Aqueduct 2.0 Project Water Indicators

The Aqueduct 2.0 is a project of the World Resources Institute, which was the source of the indicators presented here (Gassert et al., 2013).

Sustainability Goals:

Goal 1. Manage and make decisions about water in a way that integrates water availability, environmental conditions, and community well-being for future generations.

Goal 2. Improve water supply reliability to meet human needs, reduce energy demand, and restore and maintain aquatic ecosystems and processes.

Goal 4. Improve quality of drinking water, irrigation water, and in-stream flows to protect human and environmental health.

Goal 5. Protect and enhance environmental conditions by improving watershed, floodplain, and aquatic condition and processes.

Goal 6. Integrate flood risk management with other water and land management and restoration activities.

Goal 7. Employ adaptive decision-making, especially in light of uncertainties, that support integrated regional water management and flood management systems.

Sustainability Domains:

WSR – Water Supply Reliability = The availability or provision of water of sufficient quantity and quality to meet water needs for health and economic well-being and functioning.

EH – Ecosystem Health = The condition of natural system, including terrestrial systems interacting with aquatic systems through runoff pathways.

ASM – Adaptive and Sustainable Management = A management system that can nimbly and appropriately respond to changing conditions and that is equitable and representative of the various needs for water in CA.

What is it?

The Aqueduct Water Risk Atlas makes use of a Water Risk Framework (Figure 1), that includes 12 global indicators grouped into three categories of risk (physical risk quality, physical risk quantity, and regulatory) and one overall score. The following Aqueduct project indicators were used in the Framework: 1) Baseline Water Stress, which is the total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percent of the total annual available flow; 2) Interannual Variability, which is a measure of the variation in water supply between years; 3)

Seasonal Variability, which is a measure of the variation in water supply between months of the year; 4) Flood Occurrence, which is is the number of floods recorded from 1985 to 2011; 5) Drought Severity, which is a measure of the average length of droughts times the dryness of the droughts from 1901 to 2008; 6) Upstream Storage, which is a measure of the water storage capacity available upstream of a location relative to the total water supply at that location. 7) Groundwater Stress, which is a measure of the ratio of groundwater withdrawal relative to its recharge rate over a given aquifer; 8) Return Flow Ratio, which is the percent of available water previously used and discharged upstream as wastewater; 9) Upstream Protected Land, which is the percentage of total water supply that originates from protected ecosystems; 10) Threatened Amphibians, which is a measure of the percentage of freshwater amphibian species classified by IUCN as threatened.

Why is it Important?

Understanding how much water is available now, how much might be available in the future, how much of supply is consumed by society's activities, and the impact of protecting and using water systems are all critical to managing human activities for water sustainability. Each o the indicators of the Aqueduct project are used in various parts of the world to inform water management. Collectively, they provide a powerful set of indicators of condition and risk to condition. Even if the assessment presented here is inaccurate for regions or watersheds of California, local or regional data can be used to evaluate the indicators in the future.

What is the target or desired condition?

The desired condition is for all indicators to be at "low risk", because this is the condition most likely to result in sustainability over the long term. The undesired condition is for indicators to be at "very high risk", which generally signals a large departure from a safe condition.

What can influence or stress condition?

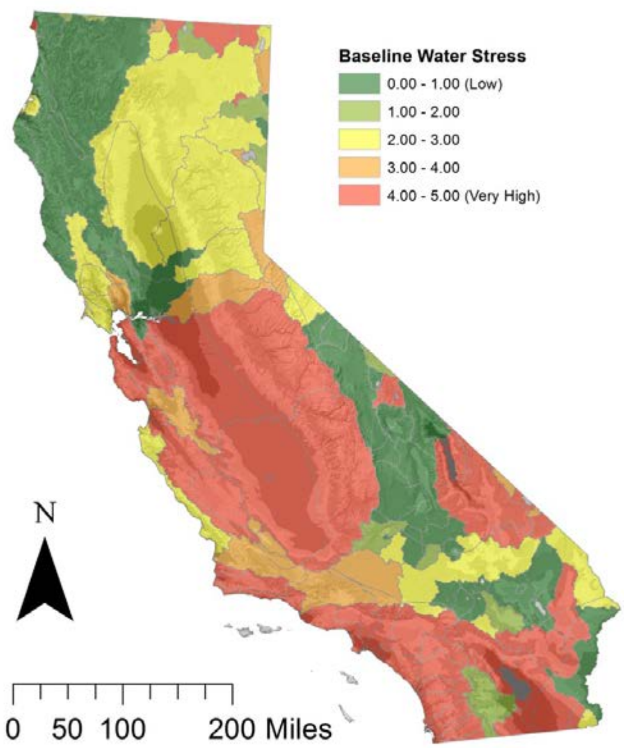
The natural and human systems represented by the indicators will be influenced by different factors, depending on the indicator. In general, all are likely to be affected by climate change, which is likely to cause departures in temperature and precipitation from current conditions and ranges. Human population (numbers and settlement patterns), land use, and efficiency of water use are all likely to influence most of the indicators shown. The degree and direction (positive or negative) of effect will vary with indicator and influence.

What did we find out/How are we doing?

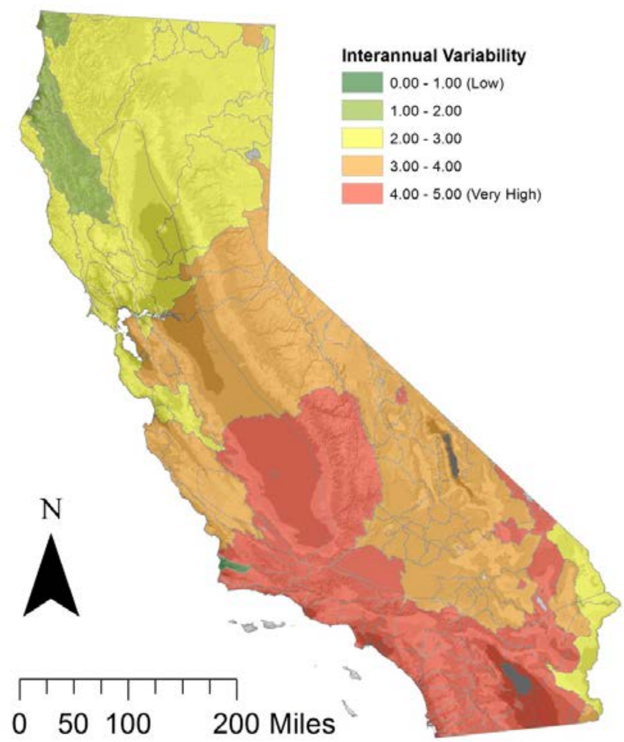
Each indicator from the Aqueduct 2.0 project was "clipped" to the extent of California. The indicators are presented using the raw values in Gassert et al. (2013), which are expressions of risk from "0" (low risk) to "5" (very high risk).

The geographic units scored are river basins and watersheds. Contiguous watersheds with similar risk scores may appear as one large region. Generally speaking, risk scores are ratios of a watershed or basin value and a base value, therefore risk scores for one indicator are not strictly-speaking comparable to scores for other indicators.

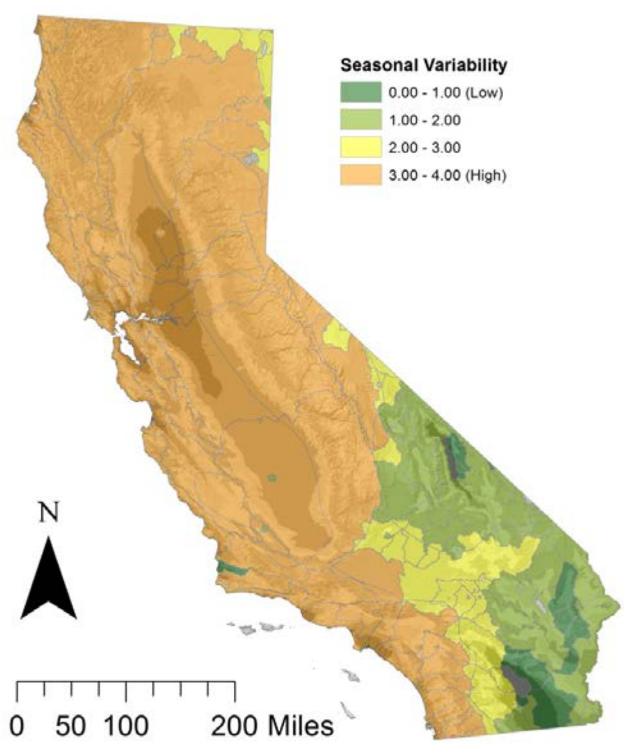
1) Baseline Water Stress, which is the total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percent of the total annual available flow (withdrawals / available flow). Higher values indicate more competition among users. Arid areas with low water use are shown in gray, but scored as high stress when calculating aggregated scores.



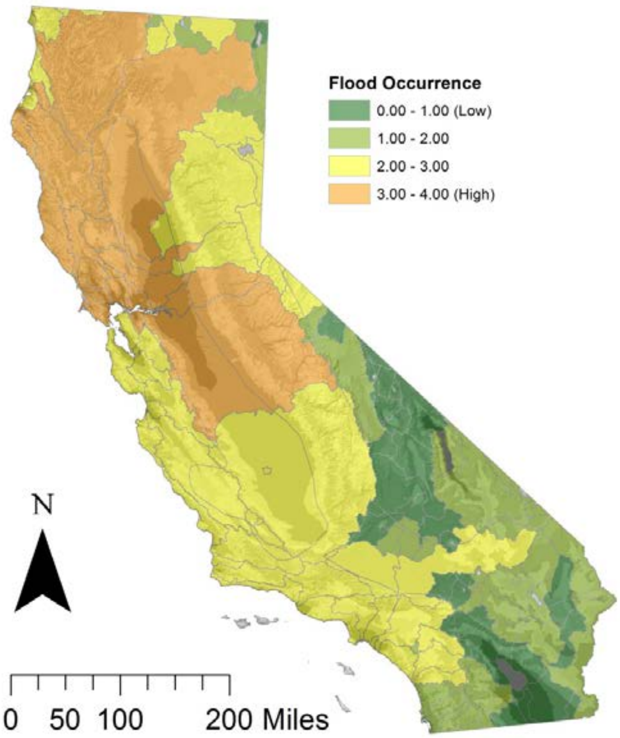
2) Interannual Variability, which is a measure of the variation in water supply between years (standard deviation / mean of total annual supply).



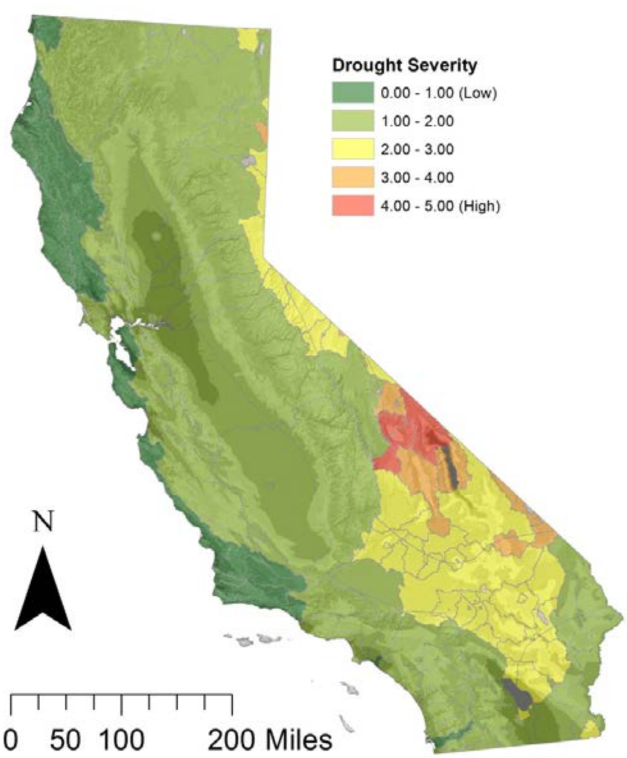
3) Seasonal Variability, which is a measure of the variation in water supply between months of the year (standard deviation / mean of total supply calculated using the monthly mean).



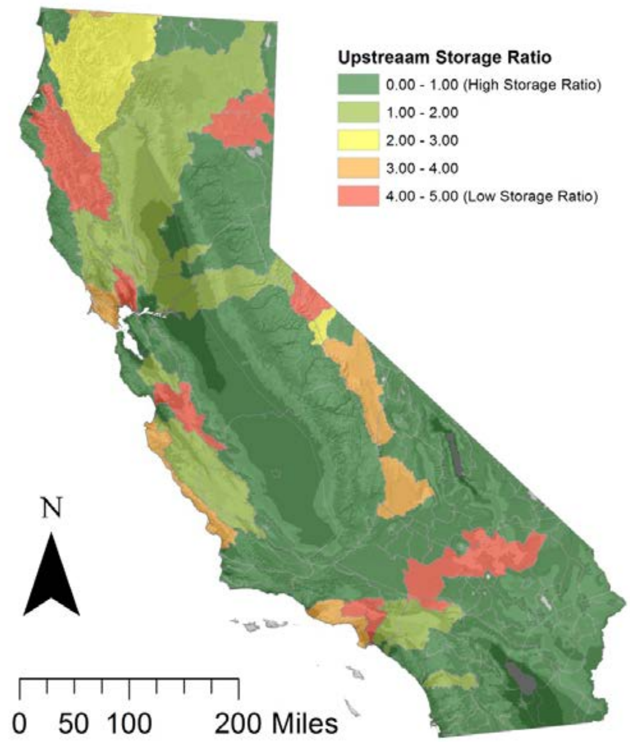
4) Flood Occurrence, which is is the number of floods recorded from 1985 to 2011.



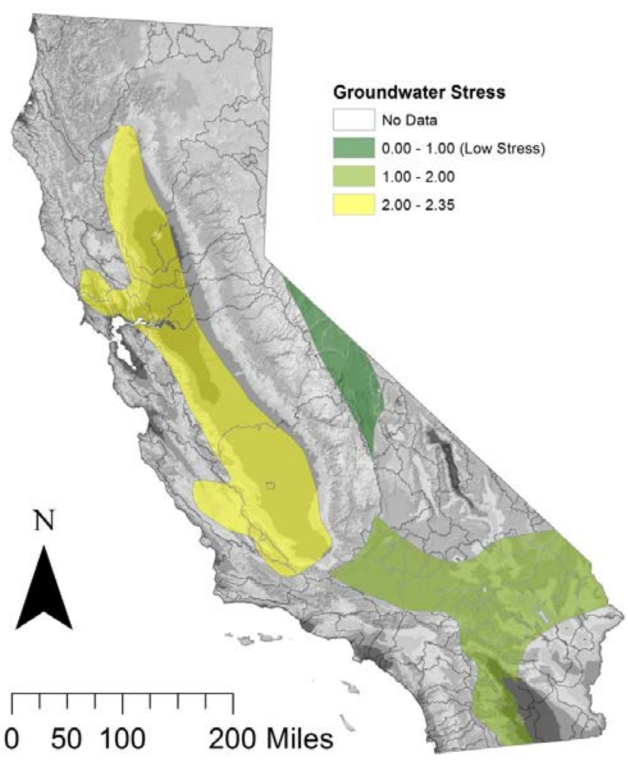
5) Drought Severity, which is a measure of the average length of droughts times the dryness of the droughts from 1901 to 2008 (mean length x dryness).



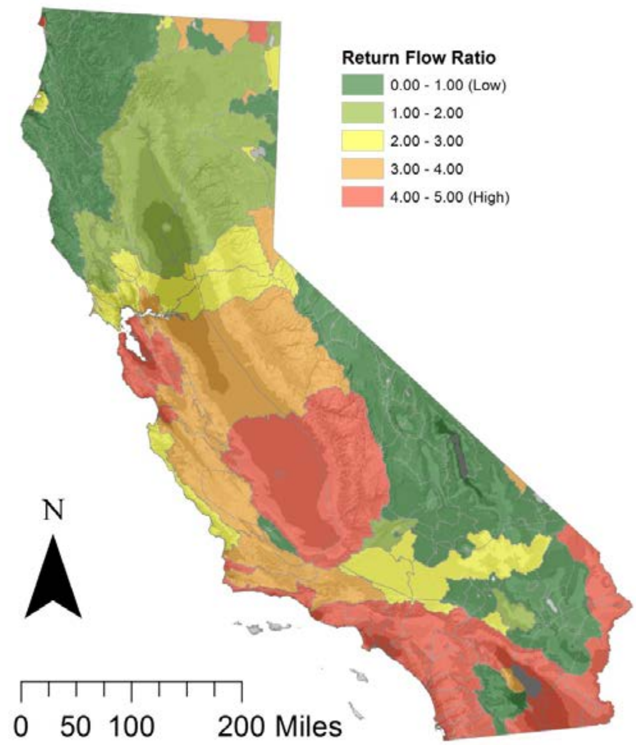
6) Upstream Storage, which is a measure of the water storage capacity available upstream of a location relative to the total water supply at that location (total supply / upstream storage capacity). Higher values indicate areas more capable of buffering variations in water supply (i.e. droughts and floods) because they have more water storage capacity upstream.



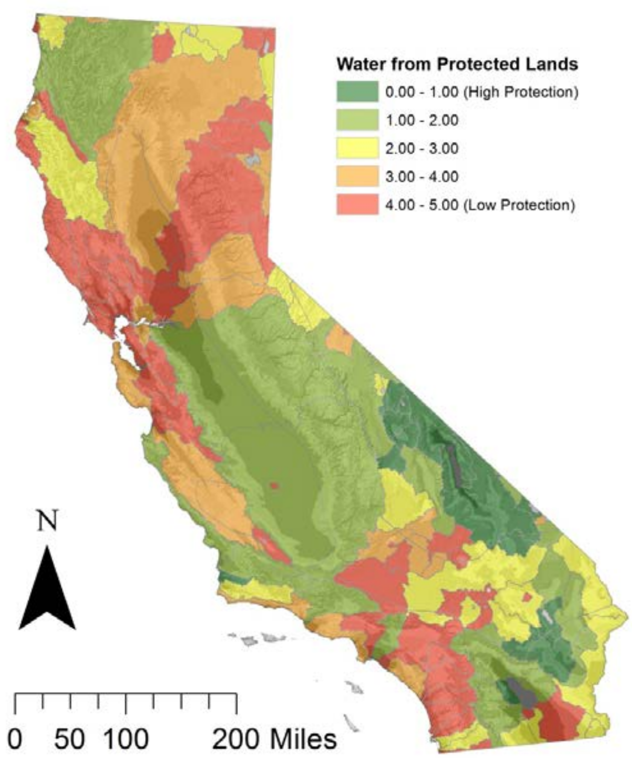
7) Groundwater Stress, which is a measure of the ratio of groundwater withdrawal relative to its recharge rate over a given aquifer (groundwater withdrawal / sustainable recharge). Values above one indicate where unsustainable groundwater consumption could affect groundwater availability and groundwater-dependent ecosystems.



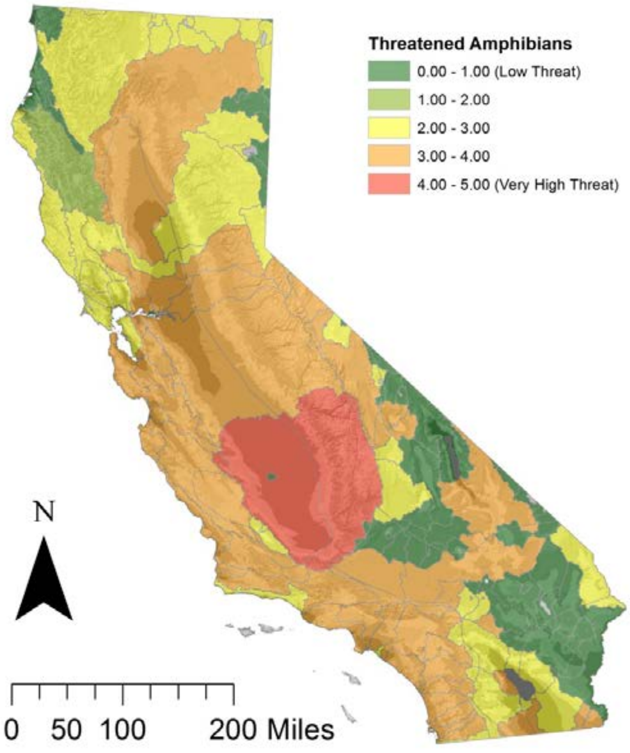
8) Return Flow Ratio, which is the percent of available water previously used and discharged upstream as wastewater (upstream non-consumptive use / available flow). Higher values indicate higher dependence on treatment plants and potentially lower water quality in areas that lack sufficient treatment infrastructure and polcies. Arid areas with low water use are shown in gray, and scored as low stress when calculating aggregated scores.



9) Upstream Protected Land, which is the percentage of total water supply that originates from protected ecosystems (% total supply originated in protected lands). Modified land use can affect the health of freshwater ecosystems and have severe downstream impacts on both water quality and quantity.



10) Threatened Amphibians, which is a measure of the percentage of freshwater amphibian species classified by IUCN as threatened (% freshwater amphibian species that are threatened). About ¾ of the state's watersheds are home to amphibian populations with moderate to very high threats, based on the proportion of amphibians that are legally threatened. Urban and agricultural areas, and mountainous regions downwind of these areas are most under threat.



Temporal and spatial resolution

The data for individual indicators are available over different time frames, varying from long timeframes with recent data (flood occurrence), to single data points that are already a few years old (e.g., pre-2004 consumptive use, which is part of several indicators). Ideally, the indicators would be evaluated annually, for measures with rate processes, or at longer periods where conditions will not change quickly (e.g., upstream protected land).

The base data for the indicator vary considerably, but in general were collapsed to the watershed-basin scale. This scale of expression may hide the actual resolution of the data, which may affect confidence and use of the data.

Technical Information

Data Sources

The risk scores were downloaded as a spatial dataset from the Aqueduct 2.0 project website: http://www.wri.org/publication/aqueduct-global-maps-20; the data sources are described in the metadata on the website.

Data Transformations and Analysis

The spatial dataset initially downloaded was the global dataset. These data were clipped in ArcGIS 10.x to the border of California. No modification of the risk scores was conducted. The risk scores were calculated and put in risk categories using the formulae and categories in the table below.

Name	Score Calculation Formula	0-1	1-2	2-3	3-4	4-5
Baseline Water Stress	(LN([raw_value])-LN([c1]))/LN([base])+1	Low (<10%)	Low to medium (10-20%)	Medium to high (20-40%)	High (40-80%)	Extremely high (>80%)
Inter-annual Variability	([raw_value]-[c1])/[base]+1	Low (<0.25)	Low to medium (0.25-0.5)	Medium to high (0.5-0.75)	High (0.75-1.0)	Extremely high (>1.0)
Seasonal Variability	([raw_value]-[c1])/[base]+1	Low (<0.33)	Low to medium (0.33-0.66)	Medium to high (0.66-1.0)	High (1.0-1.33)	Extremely high (>1.33)
Flood Occurrence	(LN([raw_value])-LN([c1]))/LN([base])+1	Low (0-1)	Low to medium (2-3)	Medium to high (4-9)	High (10-27)	Extremely high (>27)
Drought Severity	([raw_value]-[c1])/[base]+1	Low (<20)	Low to medium (20-30)	Medium to high (30-40)	High (40-50)	Extremely high (>50)
Upstream Storage	-(LN([raw_value])-LN([c1]))/LN([base])+1	High (>1)	High to medium (1-0.5)	Medium to low (0.5-0.25)	Low (0.25-0.12)	Extremely low (<0.12)
Groundwater Stress	(LN(IF([raw_value]<5, MIN(5,[raw_value]+1.5), [raw_value]))-LN([c1]))/LN([base])+1	Low (<1)	Low to medium (1-5)	Medium to high (5-10)	High (10-20)	Extremely high (>20)
Return Flow Ratio	(LN([raw_value])-LN([c1]))/LN([base])+1	Low (<10%)	Low to medium (10-20%)	Medium to high (20-40%)	High (40-80%)	Extremely high (>80%)
Upstream Protected Land	-(LN([raw_value])-LN([c1]))/LN([base])+1	High (>40%)	High to medium (20-40%)	Medium to low (20-10%)	Low (10-5%)	Extremely low (<5%)
Threatened Amphibians	(LN([raw_value]+0.05)-LN([c1]))/LN([base])+1	Low (0%)	Low to medium (1-5%)	Medium to high (5-15%)	High (15-35%)	Extremely high (35-100%)

Citations

Gassert, F., M. Landis, M. Luck, P. Reig, and T. Shiao. 2013. “Aqueduct Global Maps 2.0.” Working Paper. Washington, DC: World Resources Institute. Available online at http://www.wri.org/publication/aqueduct-metadata-global.