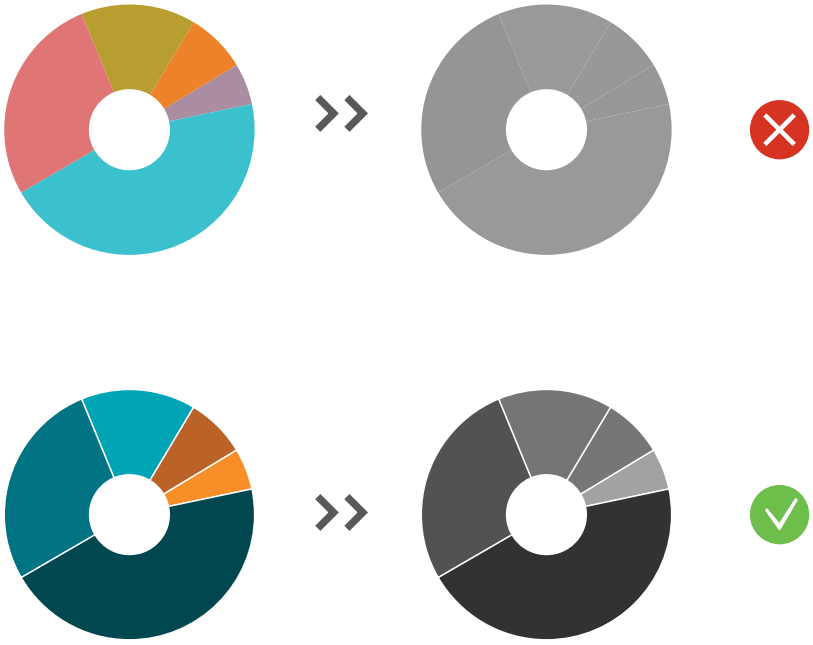


Figure 7: Pie charts in color and how they look in gray scale

Avoid unicorns and rainbows

Only use colors on the most important elements if possible. Use black, gray, and very muted colors for most parts of the chart.

In Figure 8, overuse of colors makes the charts hard to read. Additionally, they look busy and unprofessional.

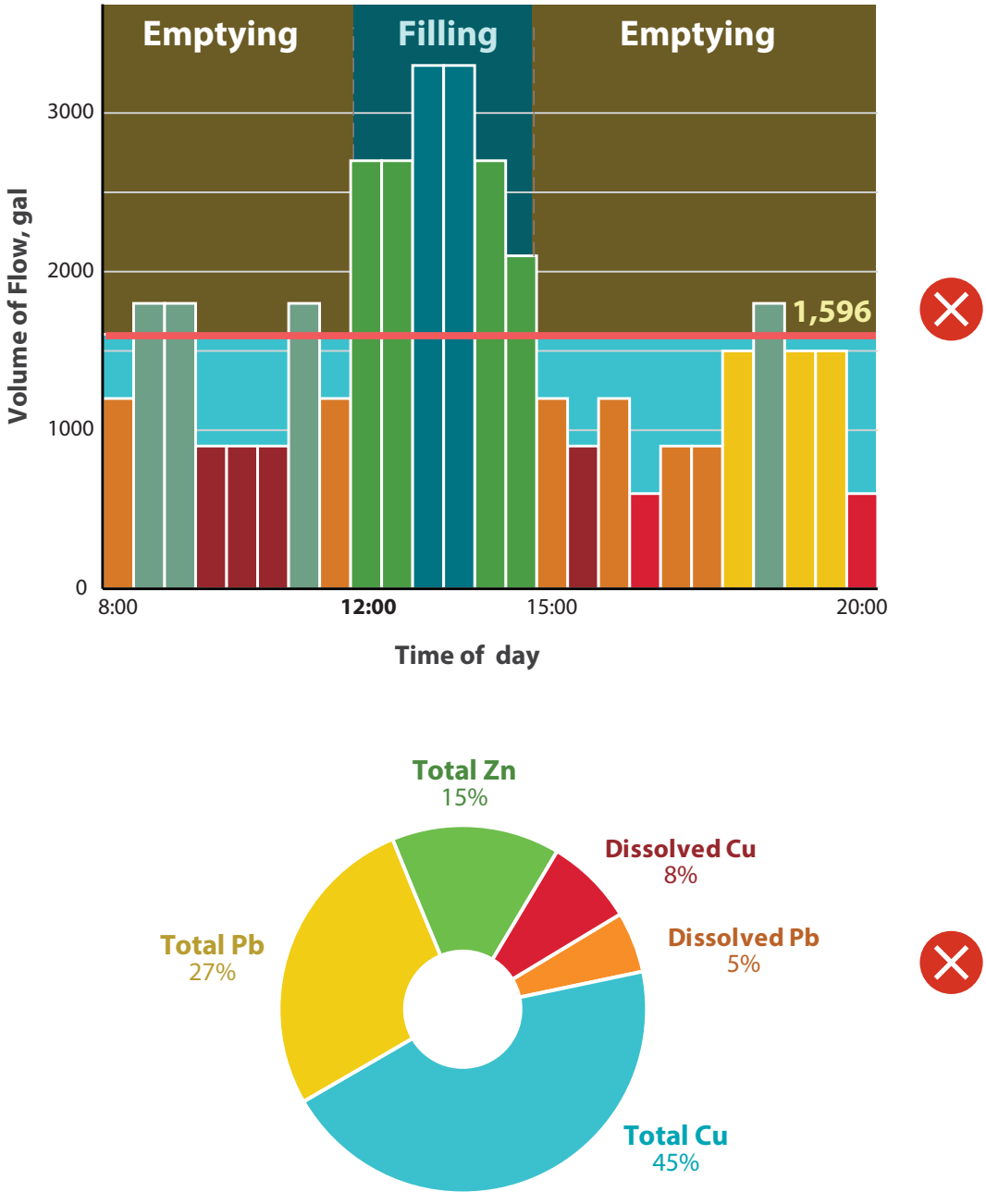


Figure 8: Examples of overuse of colors

Use OWP colors

Microsoft Office themes for OWP are available at **https://owp.csus.edu/brand/** and should be installed on your computer to help you create charts using the recommended OWP colors and fonts. Installation instructions are on the web page.

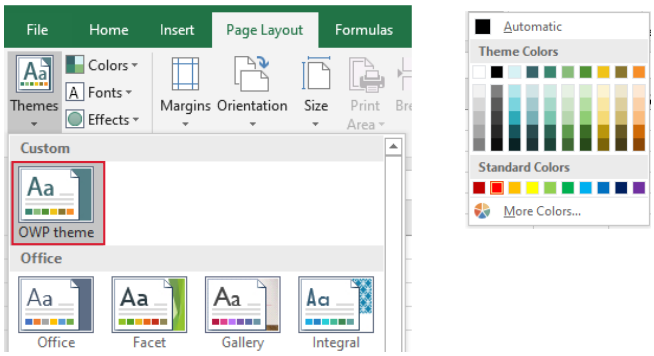


Figure 9: OWP theme in Excel

The OWP color palette contains a variety of muted colors that work nicely together.

How to use colors to attract attention

To use colors properly, it is important to think about a strategy. Overuse of colors might make the chart unreadable and distracting. The goal is to show important information as soon as possible. Ask yourself: "If the viewer saw only one element and looked away, what would be the element?" Text from the book or presentation describing the chart will help to find the element.

The original chart in Figure 10 is a gray scale bar chart. It shows all the information with the same level of importance. While it might be relatively easy to find the part discussed in the text on this chart, more complex charts will make the task challenging. The chart also contains unnecessary information, such as many entries for the time of day. Additionally, it does not have a focal point to direct the viewer's attention.

Compare the Original Chart in Figure 10 with Options A, B, and C. What stands out the most on each option?

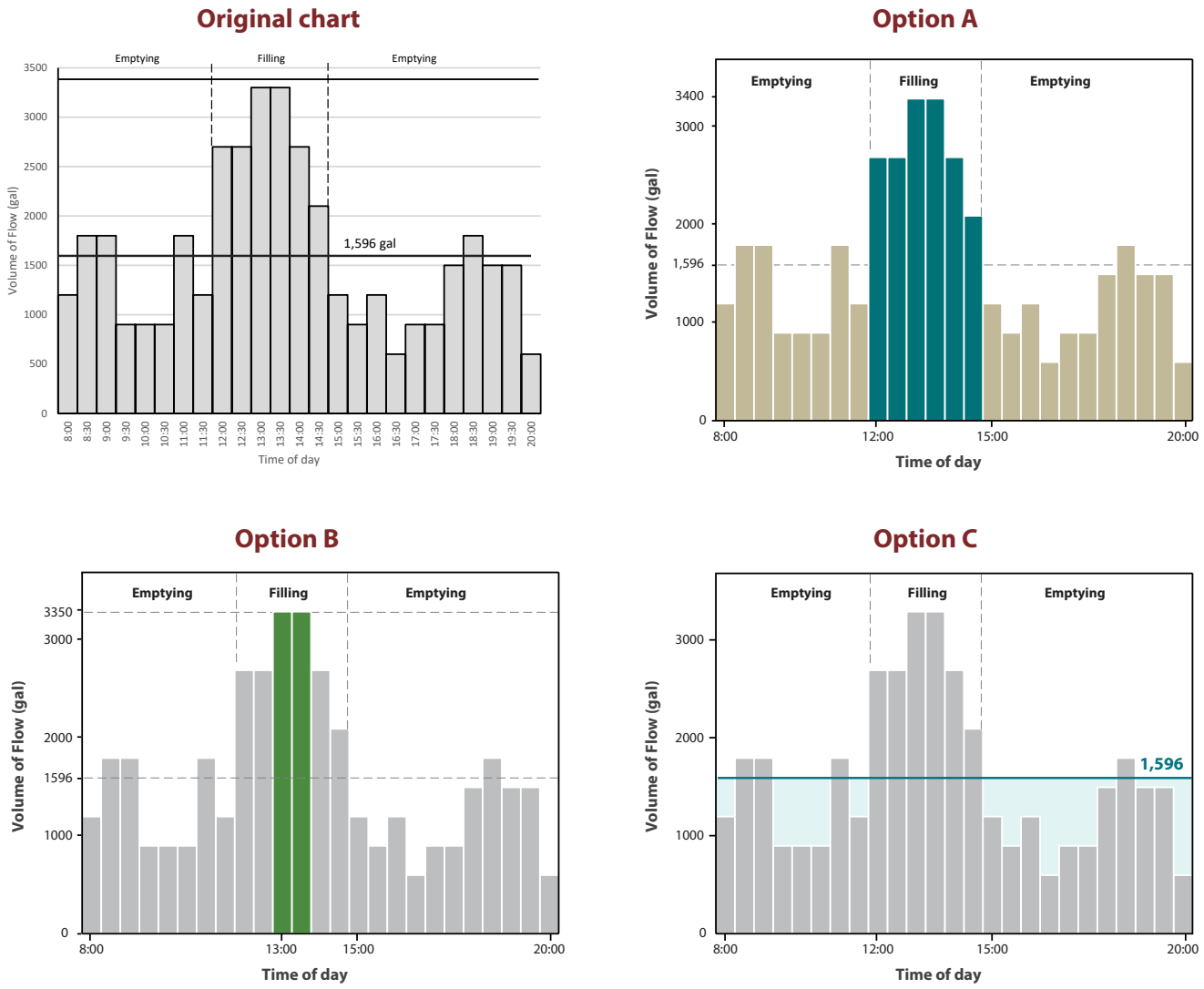


Figure 10: Chart variations for emphasizing different aspects

- Chart A highlights the filling process. Colors are used to emphasize the difference between the emptying and filling processes.
- Chart B highlights the maximum value. Using color only on the bars with the highest values attracts attention to them.
- Chart C highlights the optimal value of 1,596 gal. Adding a background color below the line makes it easier to see when the bar is above or below the optimal value.

Choose the most important part of the chart and make it stand out.

It might be helpful to use multiple variations of the same charts if you want to emphasize several aspects. For example use variation A when the presenter talks about emptying and filling processes, and switch it to variation C when the talk moves to the optimal value.

Use colors to group related elements

Colors from the same Theme Colors Column in the OWP theme can be used to show connection (Figure 11). Use two columns to show the difference between groups.

Figure 11: OWP colors selection

Figures 12 and 13 illustrate how colors can be used to show connection and separation between groups of elements. Colors separate the values for total and dissolved metals in Figure 12. Total values are in the brown color range while dissolved are in blue. Figure 13 uses a similar principle with brown and yellow color families.

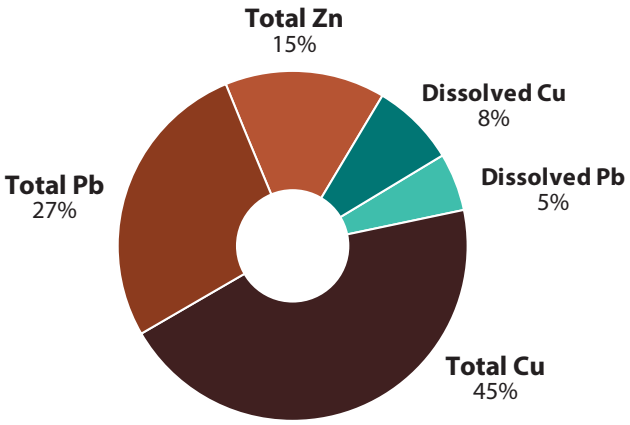


Figure 12: Use of colors for a pie chart

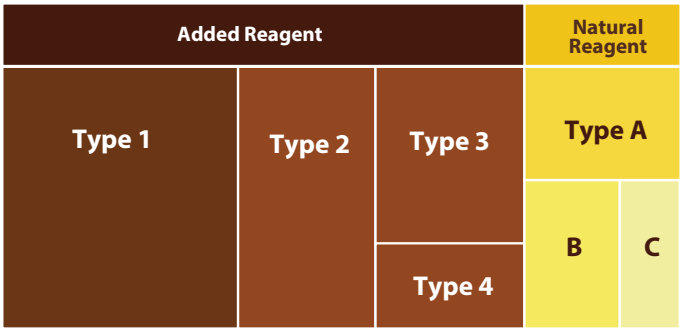


Figure 13: Use of colors for a treemap

How to choose the chart type

Change over time

Change over time charts show data over a period of time, such as trends or comparisons across multiple categories.

- **Bar charts**
- **Stacked bar charts**
- **Area charts**
- **Sparklines**
- **Line charts**
- **Timelines**
- **Horizon charts**
- **Box and whisker charts**
- **Candlestick or box plots**
- **Waterfall charts**

Category comparison

Category comparison charts compare data between multiple distinct categories.

- **Parallel coordinate charts**
- **Bar charts**
- **Grouped bar charts**
- **Bubble charts**
- **Multi-line charts**
- **Line plots**
- **Sparklines**

Ranking

Ranking charts show an item's position in an ordered list.

- **Ordered bar charts**
- **Ordered column charts**
- **Parallel coordinate charts**

Part-to-whole

Part-to-whole charts show how partial elements add up to a total.

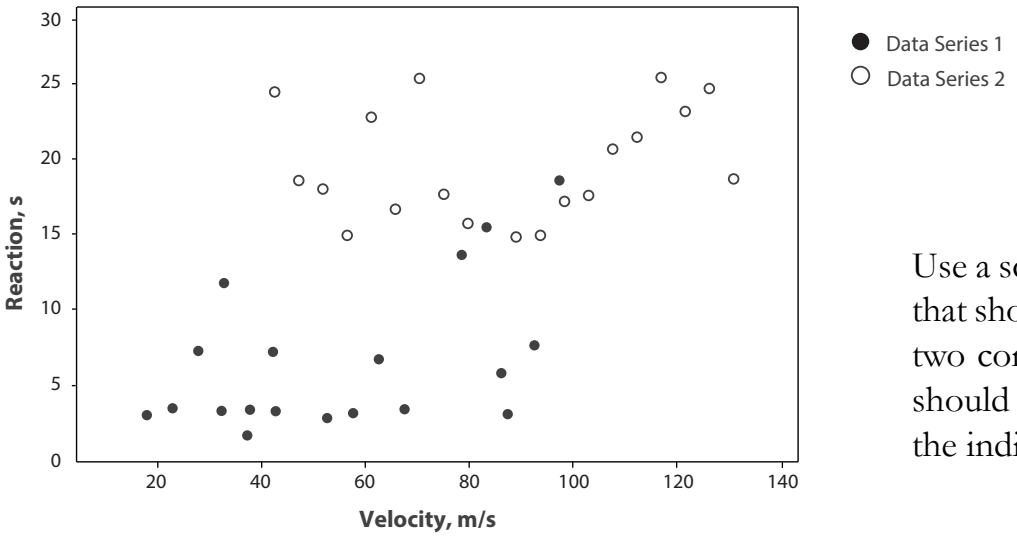
- **Stacked bar charts**
- **Pie charts**
- **Donut charts**
- **Stacked area charts**
- **Treemap charts**
- **Sunburst charts**

Correlation

Correlation charts show correlations between two or more variables.

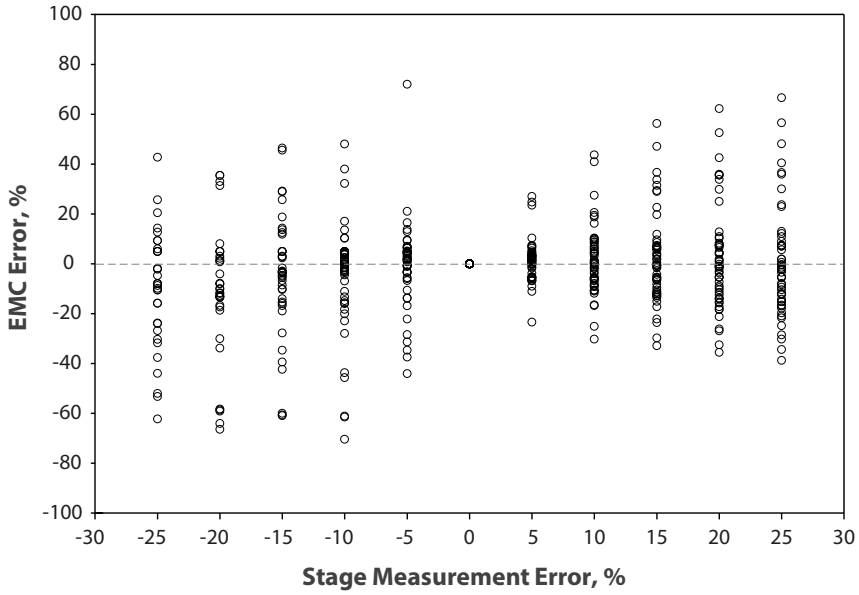
- **Scatter plots**
- **Dot plots**
- **Column and line charts**

Black and white examples



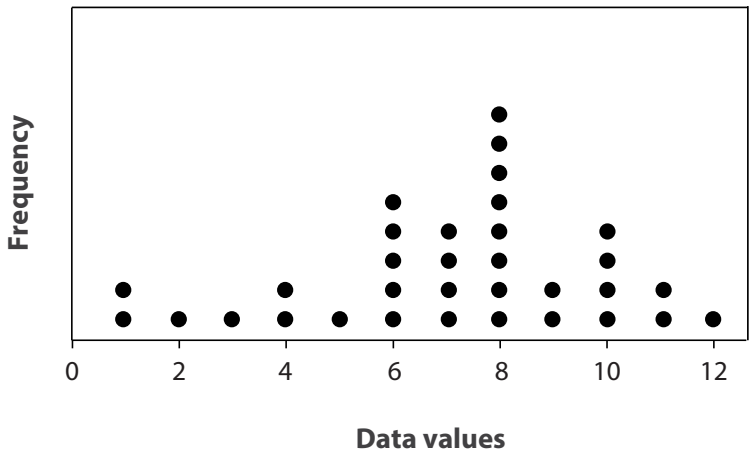
Use a scatter plot to display data that show a relationship between two continuous variables. Lines should not be used to connect the individual points.

Figure 14: Scatter plot



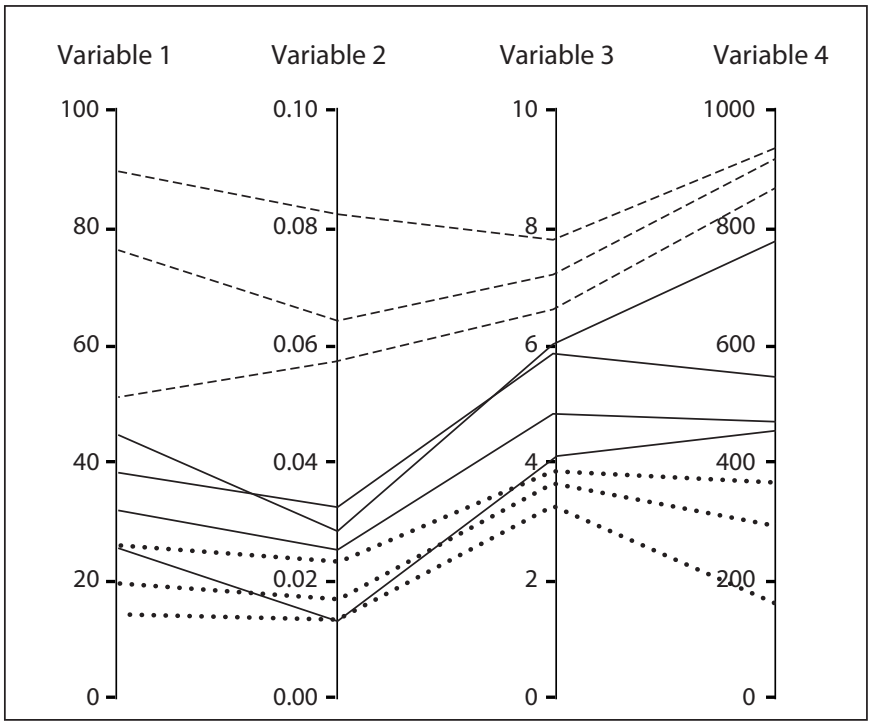
Dot plots are a good way to display continuous measurement data. They are similar to scatter pots except that the data are grouped into categories.

Figure 15: Dot plot



Dot plots can also be used as an alternate to bar chats as a way of displaying frequency. Each dot represents an occurrence, allowing the viewer to easily count the number of occurrences for data sets with smaller sample sizes.

Figure 16: Dot plot



One way to display multivariate data is to use a parallel coordinates plot. Each variable has its own coordinates (i.e., y-axis) that are laid out in parallel to each other. A line is used to connect the values across variables for a single data series. This allows the viewer to see how each data series differs between the variables.

Figure 17: Parallel coordinate charts

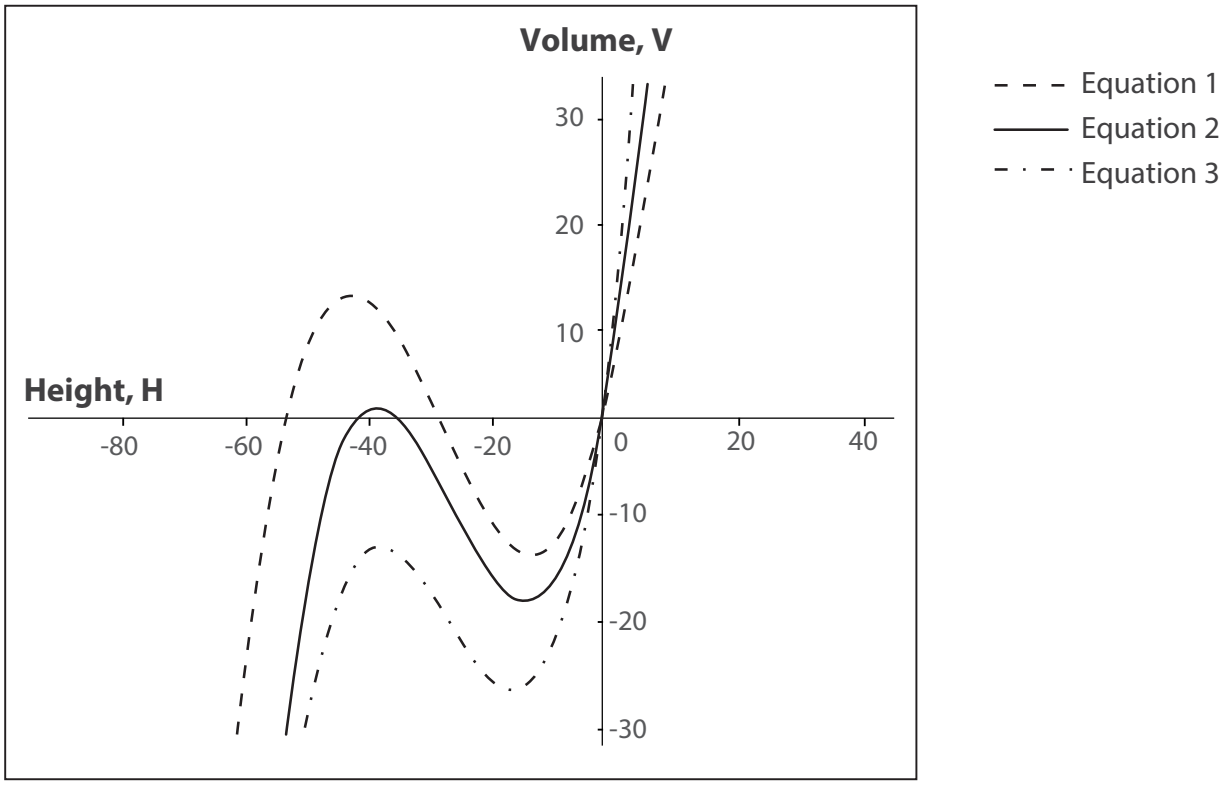


Figure 18: Line graph

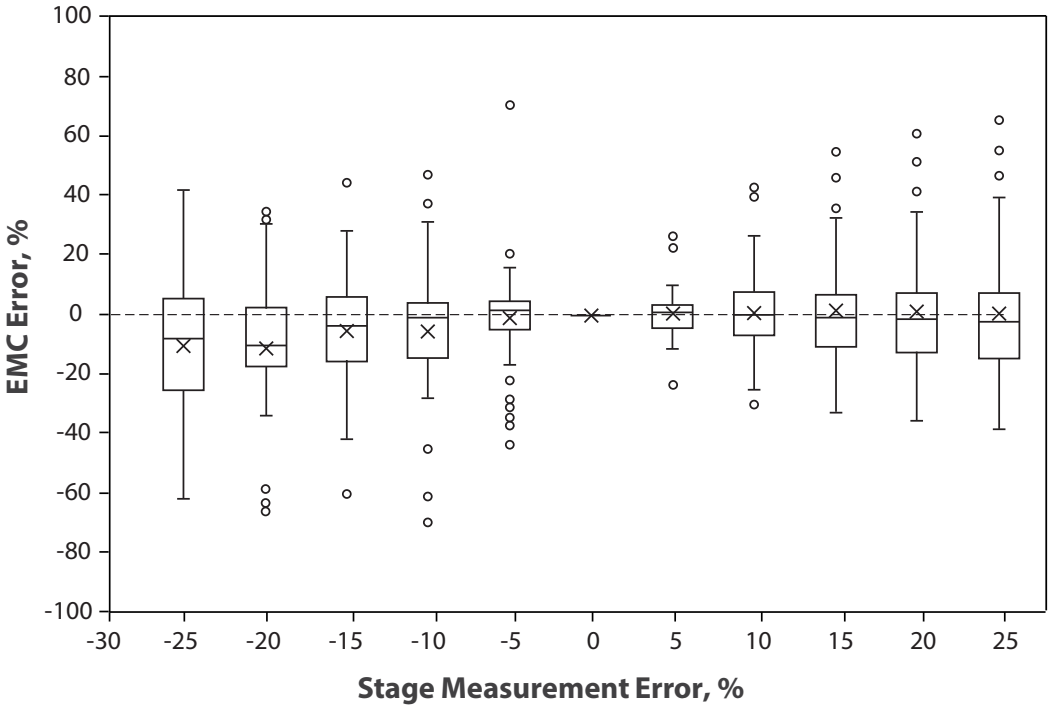


Figure 19: Box and whisker chart

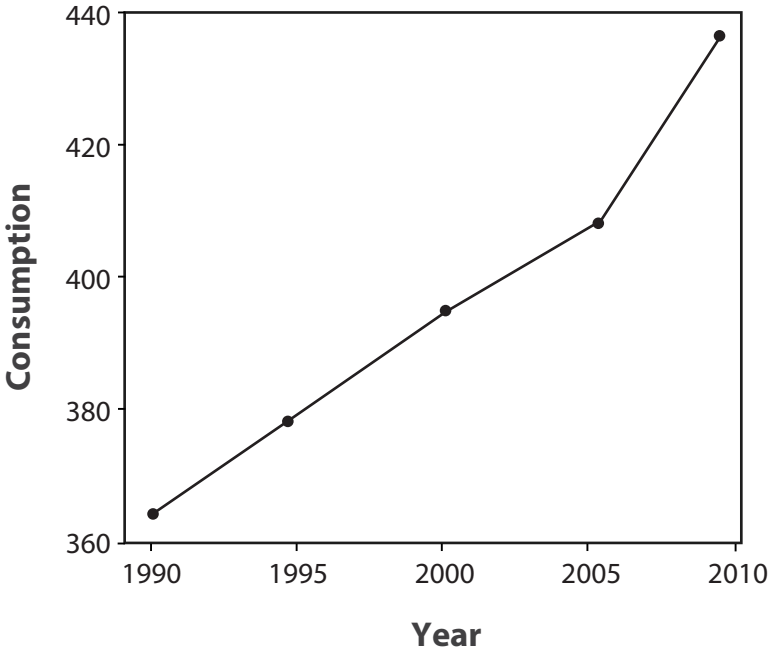


Figure 20: Time series connected graph with data points connected by straight lines

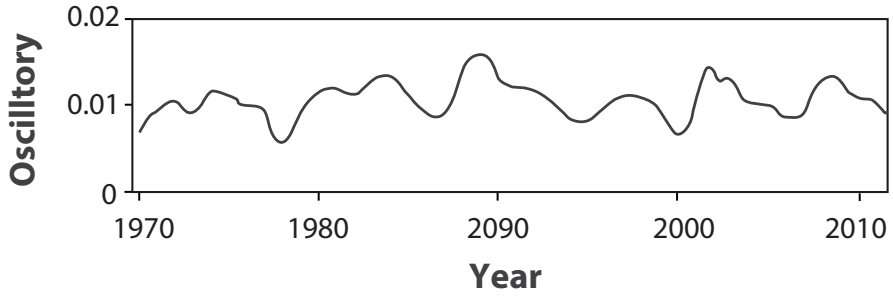


Figure 21: Time series connected graph with no points showing connected by a smooth line

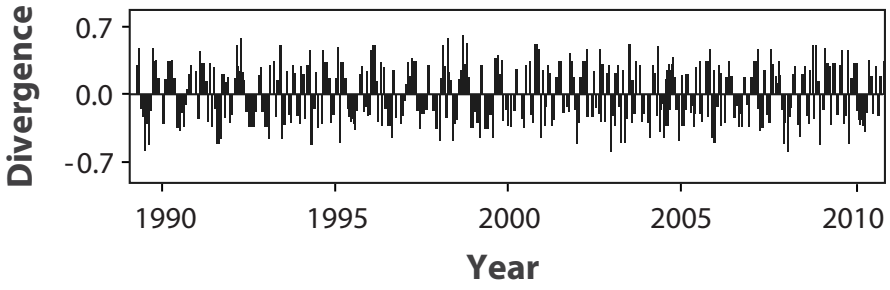


Figure 22: Time series vertical bar chart

Gray scale examples

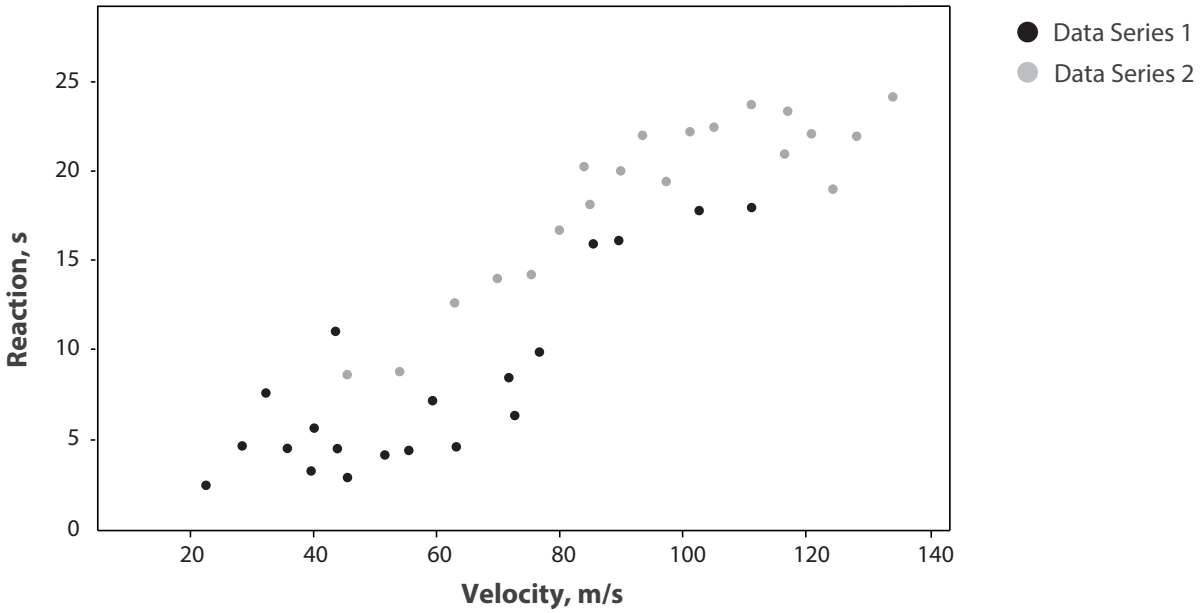


Figure 23: Scatter plot

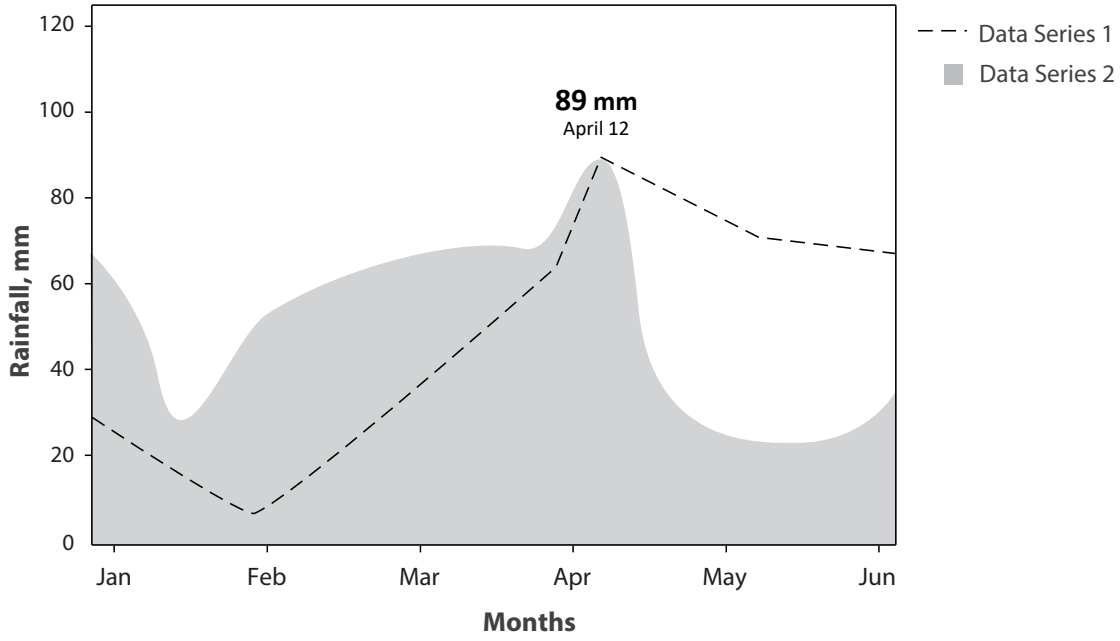


Figure 24: Area chart with line graph

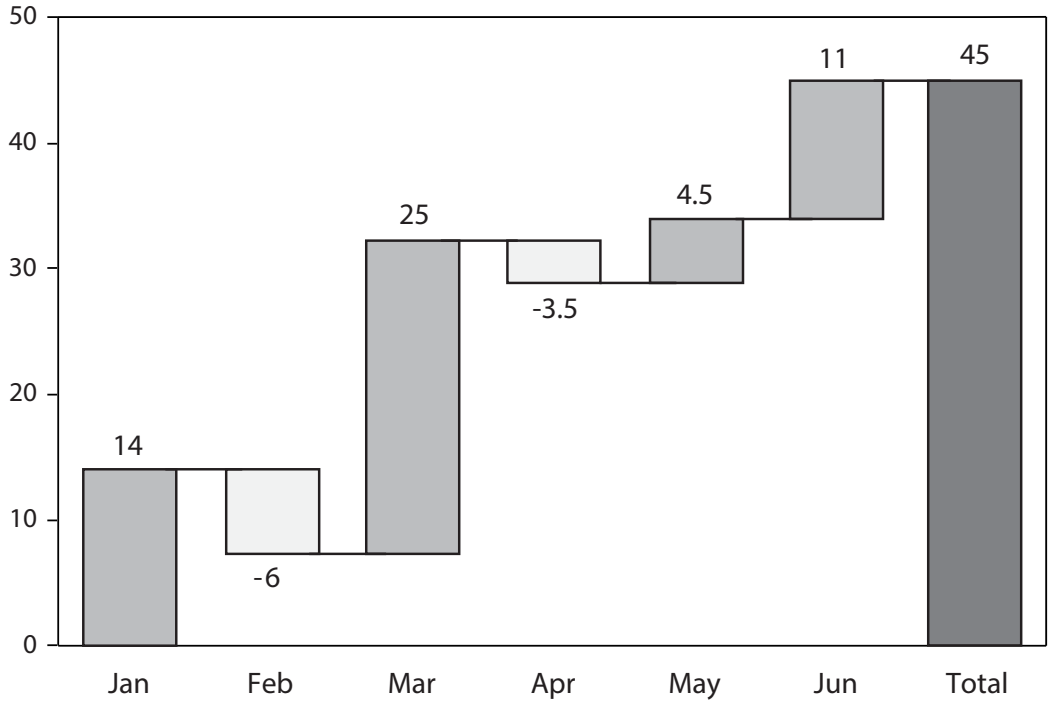


Figure 25: Waterfall

Color examples

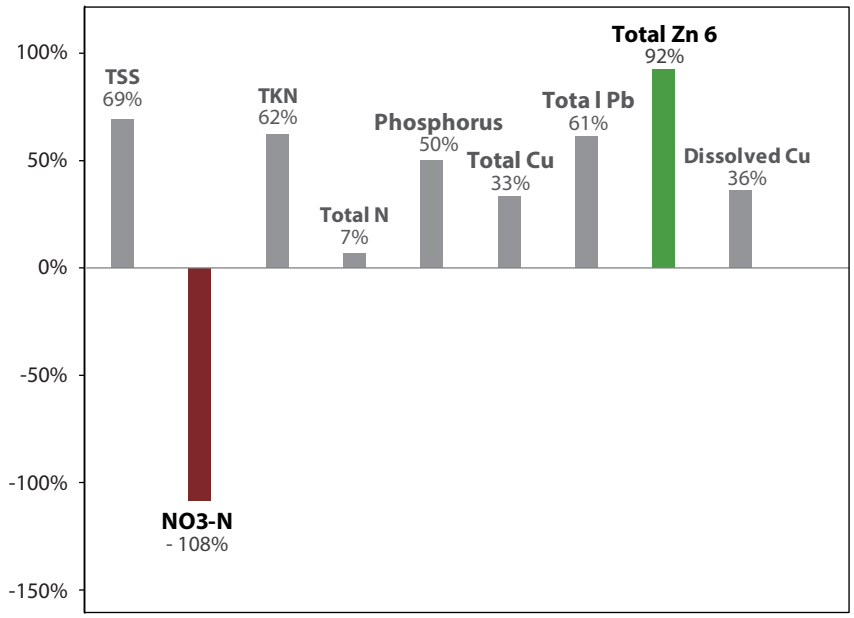
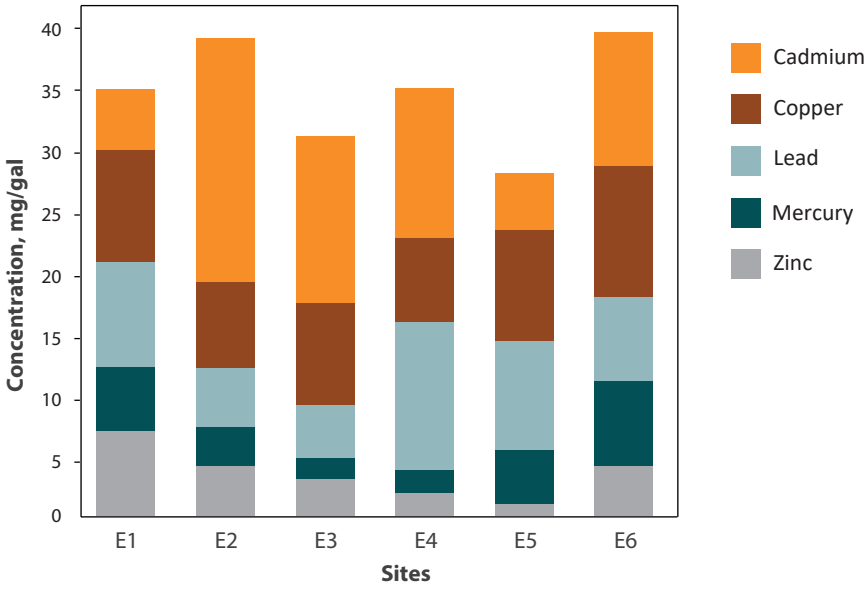


Figure 26: Bar charts with focal points on maximum and minimum values



Use strong color contrast for stacked bar charts. The colors should be different enough so people with limited vision might easily tell them apart.

Figure 27: Stacked bar chart

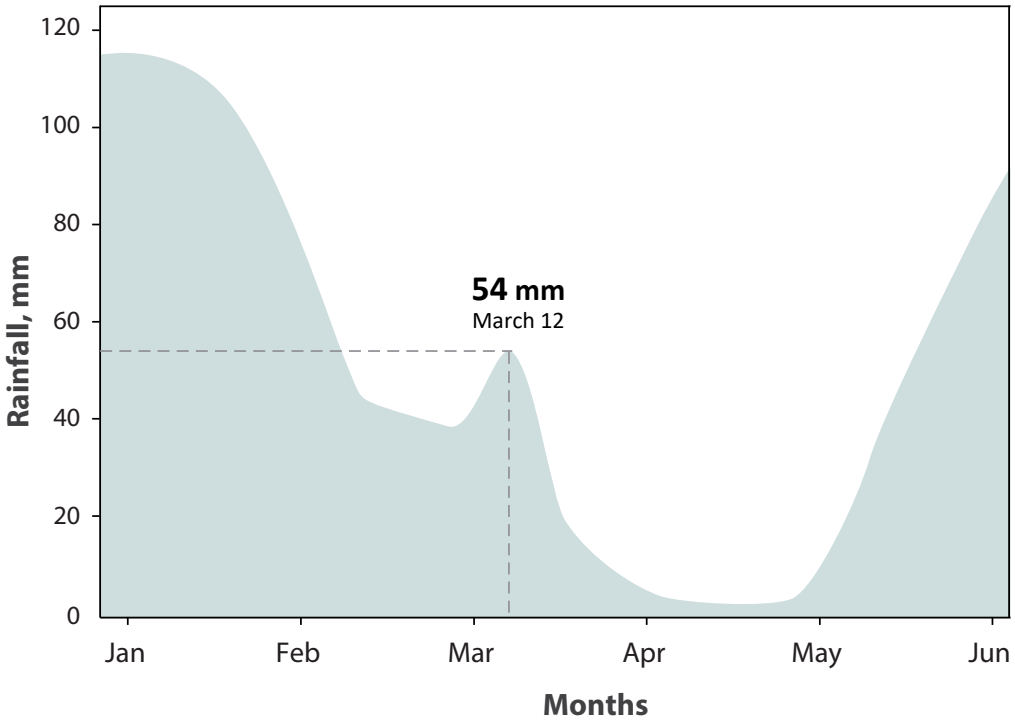


Figure 28: Area chart showing only important information or data points

Site	Jun	Jul	Aug	Sept	Oct	Nov	Dec	YTD
Sacramento	5	4	7	8	11	13	6	
Fresno	7	9	12	9	12	15	6	
Reno	11	10	12	15	17	9	12	
Elk Grove	9	12	15	14	12	13	14	
Loomis	12	14	15	13	10	14	15	
Somerset	13	15	10	11	12	15	14	

Figure 29: Sparklines

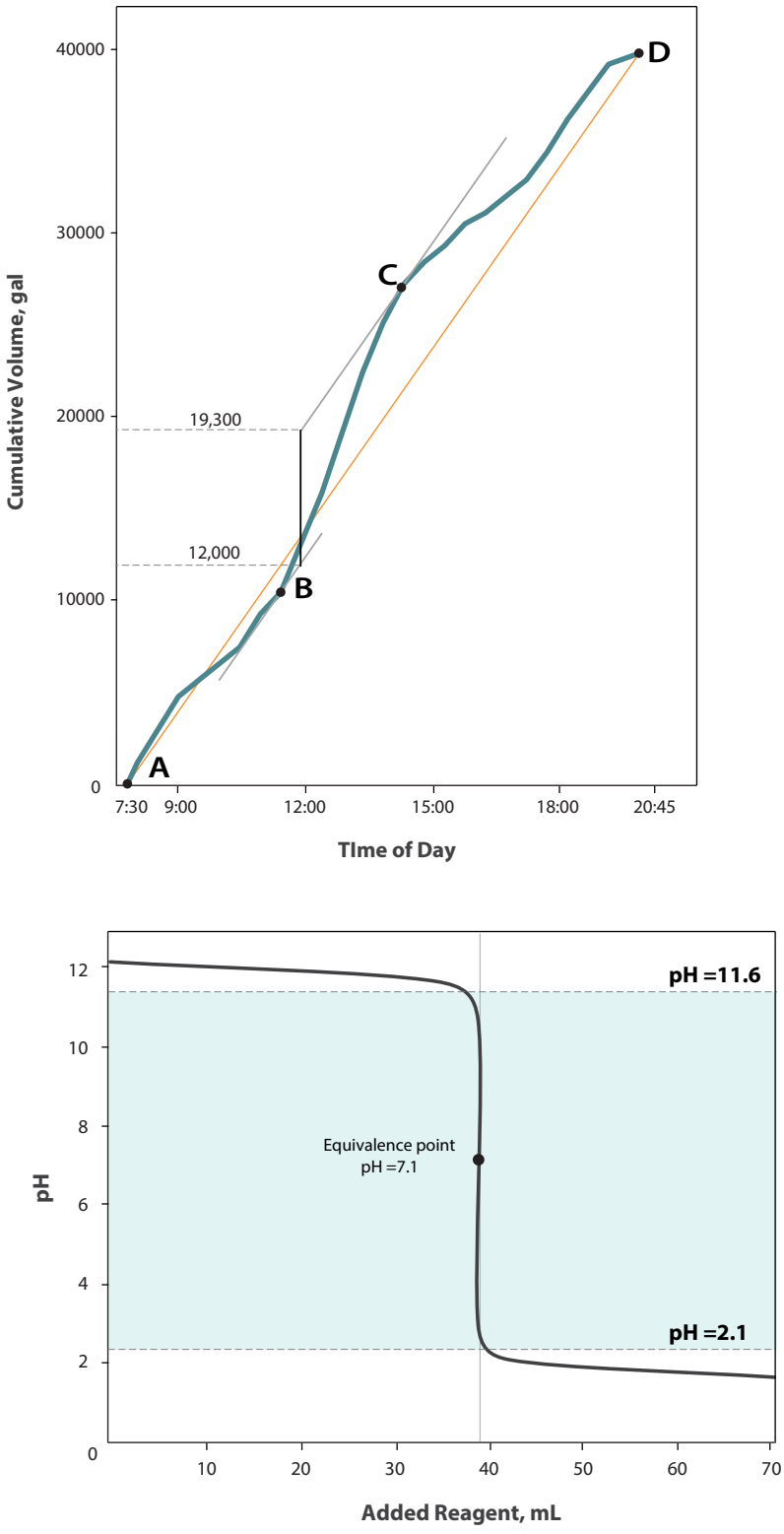


Figure 30: Line graphs

The two line charts have different focal points. The top chart focuses on the shape of the graph, with secondary accents on points A, B, C, and D. The bottom chart calls attention to the working area from pH 2.1 to pH 11.6.

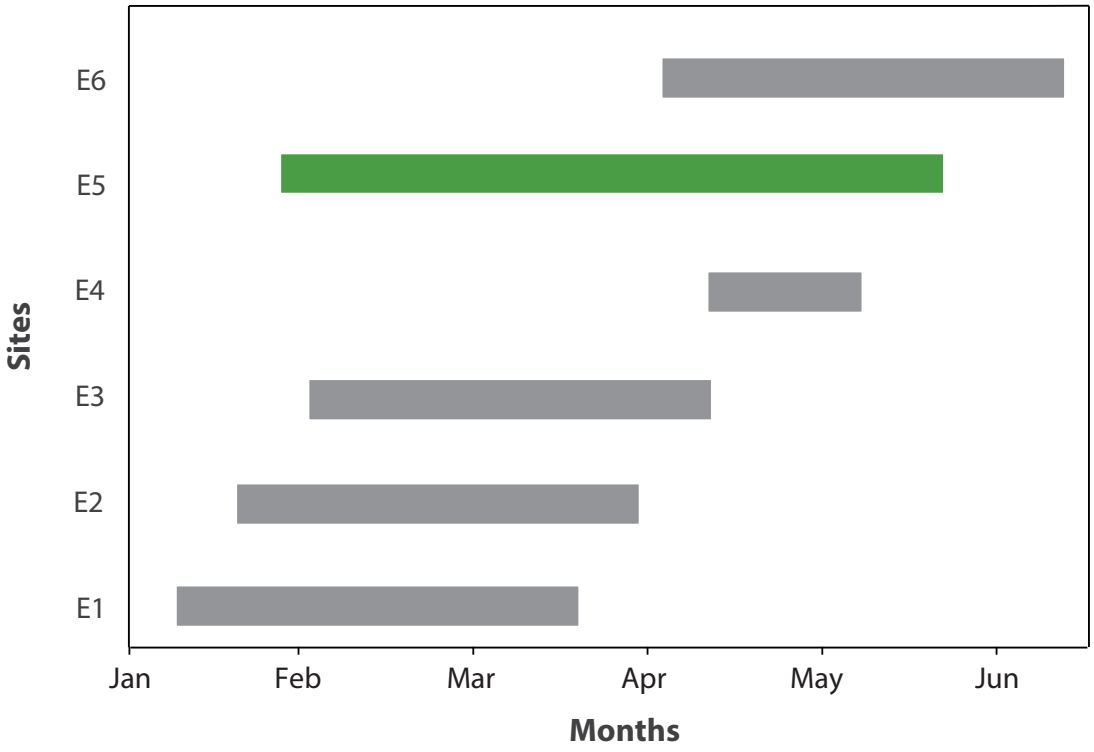


Figure 31: Timeline chart focusing on Site E5

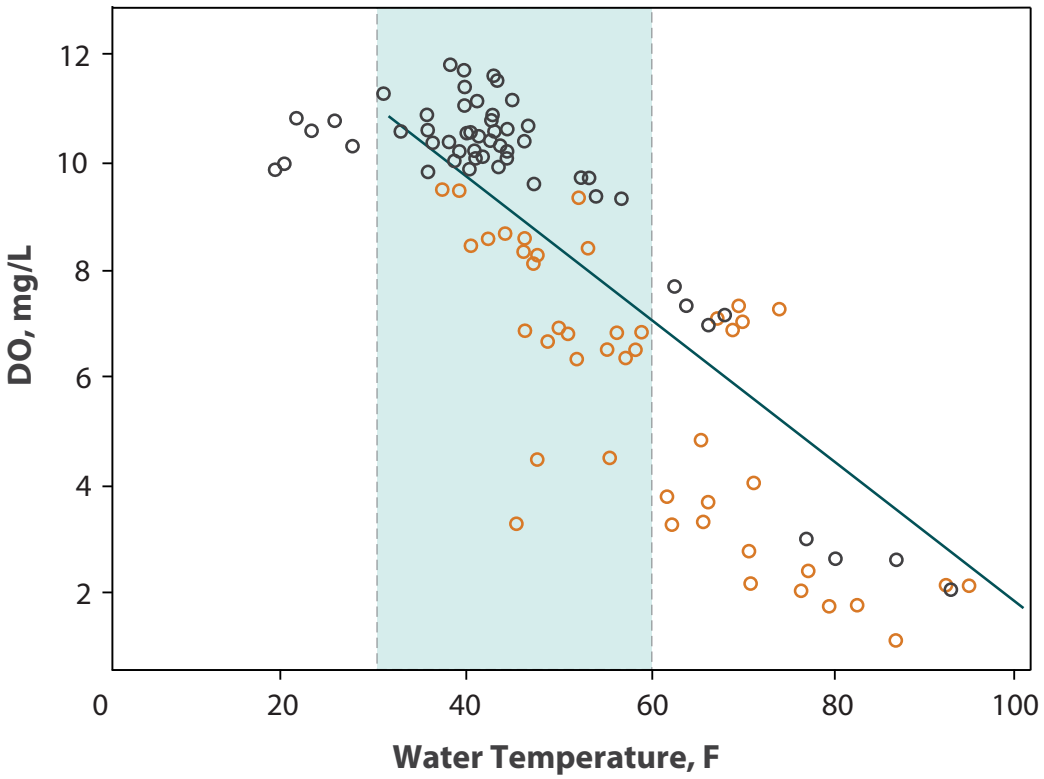


Figure 32: Scatter plot focusing on the area between 30 and 60 F

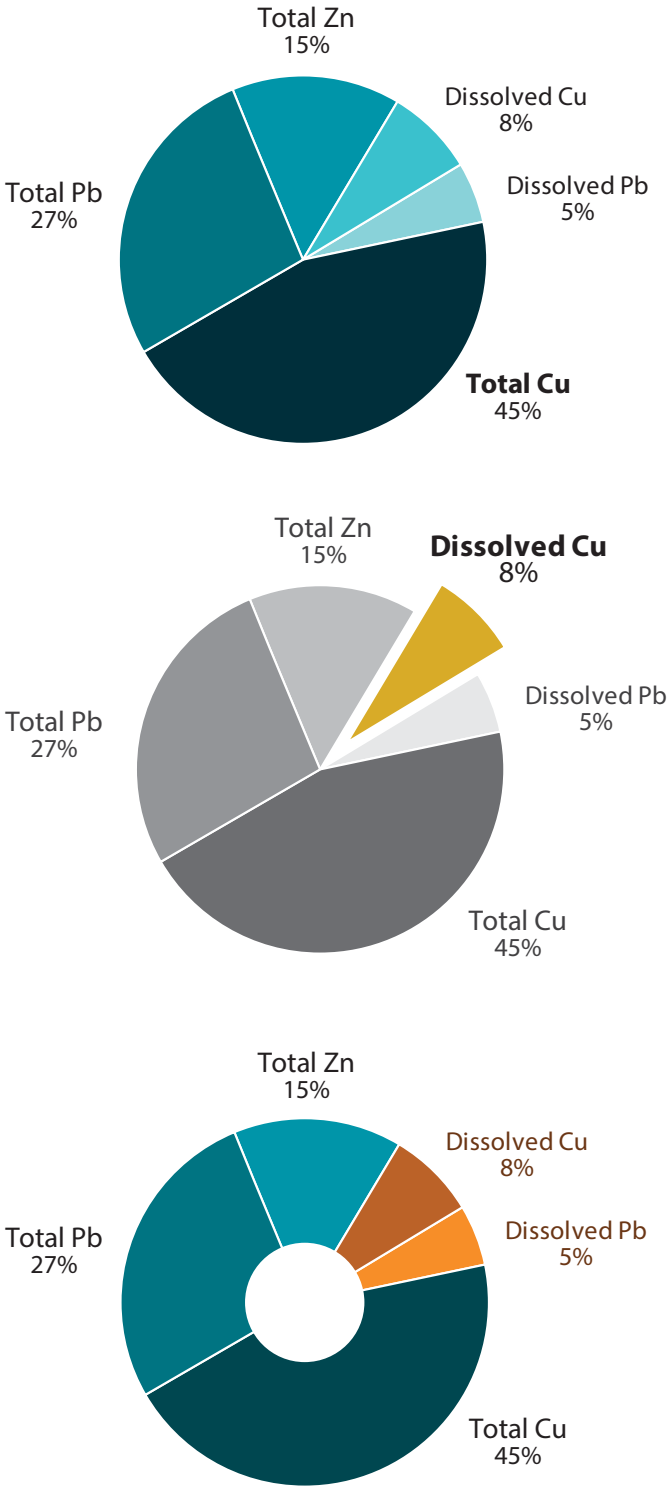


Figure 33: Pie charts

The same chart can be adjusted to show various aspects. The top pie chart shows the overall relationship between all elements while highlighting the biggest area. The middle chart emphasizes Dissolved Cu. The bottom one shows the difference between total and dissolved metals.

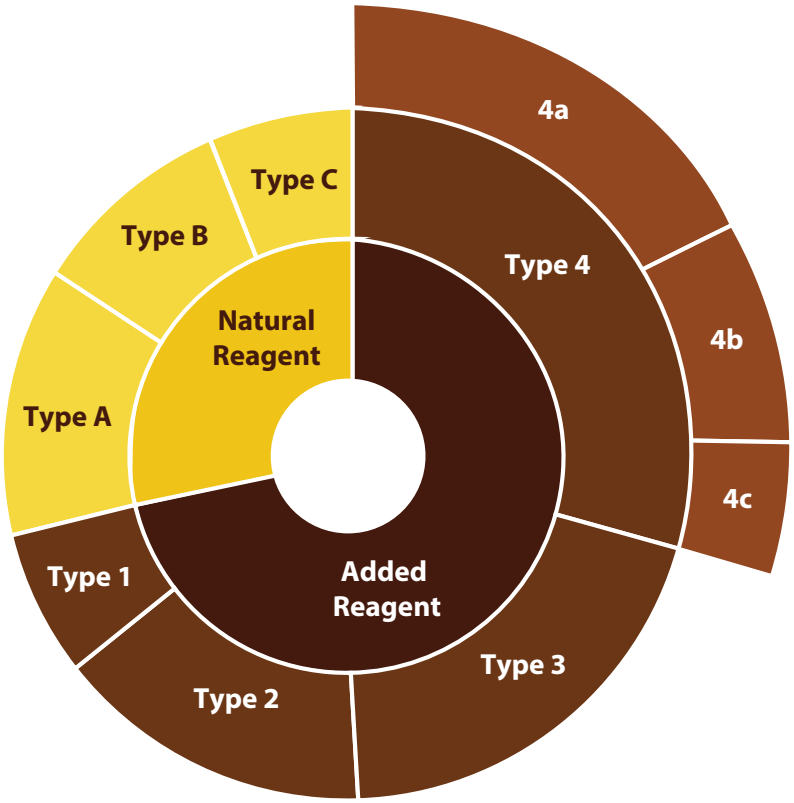


Figure 34: Sunburst chart focusing on the relationship between different kinds of reagents

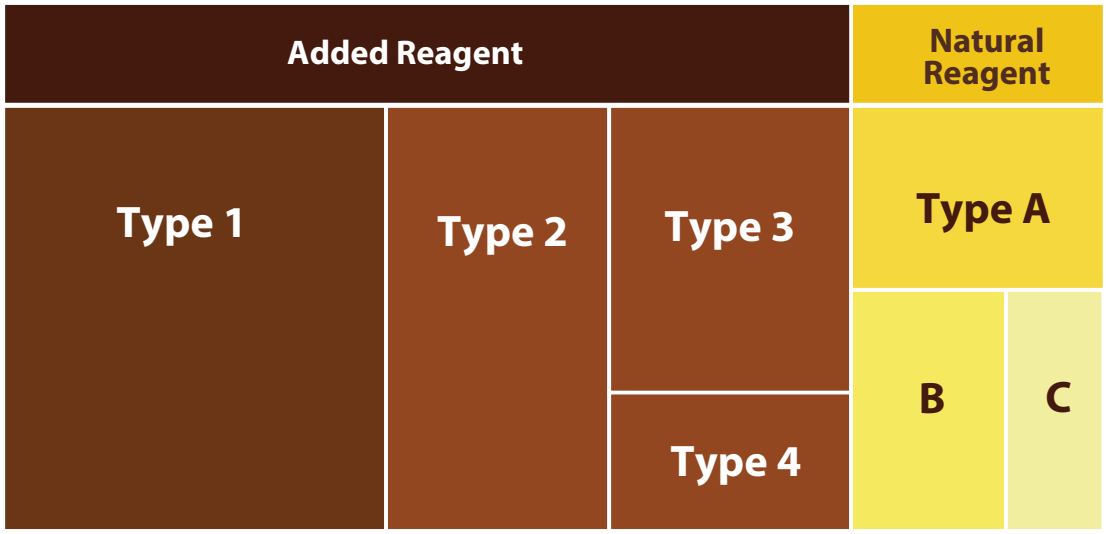
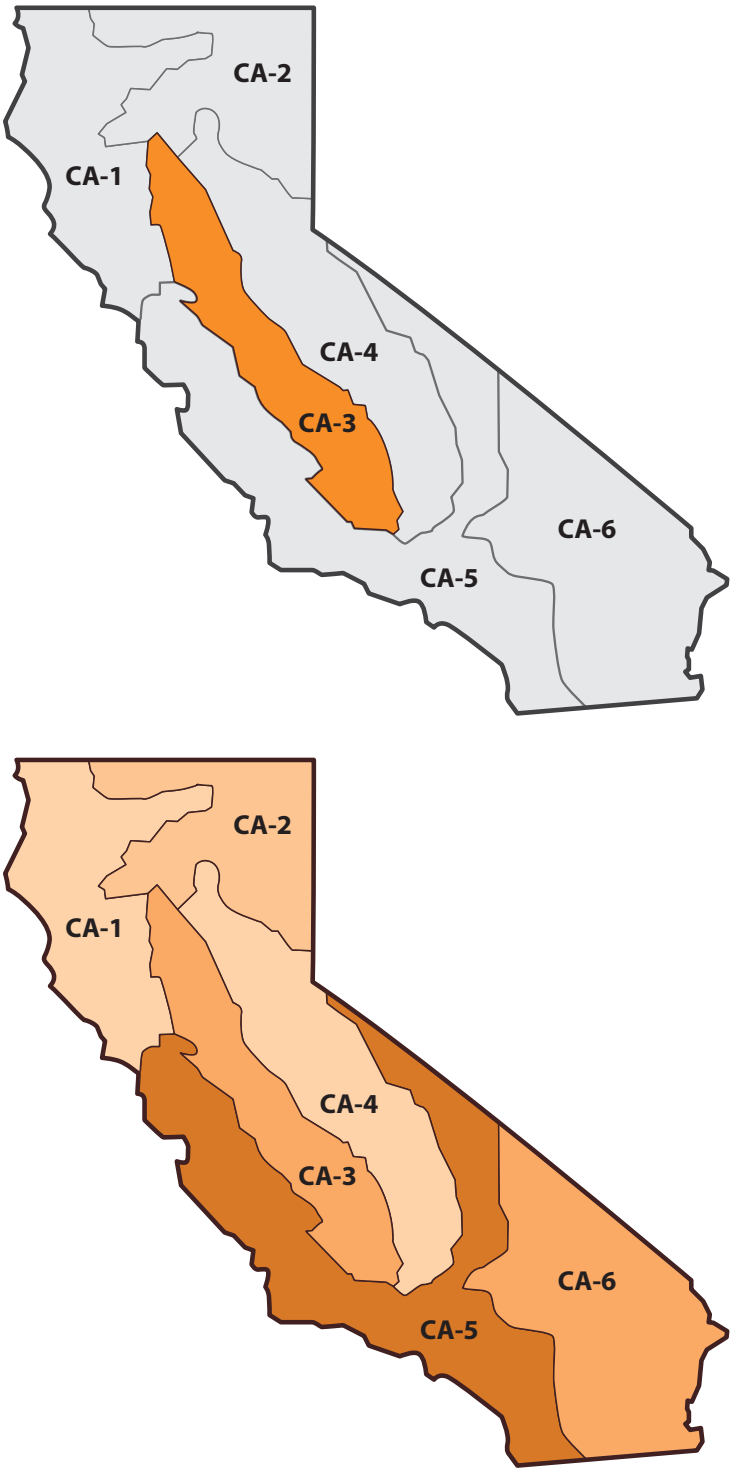


Figure 35: Treemap focusing on the value aspects of different kinds of reagents



You can apply similar design principles to maps. For example, the top map is focusing on the CA-3 area. The bottom example shows relative differences between various regions within California.

Figure 36: Maps

Additional resources

- **Chart elements**
  https://www.mit.edu/~mbarker/formula1/f1help/10-ch-c2.htm
- **Data-heavy applications: How to design perfect charts**
  uxplanet.org/data-heavy-applications-how-to-design-perfect-charts-c0c893fef6de
- **Designing charts**
  uxdesign.cc/designing-charts-principles-every-designer-should-know-5bd3969a0150
- **The Data Visualization Catalogue**
  https://datavizcatalogue.com/index.html
- **Tool for creating charts**
  www.highcharts.com
- Cleveland, William S. 1994. *The Elements of Graphing Data***.** Rev. ed. Summit, N.J.: Hobart Press.

Please contact the Graphics Group if you have questions or a complex project. We are here to help you!