SPRING INVENTORY AND PRELIMINARY GROUNDWATER DEPENDENT ECOSYSTEMS ASSESSMENT OF MANTI-LA SAL NATIONAL FOREST, WASATCH PLATEAU, UTAH

by Paul Inkenbrandt, Richard Emerson, Janae Wallace, J. Lucy Jordan, and Stefan Kirby

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Cover photo: A small spring in the Muddy Creek drainage of the Wasatch Plateau.

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SPRING INVENTORY AND PRELIMINARY GROUNDWATER DEPENDENT ECOSYSTEMS ASSESSMENT OF MANTI-LA SAL NATIONAL FOREST, WASATCH PLATEAU, UTAH

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ABSTRACT

This report is a description of hydrology data collected and compiled for the U.S. Forest Service for the Wasatch Plateau in central Utah. The data release includes spring location, water chemistry, surface water flow estimates, and wetlands land type data. We provide little interpretation of the data, and much of the products of this study were compiled for future use by the U.S. Forest Service and others who may have interest. Data from fieldwork conducted for this study are also included with this report.

INTRODUCTION

Purpose

The U.S. Forest Service (USFS) sought to identify and characterize springs, seeps, and associated wetlands in the Manti-La Sal National Forest on the Wasatch Plateau (figure 1). Information from this study will be used to establish a baseline of important surface and groundwater resource conditions, identify water sources vital to groundwater dependent ecosystems (GDEs), and provide information of GDEs to evaluate potential effects of proposed management activities. Several entities, including the USFS, U.S. Geological Survey (USGS), and the Utah Division of Oil, Gas and Mining (UDOGM), hold data on spring and wetland locations and water quality. The primary goal of this study is to bring existing information about water sources and groundwater dependent ecosystems into a consistent useable geospatial format. This publication is not meant to synthesize new observations, only describe the data compiled. We have supplemented this compilation with two seasons of fieldwork examining GDEs in areas of potential or impending groundwater impact.

This project follows the mandates of the recently proposed USFS Groundwater Directive (U.S. Forest Service, 2014). The project assesses groundwater dependent resources that could potentially be impacted by other activities within the Manti-La Sal National Forest boundaries. In accordance with lines 2560.03 4b and 2560.03 6b of the Groundwater Directive, this project uses appropriate science, information, and expertise to assess the resource in Manti-La Sal National Forest and to collaborate with a State Geological Survey to investigate and assess the hydrogeology and groundwater resources of USFS lands.

The GDE characterization benefits the Utah Geological Survey (UGS) by furthering our understanding of groundwater-associated ecosystems. The UGS is also charged with coordinating statewide wetland documentation, assessment, and conservation efforts. Expanding our partnerships and areas of study to montane wetlands of the Wasatch Plateau allows Utah's wetland program to increase its knowledge and experience base, as well as build toward our ultimate goal of documenting all wetlands throughout the state.

Study Area

The UGS compiled GDE location data for areas in Manti-La Sal National Forest on the Wasatch Plateau, a geographic high plateau in the central part of Utah (figure 1). For the sake of brevity, mention of Manti-La Sal National Forest will be in reference to only the part of the forest on the Wasatch Plateau, and not the La Sal Mountains to the east or other USFS administered areas to the west. The USFS directed UGS field investigations to areas of the Wasatch Plateau where underground coal operations may potentially impact groundwater in the following twelve-digit hydrologic unit code boundaries (HUC 12) sub-watersheds: Box Canyon-Muddy Creek (HUC 140700020203), Ivie Creek (HUC 140700020102), Upper Cottonwood Creek (HUC 140600090209), Indian Creek (HUC 140600090202), and Miller Fork Canyon-Huntington Creek (HUC 140600090105).

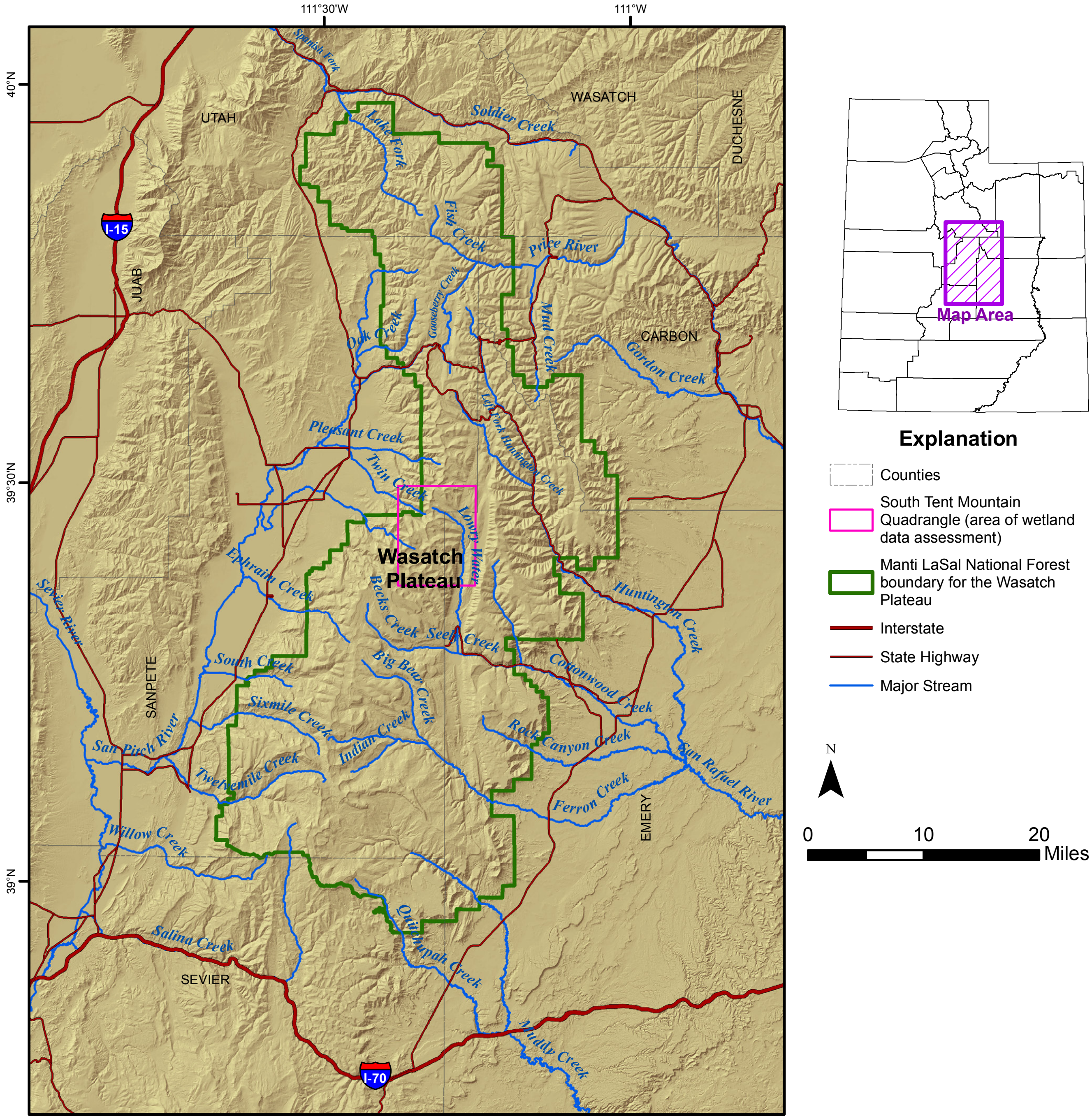

Figure 1. *The study focuses on Manti-La Sal National Forest on the Wasatch Plateau in central Utah. The South Tent Mountain quandrangle is the area of wetland mapping assessment.*

Geology

Formations in the region are Late Cretaceous to early Tertiary-age sedimentary units and include, from oldest to youngest, the Mancos Shale, the Star Point Sandstone, the Blackhawk Formation, the Castlegate Sandstone, the Price River Formation, the North Horn Formation, and the Flagstaff Limestone (figure 2). The Mancos Shale is a dark marine shale (Witkind and others, 1987). The Star Point Sandstone represents a coarsening-upward nearshore beach deposit that includes interfingering sandstone and shale (Witkind and others, 1987; Witkind and Weiss, 1991; Doelling and Kuehne, 2006). The Blackhawk Formation represents delta-plain deposits, and the lower section has thin sandstone units and economic quantities of carbonaceous shale and coal, including the Hiawatha coal seam (Witkind and others, 1987; Thiros and Cordy, 1991). The upper section has thinner coal seam lenses embedded and interfingering

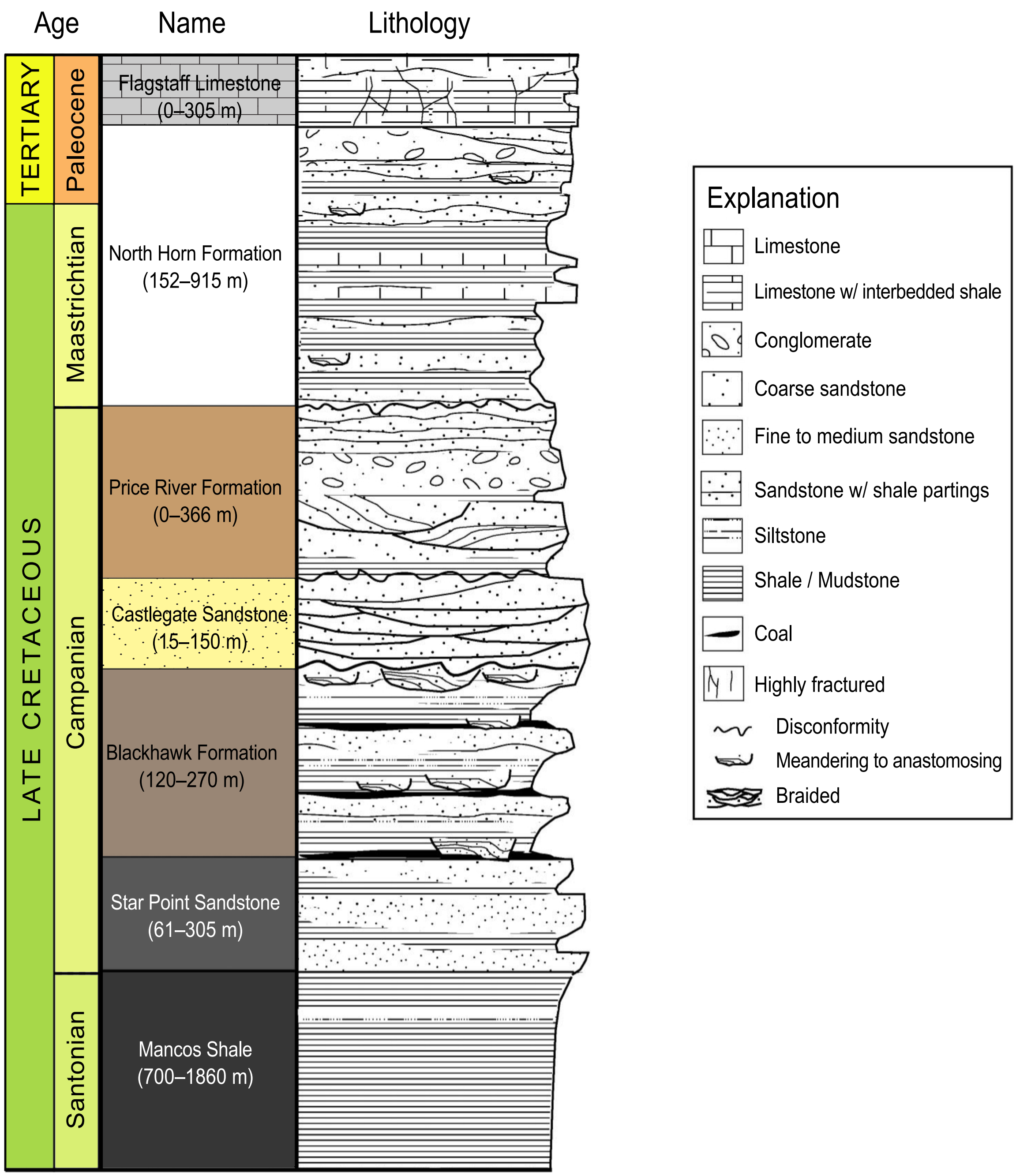

Figure 2. *Stratigraphy of the study area (modified from Mayo and others, 2003).*

with cliff-forming gray-orange sandstone units (Thiros and Cordy, 1991). The Castlegate Sandstone is a fluvial sandstone that creates gray-orange cliffs in outcrop. Overlying the Castlegate is the Price River Formation, a gray-brown sandstone with interbedded shale and dispersed conglomerates (Thiros and Cordy, 1991). The North Horn Formation consists of irregularly alternating units of mudstone, claystone, sandstone, conglomeratic sandstone, conglomerate, and sparse limestone which are prone to landslides (Witkind and others, 1987; Doelling and Kuehne, 2006). The Tertiary Flagstaff Limestone caps the Price River Formation and includes gypsum, mudstone, limestone, and dolomite (Hintze, 1988). Other Tertiary sedimentary rocks in the area overlying the Flagstaff Limestone include the Colton Formation, the Green River Formation, the Crazy Hollow Formation, and the Bald Knoll Formation, which are a mudstone, freshwater limestone, sandstone, and mudstone, respectively (Witkind and others, 1987).

Hydrology

Surface Water

Manti-La Sal National Forest straddles a major surface water divide between the Great Basin watershed to the west and the Upper Colorado River watershed to the east. Manti-La Sal National Forest intersects 18 hydrologic unit boundaries at a HUC 10 level on the Wasatch Plateau (plate 1). West of the divide, smaller tributaries contribute to the upper San Pitch River. East of the divide, smaller tributary creeks coalesce to larger tributaries that eventually flow into the Green River.

Groundwater

Aquifers in Manti-La Sal National Forest include, from oldest to youngest, the Star Point Sandstone, the Blackhawk Formation, the Castlegate Sandstone, the Price River Formation, the North Horn Formation, the Flagstaff Limestone, and alluvial and colluvial deposits (Thiros and Cordy, 1991). The upper Blue Gate Shale Member of the Mancos Shale contains groundwater in thin, discontinuous lenses of limestone and sandstone, but the Mancos Shale as a whole is considered a confining layer because it is primarily impermeable shale (Thiros and Cordy, 1991). Recharge to underlying aquifers typically occurs through the Flagstaff Limestone via fractures and faults where it is exposed. Stable-isotope data suggest that recharge to the aquifer systems is principally snowmelt seeping into outcrops (Thiros and Cordy, 1991).

Confining layers of the Wasatch Plateau are localized and complex. Most the water-bearing portions of formations overlying the Star Point Sandstone are channel-fill deposits and marine shoreface sandstone. Within those units, fluvial channel scours, mud drapes, and facies changes create horizontal and vertical barriers and baffles to fluid flow. Lithologic heterogeneity at several scales hinders regional vertical and horizontal movement of groundwater (Waddell and others, 1986; Mayo and others, 2003).

Fractures in overlying strata from mining-related subsidence can conduct water to underlying strata or to the mine workings. Downward flow from perched zones could be hindered by bentonitic shale and mudstone (Thiros and Cordy, 1991). Mayo and others (2003) conducted a geochemical analysis of the forest area hydrogeology and determined that water from upper aquifers was not directly connected to water extracted by the coal mines in the lower aquifers (Waddell and others, 1986).

METHODS

The language in the methods section requires terminology specific to the geographic information systems (GIS) community, specifically ArcGIS (ESRI, 2015) software, to properly describe the hierarchy and data organization of the spatial data we created. For the reader's convenience and for brevity, we have provided a "key terms" section (appendix A) defining the jargon applied in this section.

Springs Feature Dataset

To assess the possible extent and distribution of GDE resources on the Wasatch Plateau, we compiled spring location information from the USFS, the USGS, UDOGM, the Utah Division of Water Rights, and the U.S. Environmental Protection Agency (EPA). We also used high-resolution aerial photography to determine the potential locations of previously unmapped wetlands and springs. Once we compiled the GDE locations, we attributed them with associated geology, water rights, and water chemistry information. We merged duplicate sites when possible. The resulting compilation feature class was labeled "Springs" within a feature dataset also labeled "Springs" which is contained in a geodatabase labeled "Hydrography." The resulting database also includes all the contributing datasets, as well as all the monitoring stations within the USFS boundaries, including the associated water chemistry and flow data.

We compiled springs from the Water Quality Portal (WQP), which is a combination of the EPA STORET (STOrage and RETrieval) and USGS National Water Information System (NWIS) databases (National Water Quality Monitoring Council, 2015). The EPA STORET database is a national repository for multiple types of environmental data. For springs, it often includes location and water quality information and occasional flow information. The NWIS database contains water sample and flow measurement sites measured by the USGS (U.S. Geological Survey, 2014). To convert the spring data from the Water Quality Portal into ArcGIS feature classes, we downloaded station data, chemistry results data, and flow results data as individual comma separated files from the Water Quality Portal website using the rest-based queries embedded in the metadata of the source feature class, labeled "WQP_Spring" in the "Springs" feature dataset of the "Hydrography" geodatabase. We formatted headers to be compliant with ArcGIS feature class schema standards and converted the stations table to a feature class. The results data were converted to a database table. The join field of the stations to results tables is the station identification number. We applied a similar methodology to download all the relevant station data for the Wasatch Plateau. We included other stations, such as wells and streams, to allow for a more complete geochemical and flow characterization of geologic units in the area.

Besides NWIS, the USGS also oversees the National Hydrography Dataset (NHD), a vectorized map of watersheds, streams, and associated water features at a scale of 1:24,000. Springs from the NHD were included in our compilation. The NHD data for the Wasatch Plateau were extracted from the "NHDH_UT" geodatabase, which was downloaded from the

NHD website. The NHD springs are available in the "NHDPoint" feature class in the "Hydrography" feature dataset. From the "NHDPoint" feature class we selected all features with the "FType" field having the values "SpringSeep." The "GNIS_ID" and "GNIS_Name" from this dataset was retained from the original feature class for the compilation. The prefix "NHD-" was appended to the "Permanent_Identifier" field values to create the "SITE_ID" field in the compiled "Springs" feature class.

While many of the springs listed in the NHD were taken from USGS 1:24,000-scale topographic maps, there are many springs present on topographic maps not included in the NHD. We manually digitized springs from 1:24,000-scale USGS topographic quadrangles that were not mapped in the NHD. To digitize the springs, we used the Utah Automated Geographic Reference Center (AGRC) topographic map (AGRC, 2016) service in ArcGIS, digitized at the original map scale, and placing each point in the center of the circle symbol of each mapped spring.

We also compiled data from state agencies, including UDOGM. UDOGM data is collected to monitor water quality and flow near coal mining operations. We georeferenced 30 scanned map images available on the UDOGM website, after downloading the maps as PDF format and converting to high-resolution TIFF files. Many of the maps were in projections specific to the mines, so the maps were rubber-sheeted to match landmarks, roads, benchmarks, and mine audits with as low of error as possible. Once the maps were georeferenced, we digitized all the stations plotted on each map and added all available mapped information to the initial UDOGM station feature class. A feature class was created for each mine, then all the feature classes were merged into a single feature class (plate 2). The results of the digitization are in the "Mines" feature dataset, including the georeferenced maps and the individual feature classes for each set of mine monitoring stations. The individual mine feature classes were merged into the feature classes "Mine_Monitoring_Points."

Another Utah dataset that contains spring locations is the Water Rights Points of Diversion (WRPOD) shapefile managed and provided by the Utah Division of Water Rights (Utah Division of Water Rights, 2014). These points represent the geographic location associated with water rights administered by the Utah Division of Water Rights. They give information pertaining to water right priority, modification, ownership, amount, and type. Water rights were winnowed to spring locations by merging duplicate entries. Values having matching "WRNUM," "LOCATION," and "SOURCE" values were also merged. The join column for these data to water rights tables is the "WRLINK" field.

Finally, we digitized GDEs using high-resolution aerial orthophotography. The orthophotos used were a base layer service from ArcMap named "World_Imagery," which includes data from the following sources: ESRI, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community. Using the "World_Imagery" layer draped over 10 m NED DEMs and lidar data (when available) in the ArcGlobe interface, we identified locations that could indicate a spring. Indication criteria included: a wet pool having an outlet, variations in vegetation color, associations to streams (beginning of stream or tributary), effects on land surface (e.g., erosion). The three-dimensional interface of ArcGlobe allowed for rapid assessment of the areas to verify potential spring locations. We compared our criteria to field-located springs for verification. The resulting source layer for spring sites digitized using aerial photographs was the "Air_Photo_Spring" feature class of the "Springs" feature dataset. We used the same techniques to digitize wetland/GDE areas, which resulted in the "Air_Photo_Wetland" feature class of the "Springs" feature dataset.

All the various data sources were compiled into a feature class named "Springs," the schema of which is summarized in table 1. We also fit the "Springs" dataset into the draft schema of the "HydroEcosysPt" feature class of the "HydroEcosystem Observations" feature dataset to match the schema established by the USFS (2015). The "HydroEcosysPt" feature class domains were built based on the draft document, meaning that this feature class might not exactly match feature classes based on the complete and reviewed document. Duplicates were determined primarily by location and names. Station data were merged into a single point. Once the data were merged into a single feature class ("Springs"), we added attributes using a spatial join technique available in ArcGIS.

Stations Feature Dataset

To better understand the current hydrologic status of the Wasatch Plateau, we also compiled chemistry and flow data for all springs, wells, and surface water in the region, and summarized those data by geology and watershed. To explicitly record the exact process of data download, compilation, and manipulation, we scripted into a IPython Notebook (Pérez and Granger, 2007) script file (Inkenbrandt, 2016). This allowed our results to be reproduced exactly with publicly available open-source software, and provided a detailed record of techniques applied for data consistency.

To merge UDOGM and WQP data, we first downloaded the data from the various sources. Each dataset contains two major tables, one containing the information on each station and one listing analytical chemistry results, including field parameters and flow and depth to water measurements. We normalized the schemas of the data in both tables for each dataset by dropping unnecessary fields and standardizing field names across features. Once the fields and schemas of the two datasets were normalized, we combined the stations and results tables of the two datasets to get a single station table and a single result table. We generated summary statistics using this combined dataset (appendix B).

Table 1. *Fields in the compiled "springs" feature class.*

Field Name	Field Description	Link to Additional Information
OBJECTID *	A unique, not null integer field used to uniquely identify rows in tables in a geodatabase. ObjectIDs are limited to 32-bit values, which store a maximum value of 2,147,483,647	http://desktop.arcgis.com/en/arcmap/10.3/manage-data/using-sql-with-gdbs/object-id.htm
GNIS ID	Geographic Names Information System formal name, if available	http://nhd.usgs.gov/gnis.html
GNIS Name	Geographic Names Information System Identification number, if available	http://nhd.usgs.gov/gnis.html
SITE ID	Site Identification Number; Agency abbreviation followed by agency identification number for that site	
Formation Type	Formation extracted from geologic map (UGS 30′ x 60′) or hydrologic report (provided by mines)	
WRLINK	Utah Water Right number to link to water right file associated with site	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
Water Right Num	Utah Water Right numbers associated with site	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
CHEXNUM	Utah Water Right application number associated with site	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
USES	Approved uses for site from Utah Water Right	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
CFS	Allotment of use for site from Utah Water Right	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
OWNER	Owner of Water Rights on file	https://www.waterrights.utah.gov/gisinfo/wrpod.htm
SOURCE	Primary source of data and location	
WRSRCNM		https://www.waterrights.utah.gov/gisinfo/wrpod.htm
Compilation Comments	Comments on how data were compiled	
UTM_N	North American Datum 1983 Universal Transverse Mercator (UTM) Zone 12 meters East	
UTM_E	North American Datum 1983 Universal Transverse Mercator (UTM) Zone 12 meters North	
STATE_FIPS	Federal Information Processing Standard code for Utah	https://www.census.gov/geo/reference/codes/cou.html
County Name	County Name	http://www.utah.gov/government/countymap.html
County FIPS	County Federal Information Processing Standard for county where site is located	https://www.census.gov/geo/reference/codes/cou.html
Geologic Unit	Geologic unit as identified from geologic maps	http://geology.utah.gov/apps/intgeomap/
Geologic Age	Geologic age as identified from geologic maps	http://geology.utah.gov/apps/intgeomap/
Geo Description	Geologic description as identified from geologic maps	http://geology.utah.gov/apps/intgeomap/
Cover	US Department of Agriculture US Forest Service Geodata Clearinghouse cover id	http://data.fs.usda.gov/geodata/edw/datasets.php
DENSITY	US Department of Agriculture US Forest Service Geodata Clearinghouse cover density	http://data.fs.usda.gov/geodata/edw/datasets.php
Soil Unit	US Department of Agriculture US Forest Service Geodata Clearinghouse cover type	http://data.fs.usda.gov/geodata/edw/datasets.php
NED10m	Elevation derived from U.S. Geological Survey National Elevation Dataset (10-meter horizonal resolution)	http://nationalmap.gov/elevation.html
Latitude NAD83	North American Datum 1983 Latitude	
Longitude NAD83	North American Datum 1983 Longitude	
PLSS	Public Land Survey System Identification Number	https://gis.utah.gov/public-land-survey-system-plss-version-2-0-release/
USGSCAD	Label for site based on USGS cadestral identification system for groundwater sources (DDMMSSDDDMMSS)	https://help.waterdata.usgs.gov/faq/sites/do-station-numbers-have-any-particular-meaning
HUC12	Hydrologic Unit Code (12-digit resolution)	http://nhd.usgs.gov/data.html
Stream Name	Name of Nearest Stream	http://nhd.usgs.gov/data.html
Lowry Elevation	LiDAR-based elevation if available	http://www.opentopography.org/
UGS Lidar Elevation	LiDAR-based elevation if available	http://www.opentopography.org/
Reach Code	Hydrologic code of nearest stream reach	http://nhd.usgs.gov/data.html
USGS Quad ID	1:24,000-scale topographic quadrangle number that contains the spring	
USGS Quad Name	1:24,000-scale topographic quadrangle name that contains the spring	
Allotment ID	US Department of Agriculture US Forest Service Geodata Clearinghouse allotment id	
Allotment Number	US Department of Agriculture US Forest Service Geodata Clearinghouse allotment number	
Allotment Name	US Department of Agriculture US Forest Service Geodata Clearinghouse allotment name	
LTA_ID	US Forest Service Land Type Association Identification Number	
MAP_UNIT_SYMBOL	US Forest Service map unit identifier	
SUBSECNAME	US Forest Service Geographic Region Name	
FORM	US Forest Service primary geographic features	
CHARACTERI	US Forest Service slope stability description	
NAME_1	US Forest Service area description	
Ecological Section	Ecological Section	
Ecological Section Description	Ecological Section Description	

Flow and Precipitation Data

Flow data for 60 USGS surface stations in the Wasatch Plateau region were compiled and analyzed. We chose the sites in the immediate vicinity of the area of study having extended measurement durations of at least 1 year (plate 3). We summarized the USGS surface station data in terms of average yearly discharge (table 2) and summarized the yearly surface water outflow of the western and eastern areas of the forest using the average yearly discharge (table 3). We also summarized the station data using boxplots, which show the range and distribution of the flow data by category. Finally, we plotted the data using flow distribution curves, to show how the flow of the various drainages has changed over time (appendix B).

Wetland Data

We analyzed three wetland datasets—two from the USFS titled "wetlands" and "wetlands_miller_flat_update" and one from the USFWS National Wetland Inventory (NWI)—for accuracy and completeness. The three datasets were all attributed according to Cowardin and others (1979) which allowed for direct comparison of the three datasets. The Miller Flat update included additional attributes, including chemistry and landscape characteristics provided to the USFS from a special study limited to the Miller Flat area. The USFS "wetlands" dataset was a wetland layer produced from 2006 imagery and was produced specifically for the Manti-La Sal National Forest, and the NWI data was produced in early 1983 by the USFS. We chose the 2006 "wetland"-titled dataset provided to us by the USFS for regional analysis because metadata was complete and, of the three datasets, was the most current and representative of wetlands across the Wasatch Plateau. From here on we will refer to the chosen dataset as the USFS wetlands dataset. We added a "Utah Type" description field and populated it according to a functional crosswalk developed for Utah wetlands to provide a more descriptive characterization based on geomorphic, hydrodynamic, and vegetation characteristics (Sumner and others, 2010; Emerson and Hooker, 2011). We then generated wetland landscape profiles which summarized wetlands by type across HUC10 and HUC12 watersheds showing total acreage of wetlands and wetland type for each watershed.

We also prepared a more detailed assessment of spatial and attribution accuracy for the datasets in the South Tent Mountain quadrangle where all three datasets overlap and the availability of high-resolution (1 m) lidar provided an opportunity to map depression wetland features through semi-automated processes that identify areas of water accumulation, even through thick forest canopy. Wetlands were identified in the South Tent Mountain quadrangle using lidar and color infrared imagery from multiple seasons and years to capture seasonality as well as dry and wet cycles. Lidar was processed to extract areas of depression and zero slope that favor wetland development. The lidar was processed first running the "Fill" tool in ArcGIS followed by the "Slope" tool on the resulting raster. Depressions will yield a zero slope after the raster is filled allowing for automated extraction of these areas that represent depressions or flat surfaces where water could potentially accumulate to form a wetland (figure 3). Depression features greater than 40 m^2 were investigated by using high resolution (1 m) color infrared and 15 cm color imagery. Polygons were adjusted per properties observed in the imagery and lidar or deleted if insignificant wetland properties were observed.

Through additional processing of the lidar we generated a Canopy Height Model (CHM) by subtracting the terrain model (ground surface or digital elevation model) from the surface model (canopy top or digital surface model). This information is useful for differentiating scrub-shrub wetlands from emergent and forested wetlands. Additionally, we generated a stream network from the lidar which was buffered to include riverine wetlands in the dataset. Currently, the USFS wetlands dataset does not include riverine wetlands, which are a new requirement of National Wetland Inventory. A limitation of lidar is that it does not aid in the detection of slope wetlands, or wetlands that do not form a flat or depression feature. We relied on the existing USFS dataset to identify these wetlands and then added these to the wetland dataset we generated. A comparison of all three wetland datasets for the South Tent Mountain quadrangle is available in the Results section of this report.

Some minor changes were made to the existing USFS wetland dataset in the South Tent Mountain quadrangle including fixing location errors or attribute updates to conform with recent changes to the NWI data codes. Water regime codes were refined in 2015 to define seasonally flooded and seasonally saturated wetlands. Code "D" was added to define continuously saturated wetlands, and code "B" was changed to define seasonally saturated wetlands. In addition to the water regime changes, updated protocol now limits water regimes to clearly defined systems, subsystems, classes, and subclasses. An updated Wetlands and Deepwater Habitats Classification chart and water regime restriction table, limited to those wetlands in the State of Utah, is included in appendix C.

Our field investigation of wetlands was limited to the Greens Hollow mining analysis area in the Muddy Creek area (HUC 1407000202) while conducting GDE assessments (see Field Investigation section below). Only 16 wetland areas totaling 7.3 acres are mapped in the Greens Hollow area which did not allow a large enough sample size to make any conclusions regarding the accuracy of the wetland mapping for the Wasatch Plateau. We did find several very small wetlands associated with forested springs or seeps and springs along stream margins which were not mapped in the USFS wetlands or NWI dataset. They were often very difficult to locate in the field and their size and location made them even more difficult to find using traditional wetland mapping techniques which rely on aerial imagery. Additionally, some of the wetlands from the USFS dataset we visited did not exhibit wet soils nor show hydric soil indicators and had very sparse to no hydrophytic vegetation or were much smaller in extent than indicated by the data.

Table 2. *U.S. Geological Survey stations and average flow volumes on the Wasatch Plateau. Row colors grouped by first four digits of the "HUC 8 of Station" field.*

Station Information					Annual Flow Information					
USGS Station Name	USGS Station Id	Data Start Date	Data End Date	HUC 8 of Station	Years of Data	Std Dev (ac-ft)	Min (ac-ft)	Max (ac-ft)	Median (ac-ft)	Mean (ac-ft)
FAIRVIEW DITCH NEAR FAIRVIEW, UTAH	9309500	8/18/1949	9/30/1965	14060007	17	2281	596	7214	3401	3674
FAIRVIEW TUNNEL NEAR FAIRVIEW, UTAH	9309600	10/1/1967	8/30/2015	14060007	48	2535	1554	11086	4891	5411
GOOSEBERRY CREEK NEAR FAIRVIEW, UTAH	9309800	10/1/1959	6/30/1969	14060007	9	2564	3149	11301	7163	7296
GOOSEBERRY CREEK NEAR SCOFIELD, UTAH	9310000	10/1/1930	9/30/2003	14060007	66	7237	3372	51311	12406	14190
FISH CREEK ABOVE RESERVOIR, NEAR SCOFIELD, UTAH	9310500	6/1/1931	8/30/2015	14060007	79	15889	6841	81920	32254	34068
PONTOWN (PONDTOWN) CREEK, NEAR SCOFIELD, UTAH	9310550	9/5/1979	10/22/1980	14060007	3	1116	5035	7114	5373	5840
BOARDINGHOUSE CR. AT MOUTH SOUTH OF SCOFIELD	9310575	11/18/1982	9/30/1984	14060007	2	50	2525	2595	2560	2560
ECCLES CANYON NEAR SCOFIELD, UTAH	9310600	10/1/1979	9/30/1984	14060007	5	1507	1188	4913	3338	3409
MUD CRK BL WINTER QUARTERS CYN @ SCOFIELD, UTAH	9310700	8/22/1978	8/30/2015	14060007	35	5483	1791	22423	11093	11941
PRICE RIVER NEAR SCOFIELD, UTAH	9311500	11/17/1917	10/16/1980	14060007	45	23760	13771	145253	42989	49333
PRICE RIVER NEAR SOLDIER SUMMIT, UTAH	9311700	8/1/1961	9/30/1963	14060007	3	16700	8875	39711	35408	27998
WHITE R BL TABBYUNE CRK NR SOLDIER SUMMIT, UTAH	9312600	5/19/1967	8/30/2015	14060007	49	12137	1598	44850	19302	18861
BEAVER CREEK NEAR SOLDIER SUMMIT, UTAH	9312700	10/1/1960	10/3/1989	14060007	30	2483	80	9960	2626	3196
BOULGER CREEK NEAR FAIRVIEW, UTAH	9317000	5/27/1938	9/30/1949	14060009	12	694	1966	4335	2758	2906
CRANDALL CANYON AT MOUTH NR HUNTINGTON, UTAH	9317919	10/20/1977	9/30/1984	14060009	7	3139	611	8638	3967	3874
TIE FORK CANYON NEAR HUNTINGTON, UTAH	9317920	10/20/1977	10/7/1981	14060009	5	1680	320	4369	621	1468
HUNTINGTON CREEK NEAR HUNTINGTON, UTAH	9317997	4/25/1979	9/30/2006	14060009	24	24037	25166	110765	52087	56218
HUNTINGTON CREEK NR HUNTINGTON, UTAH	9318000	5/3/1909	10/4/1979	14060009	67	37494	25718	230585	71557	79608
HUNTINGTON CREEK NEAR CASTLE DALE, UTAH	9318500	6/26/1911	8/13/1921	14060009	11	23182	18563	89854	51294	49815
EPHRAIM TUNNEL NEAR EPHRAIM, UTAH	9319000	10/1/1960	8/30/2015	14060009	55	3389	1568	15200	5326	6027
EPHRAIM TUNNEL SUPPLEMENTAL DATA	9319001	8/20/1981	10/13/1983	14060009	4	10248	1234	23112	3553	7863
REEDER DITCH NEAR SPRING CITY, UTAH	9323500	9/10/1949	9/30/1958	14060009	10	354	89	1067	317	448
SEELY CREEK NEAR ORANGEVILLE, UTAH	9324000	9/9/1953	9/30/1957	14060009	5	28361	20581	97088	41894	50138
CTNWD C AB STRAIGHT CANYON NR ORANGEVILLE, UTAH	9324200	10/1/1977	10/7/1981	14060009	5	835	417	2360	524	875
COTTONWOOD CREEK NEAR ORANGEVILLE, UTAH	9324500	5/1/1909	11/15/1984	14060009	70	44734	21650	291594	69355	79960
COTTONWOOD CREEK NEAR CASTLE DALE, UTAH	9325000	7/1/1947	9/30/1958	14060009	12	29997	12455	109945	23951	37821
SAN RAFAEL R ABOVE FERRON CR NR CASTLE DALE, UTAH	9325100	10/1/1964	10/13/1970	14060009	7	35854	32958	131955	51001	66032
FERRON CREEK (UPPER STATION) NEAR FERRON, UTAH	9326500	10/1/1911	8/30/2015	14060009	80	18778	12726	101549	43714	47194
FERRON CREEK NEAR CASTLE DALE, UTAH	9327500	10/1/1911	9/30/1958	14060009	14	17970	4585	64959	18653	24928
FERRON CREEK BL PARADISE RANCH NR CLAWSON, UTAH	9327550	10/1/1975	9/30/1986	14060009	11	44021	2891	134667	30552	43341
MUDDY CREEK NEAR EMERY, UTAH	9330500	10/1/1910	8/30/2015	14070002	71	13140	6810	67447	25390	28435
CONVULSION CANYON NEAR EMERY, UTAH	9331850	10/1/1980	10/5/1984	14070002	5	258	299	956	760	729
QUITCHUPAH CREEK NEAR EMERY, UTAH	9331900	7/1/1978	10/1/1981	14070002	5	2745	1384	7799	4878	4255
CHRISTIANSEN WASH NEAR EMERY, UTAH	9331950	8/1/1978	9/30/1984	14070002	7	1442	590	4649	2407	2550
MUDDY CREEK BL I-70 NR EMERY, UTAH	9332100	8/5/1973	9/30/2006	14070002	16	17004	2777	59149	20784	22180
NEBO CREEK NEAR THISTLE, UTAH	10148400	10/1/1963	9/30/1973	16020202	10	4306	6898	20707	10003	11101
SPANISH FORK AT THISTLE, UTAH	10148500	1/1/1908	9/30/1974	16020202	61	28093	19142	161227	59793	64002
SALINA CREEK NEAR EMERY, UTAH	10205030	10/1/1963	8/30/2015	16030003	52	5876	3317	38390	11093	12092
SALINA CREEK AT SALINA, UTAH	10206000	4/25/1914	9/30/1995	16030003	53	20688	2746	124873	16289	20381
SEVIER RIVER BELOW SALINA CREEK NEAR SALINA, UTAH	10206001	10/1/1943	9/30/1986	16030003	38	95616	33319	451055	74959	104663
SEVIER RIVER NEAR GUNNISON, UTAH	10208000	10/1/1900	9/30/1917	16030003	17	114989	55145	406870	207648	212188
SEVIER RIV BLW SAN PITCH RIV NR GUNNISON, UTAH	10217000	10/1/1917	8/26/2015	16030003	98	138455	62659	975275	139380	184396
Salina Creek Total				16030003						24928
Salina Creek Total 2				16030003						20673

Table 2. *continued*

Station Information					Annual Flow Information					
USGS Station Name	USGS Station Id	Data Start Date	Data End Date	HUC 8 of Station	Years of Data	Std Dev (ac-ft)	Min (ac-ft)	Max (ac-ft)	Median (ac-ft)	Mean (ac-ft)
CANDLAND DITCH NEAR MT PLEASANT, UTAH	9317500	10/1/1949	9/30/1958	16030004	9	152	81	583	154	214
HORSESHOE TUNNEL NEAR EPHRAIM, UTAH	9320000	10/1/1949	9/30/1958	16030004	9	510	865	2394	2073	1762
LARSEN TUNNEL NEAR EPHRAIM, UTAH	9320500	8/14/1949	9/30/1958	16030004	10	1397	72	5448	1923	2252
COAL FORK DITCH NEAR MT PLEASANT, UTAH	9321000	8/17/1949	9/30/1958	16030004	10	353	121	1217	430	536
TWIN CREEK TUNNEL NEAR MT PLEASANT, UTAH	9321500	5/1/1950	9/30/1958	16030004	9	373	360	1500	608	697
BLACK CANYON DITCH NEAR SPRING CITY, UTAH	9322000	10/1/1949	9/30/1958	16030004	9	430	490	1698	687	861
CEDAR CREEK TUNNEL NEAR SPRING CITY, UTAH	9322500	9/13/1949	9/30/1958	16030004	10	306	169	1225	472	542
SPRING CITY TUNNEL NEAR SPRING CITY, UTAH	9323000	10/1/1960	9/30/2003	16030004	43	1769	864	8078	3686	3913
JOHN AUGUST DITCH NEAR EPHRAIM, UTAH	9325500	8/29/1949	9/30/1958	16030004	10	212	15	834	539	525
MADSEN DITCH NEAR EPHRAIM, UTAH	9326000	5/1/1950	6/30/1958	16030004	9	194	21	620	47	130
OAK CREEK NR. FAIRVIEW, UTAH	10208500	10/1/1964	9/30/1989	16030004	25	4378	1931	19646	8083	8924
PLEASANT CREEK NEAR MOUNT PLEASANT, UTAH	10210000	10/1/1954	9/30/1975	16030004	21	2730	7912	16889	13262	12820
SAN PITCH RIVER NEAR MT PLEASANT, UTAH	10210500	10/1/1988	9/30/1989	16030004	1		15576	15576	15576	15576
TWIN CREEK NEAR MOUNT PLEASANT, UTAH	10211000	10/1/1954	9/30/1966	16030004	12	1657	4073	8776	5560	6065
OAK CREEK NEAR SPRING CITY, UTAH	10215700	10/1/1964	9/30/1994	16030004	26	2442	4925	14933	7268	7851
MANTI CREEK BLW DUGWAY CREEK, NR MANTI, UTAH	10215900	10/1/1964	8/30/2015	16030004	47	8292	9238	44190	18418	19955
SAN PITCH RIVER NEAR STERLING, UTAH	10216210	10/1/1964	9/30/1980	16030004	16	15770	4920	63219	31608	32562
TWELVEMILE CREEK NEAR MAYFIELD, UTAH	10216400	10/1/1959	9/30/1980	16030004	21	8209	6379	34269	22734	22420
San Pitch Total				16030004					48132	59352
Mnt Frnt Drainages (Before Cities) includes import				16030004					52591	78036
Imported Water From East to West Side				14060009					18979	20604

Table 3. *Surface water discharge on the Wasatch Plateau.*

Side	Creek	HUC10	Stations(s)	Mean discharge ac-ft/yr
Upper Colorado Watershed (East Side)	Huntington	1406000901	9318000	71,557
	Cottonwood	1406000902	9324500	69,355
	Ferron	1406000903	9326500	43,714
	Muddy	1407000202	9330500	25,390
	Quichupah	1407000201	9331900	4878
	Total			214,894
Great Basin Watershed (West Side)	Oak	1603000402	10208500	8083
	Pleasant	1603000402	10210000	13,262
	Twin	1603000402	10211000	5560
	Oak	1603000403	10215700	7268
	South	1603000405	10215900	18,418
	Twelvemile	1603000404	10216400	22,734
	Total			75,325

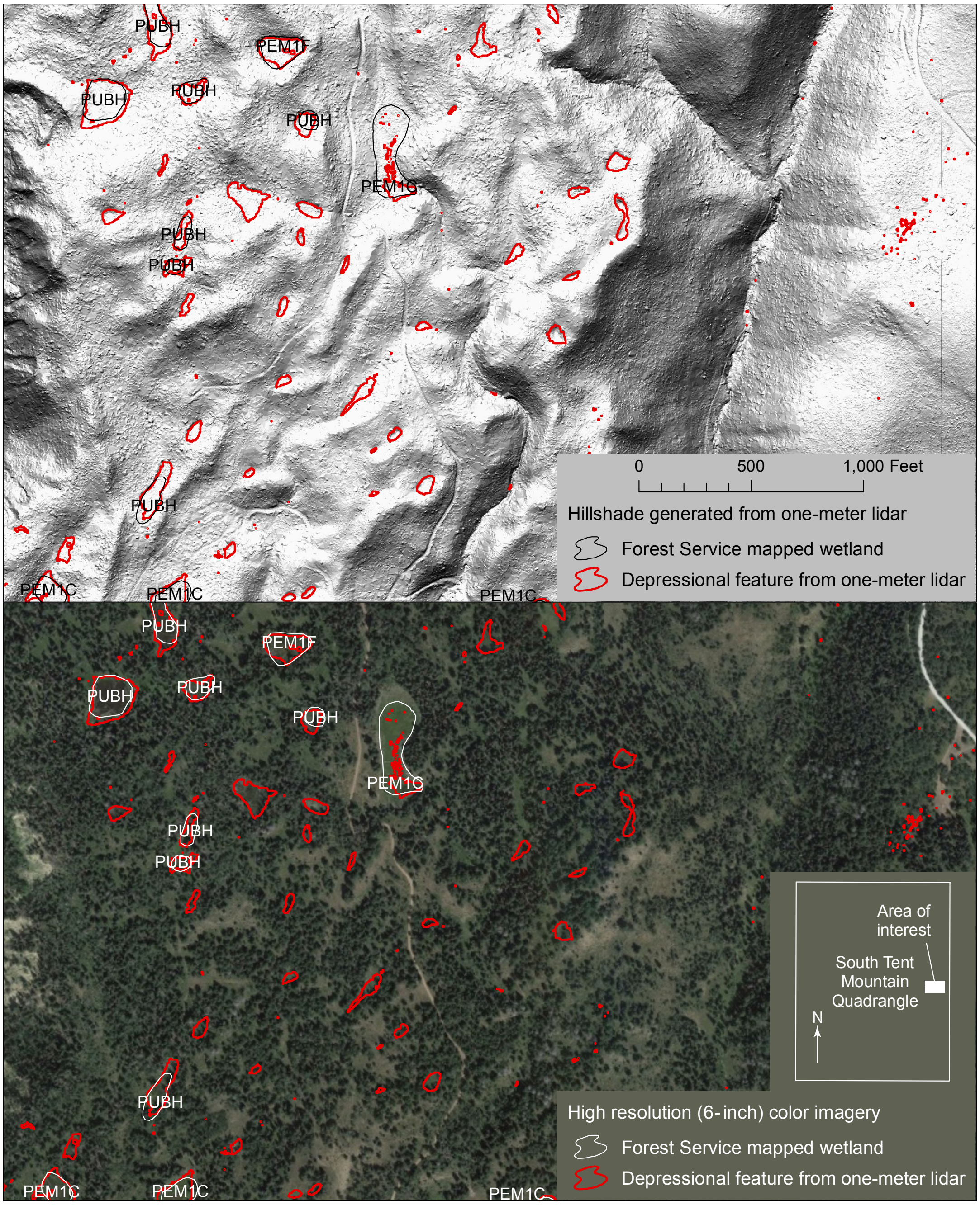

Figure 3. *Depressional features generated from high resolution lidar data. See figure 1 for the location of the South Tent Mountain quadrangle.*

Field Investigation

We verified digitized spring and seep sites and gained additional site information by conducting site visits in two specific areas of Manti-La Sal National Forest: Muddy Creek (HUC 1407000202) and Cottonwood Creek (HUC 1406000902). We surveyed during baseflow conditions and focused on perennially flowing springs, seeps, and wetlands.

The fieldwork consisted of finding GDEs and then performing a Level 1 GDE assessment using the level 1 GDE field guide (Coles-Ritchie and others, 2012). We supplemented this guide with a soil identification field guide (Schoeneberger and others, 1998). Field sites were not randomly selected, as fieldwork attempted to catalog all GDEs in the watersheds assigned by USFS officials. Once Level 1 GDE assessments were complete, UGS staff entered the data into a Microsoft Access database designed and distributed by the USFS.

GDE assessments are comprehensive in nature and consist of cursory description of the geologic, hydrologic, soil, vegetation, and land use conditions. We measured flow using portable 90-degree weir plates and a Swoffer stream velocity meter. At each site, we used pen-sized multi-parameter probes to measure field chemistry parameters, including pH, electrical conductivity, temperature, and oxidation-reduction potential.

RESULTS

Precipitation and Flow Data

Most precipitation falling onto the Wasatch Plateau is in the form of snow. Mean annual precipitation for the area on the Wasatch Plateau within the USFS boundary is 13.6 inches of water (PRISM Climate Group, 2014). Total mean annual precipitation for the Manti-La Sal National Forest area on the Wasatch Plateau is 1,667,800 acre-ft, 66.9% (1,116,200 acre-ft) of which falls onto the Colorado River watershed and 33.1% (551,600 acre-ft) falls onto the Great Basin watershed (plate 3).

The Upper Colorado watershed (HUC 2 = 14) side of Manti National Forest is larger in area, receives more precipitation, and has higher discharge drainages than the Great Basin watershed (HUC 2 = 16). The drainage area on the Great Basin side of the forest is smaller (998 square miles) than the Upper Colorado side of the forest. Based on the USGS gage data, the San Pitch River and its tributaries (HUC 16030004) contribute a little less than 54,300 acre-ft of water on average per year to the Sevier River, based on the sum of the median annual values from USGS stations 10216400 and 10216210. Gaged tributaries in the Great Basin watershed coming from the Wasatch Plateau contribute 78,000 acre-ft/yr, meaning 23,700 acre-ft/yr are diverted, evaporated, and/or infiltrated (table 3). Salina Creek contributes a yearly median of 16,300 acre-ft of water, and upper Salina Creek, which emanates from Manti-La Sal National Forest, contributes a median of 11,100 acre-ft/yr. Thistle Creek, which ultimately contributes to Utah Lake from Spanish Fork Canyon, contributes a median water volume of 64,000 acre-ft/yr. The total amount of water flowing off the Wasatch Plateau in the Great Basin watershed is 142,000 acre-ft/yr, which is 409,000 acre-ft/yr less than the reported precipitation for the watershed, meaning that a significant amount of water infiltrates, is diverted, and is lost to evapotranspiration (table 3; plate 3).

Wetlands

A total of 6903 acres of wetlands were mapped in the USFS dataset on the Wasatch Plateau within USFS administered lands. Cowardin and others' (1979) classification yields 49 unique wetland types which were simplified to eight distinct wetland types described in table 4. Total wetland area by type for the USFS administered lands on the Wasatch Plateau is shown in figure 4. Wetland types were summarized by both HUC 10 and HUC 12 watersheds. Summary tables can be found in appendix D.

The completeness of the current wetland dataset was assessed for the South Tent Mountain quadrangle. We compared the results of our lidar mapping effort to the 2006 wetland data, the Miller Flat update, and the NWI data. Our

Table 4. *Wetland functional reclassification descriptions.*

Type	Cowardin Code(s)	Description
Emergent Wet Meadow	PEM1A/B/C	Temporarily or seasonally flooded or seasonally saturated emergent wetland with greater than 30% hydrophytic vegetation cover
Emergent Marsh	PEM1F/H	Permanently or intermittently exposed emergent wetland with greater than 30% hydrophytic vegetation
Lacustrine (Reservoir)	L1UBHh/x	Deepwater reservoir (area > 20 acres, depth >2 m) flooded year round (all deepwater habitats were exclusively impounded reservoirs on the Wasatch Plateau)
Lacustrine Shore	L2USCh/x L2USFh/x	Deepwater reservoir shoreline (area > 20 acres, depth < 2m) seasonally or semipermanently flooded
Palustrine (Pond)	PUBH/b PUSF/C	Naturally occurring pond (agrea < 20 acres)
Stock Pond or Small Reservoir	PUBFh/x PUBHh/x PUSCh/x	Impounded or excavated pond or enlarged natural pond constructed to store water for domestic or agricultural use (area < 20 acres)
Scrub-Shrub	PSS	> 30 % woody plants < 6m in height
Forested	PFO	> 30% woody plants > 6m in height

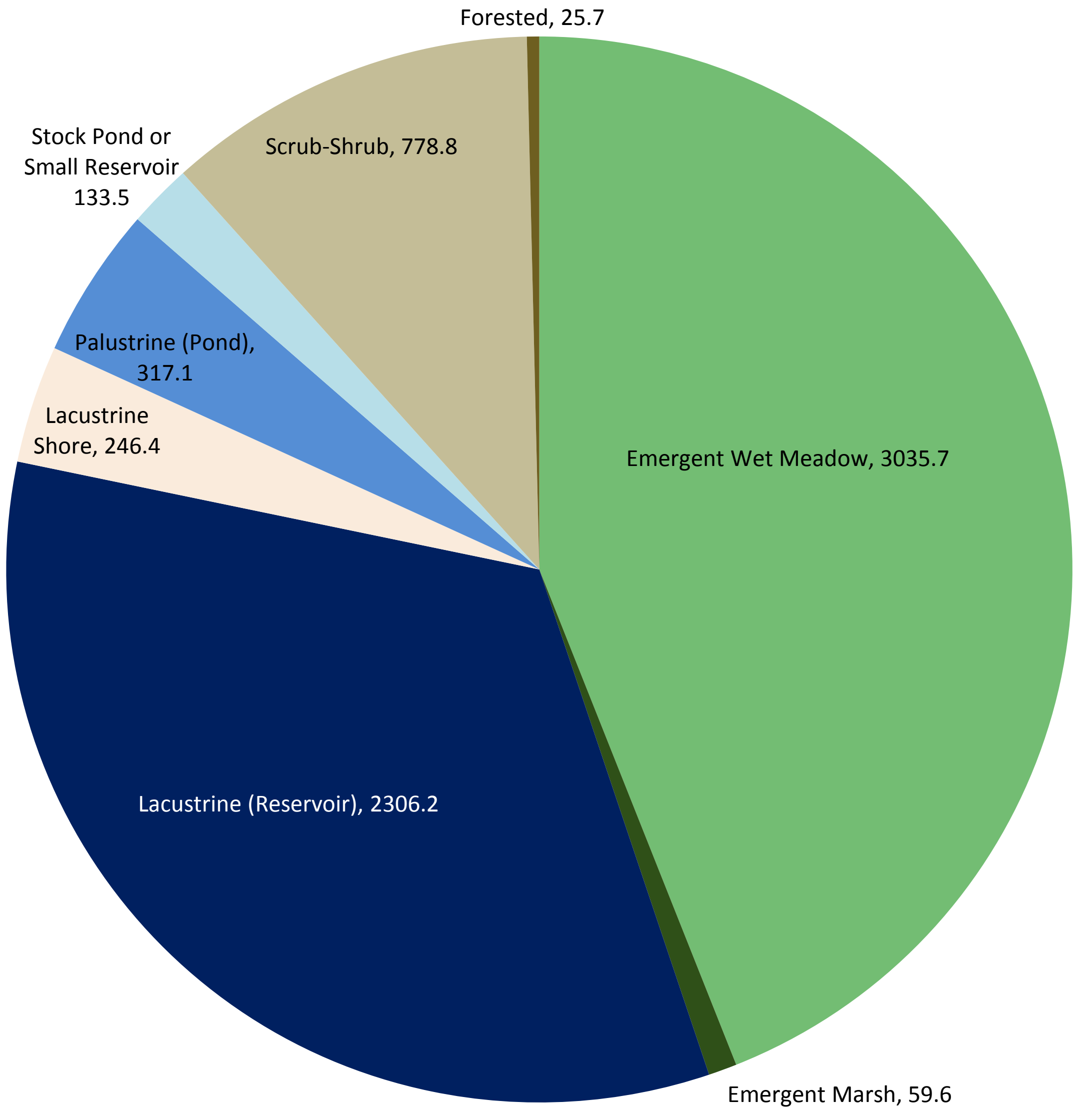

Figure 4. *Total wetland acres by type for the U.S. Forest Service administered lands on the Wasatch Plateau.*

data confirmed the extent of the depressional wetlands identified by both USFS wetland datasets, which had 52 additional acres when compared to the Miller Flat update and 81 additional acres when compared to the USFS wetlands data (figure 5). We did not include the newly added Riverine class of wetlands mapped from lidar in this comparison since they were not originally inventoried as part of USFS mapping efforts. We reclassified many of the depressional wetlands using imagery captured at different times of the year by confirming springtime flooding only (seasonally flooded) and late summer saturation or standing water (semipermanently to permanently flooded). The most notable increase in mapped wetlands was in the Forested type. Forested wetlands are difficult to detect through image analysis as the canopy conceals the presence of water or wet soils. We were only able to identify these wetlands because of the ability of lidar to penetrate the canopy to reveal depressional features. We verified the presence of water in some of the deciduous forested depressions by analyzing imagery flown in the spring, prior to leaf development, but evergreen forested wetlands were not verified and should be field checked.

The NWI requires that all wetlands larger than 0.1 acre (0.4 ha) be mapped but will accept smaller polygons from a project. We mapped wetlands as small as 0.016 acres (0.0065 ha) to match the USFS wetland dataset which included polygons this size. We attempted to locate smaller depressions but found the number of depressions smaller than 0.016 acres to be too small to efficiently investigate as well as having a higher likelihood of being associated with noise in the DEM. While we identified the presence of water in many of the depressions we mapped, we caution that delineation of wet-

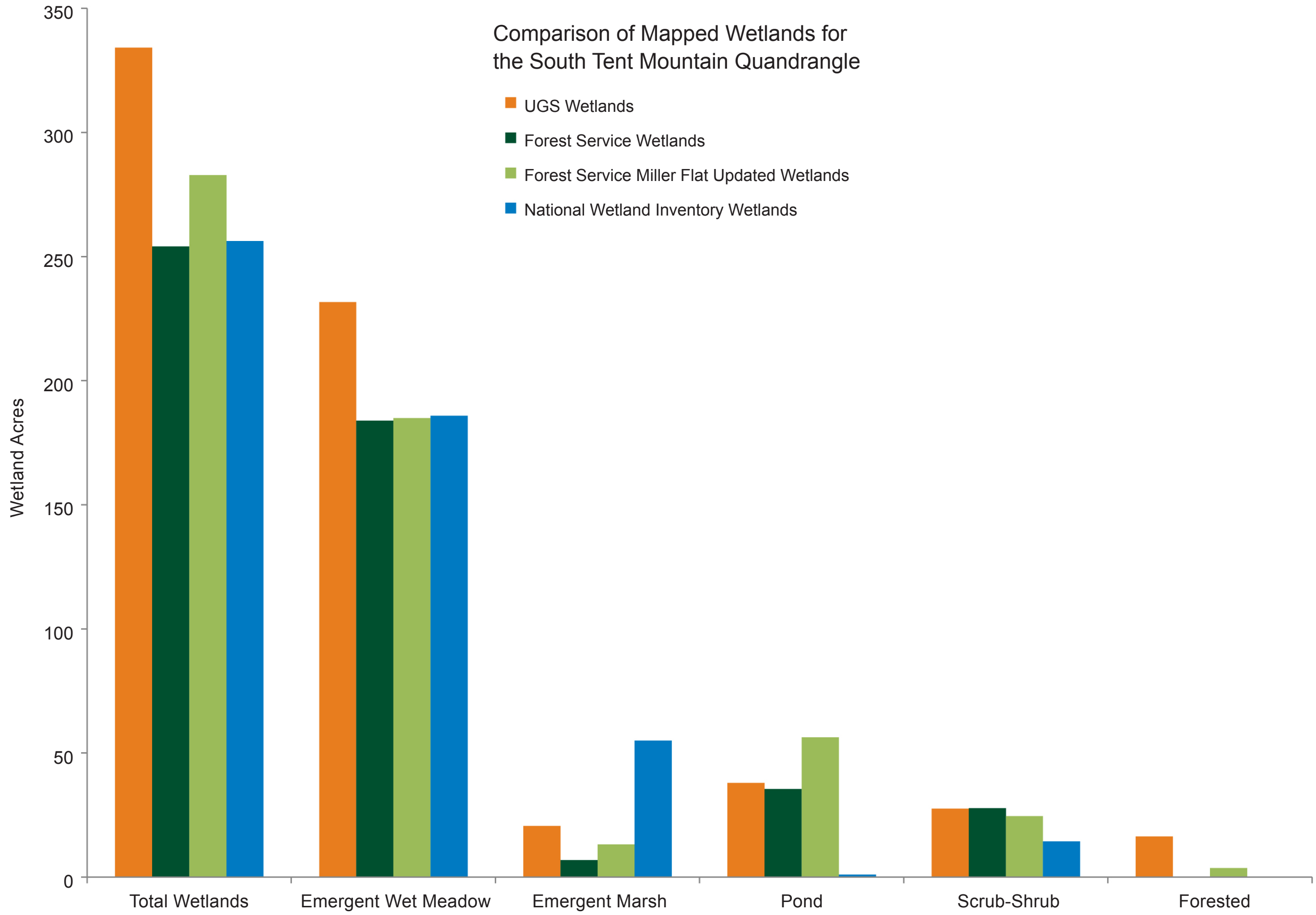

Figure 5. *Total wetland acreage as mapped by UGS, Forest Service, and National Wetlands Inventory for the South Tent Mountain quadrangle.*

lands smaller than 0.1 acres (0.04 ha) typically cannot be accomplished consistently from aerial imagery and would normally require field investigation and/or remotely sensed data like lidar and high-resolution imagery (sub-meter). Exclusion errors can be introduced if the entire area is not assessed using the same methods or extensive field reconnaissance.

Field Investigation

During our preliminary field investigations, we completed a level 1 GDE field investigation (Coles-Ritchie and others, 2012) on a total of 56 sites, some with multiple visits. The data from the field investigations are summarized in the GDE database (appendix E) and as the feature class "Field_point."

Most GDE locations encountered were impacted to some degree by grazing. Extensive pugging was observed at many GDEs. Pugging occurs when prolonged cattle grazing damaged vegetation roots, which normally stabilize saturated soils, leaving behind small elevated clumps of vegetation on compacted soil pedestals. Most of the areas not trampled had limited grazing or fencing to exclude grazing.

Many of the mid-elevation GDEs were smaller than would be visible in aerial photographs, and many of the GDEs were seepage zones and gaining sections along streams which make them undetectable in aerial imagery. Extensive field investigation is required to locate most of these GDEs. We also noted that many of the springs compiled for the Springs feature class discharged in similar geologic settings. Many of the higher elevation springs issue from formation contacts, especially along contacts of the North Horn Formation with fractured portions of the Flagstaff and Price River Formations and other springs were commonly associated with landslide complexes of the North Horn Formation. Many of the GDEs are likely part of a perched system (Mayo and others, 2003) based on the discrete and localized flows of the springs, as well as the small area and discontinuity of many of the GDEs.

Based on spring digitization/compilation efforts and experience in the field, we concluded that GDE identification is highly dependent on the mapping scale and the season in which the spring is surveyed. The compilation shows that identified GDEs are clustered in active mining areas. This clustering is due to comprehensive efforts of mining hydrologists focused on identifying springs in the Greens Hollow mining impact area. The clustering is due to better mapping of the area, not because of the presence of higher density of springs.

SUMMARY

For this report, we compiled hydrology and wetlands data for the Wasatch Plateau. We digitized monitoring stations from paper maps for 22 mines, resulting in 2441 attributed feature class points. We used federal and state databases, as well as high-resolution aerial photography, to map 2189 potential spring locations. We compiled water chemistry data from five different government agencies into a point feature class containing 10,625 unique sampling instances having complete major ion chemistry. We compiled surface flow data for 40 USGS flow gaging stations and summarized the flow measurements in appendix B. We classified over 6900 acres of wetland on the Wasatch Plateau into type categories and surveyed 56 springs using the GDE protocol. All the data resulting from this compilation and their metadata are provided in an attributed geodatabase.

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APPENDICES

APPENDIX A

KEY TERMS

For a more exhaustive description of terms, see the ESRI GIS Dictionary (http://support.esri.com/en/knowledgebase/GIS-Dictionary/search) and/or the GIS Glossary (http://wiki.gis.com/wiki/index.php/GIS_Glossary), from which these definitions are paraphrased.

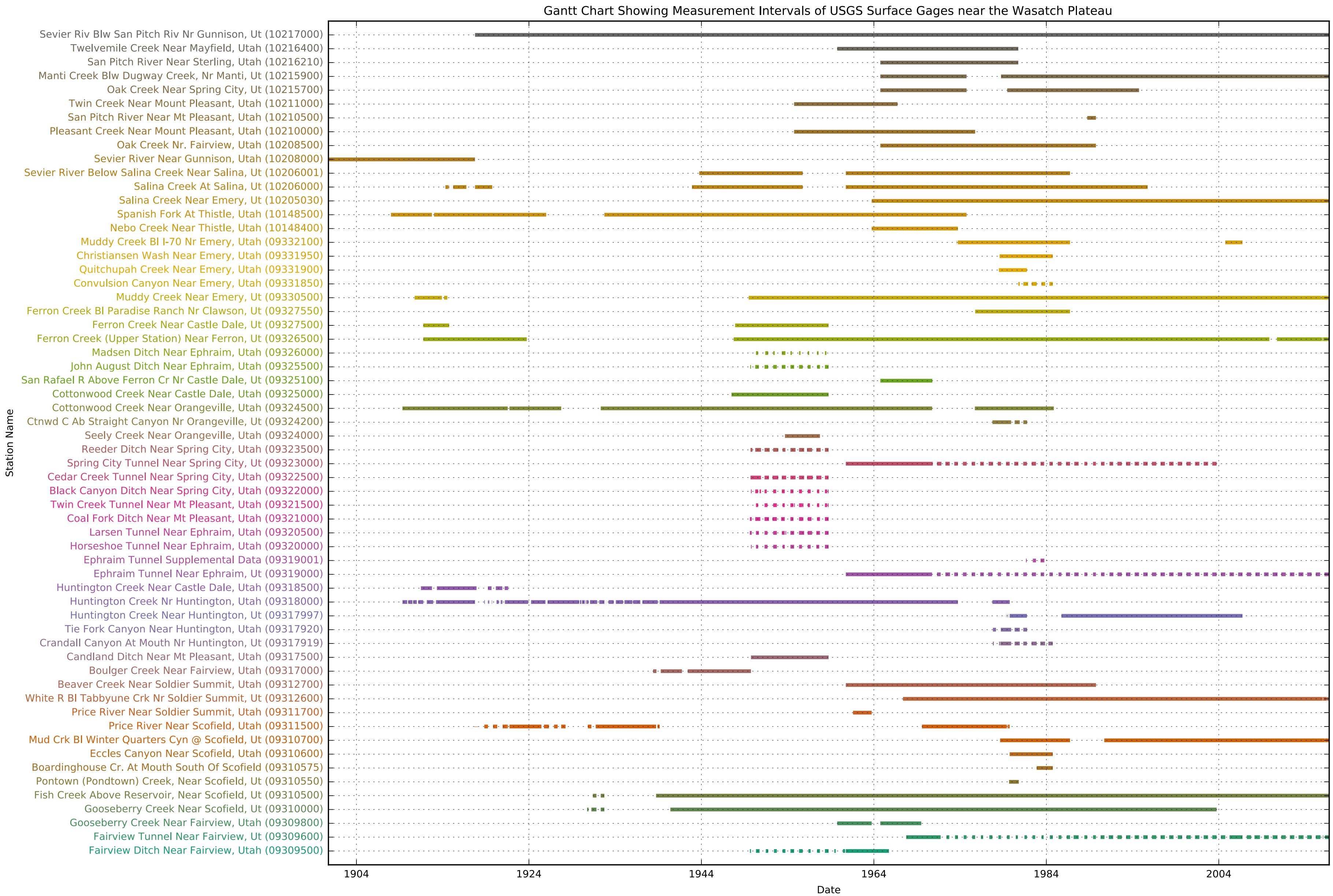
- **ArcGIS** – proprietary software (ESRI, 2014) used to create digital maps; ArcGIS is a type of geographic information system.
- **attribute** – information stored in a table that is usually embedded with a spatial feature. Attribute information does not have to be spatial.
- **digital elevation model (DEM)** – a three-dimensional raster representation of land surface, where each pixel represents an elevation value of the land surface. Pixel size is dictated by the horizontal resolution of the dataset (e.g., 10 meter DEM has pixels with the horizontal dimensions 10 m x 10 m).
- **digitize** – convert an analog representation such as a paper map, drawing, or photograph into a digital equivalent.
- **feature class** – a file format used to store vector-based geographic features that have the same type of geometry (line, point, polygon) and the same type of attributes.
- **feature dataset** – a filespace within a geodatabase that holds a collection of feature classes having the same spatial reference; generally, feature classes in the same feature dataset have something in common (e.g., data type, location, or geometry), but it is not a requirement.
- **geodatabase (GDB)** – a database used to store and modify spatial data. Geodatabases store spatial reference information, the type of geometry, attributes of features, and rules for the data.
- **geographic information system (GIS)** – computer software and data to view, manage, analyze, and manipulate digital geographic data.
- **geometry** – location, orientation, and type of manifestation/representation in the spatial zone. This term is generally applied to vectors, and refers to points, lines, or polygons on a map.
- **merge** – combining the features and attributes of multiple data sets.
- **projected** – when a raster or vector is converted from one type of spatial reference to another.
- **raster** – representation on a map or drawing depicted using a grid of interconnected pixels.
- **relationship class** – defines how two sets of attributes are related.
- **representation** – a symbol, drawing, or depiction of something in the real world.
- **schema** – defined structure and format for a table, including the data format of each field.
- **shapefile** – a file format used to store vector files, spatial references, and associated attributes; shapefiles and feature classes essentially represent the same types of data, except that feature classes are a more effective and efficient way to store data.
- **spatial join** – combining information and attributes from two separate representations based on their spatial relationships (e.g., add name of state if feature is within the state).
- **spatial reference** – a description of a representation's (raster or vector) coordinate system, datum, resolution, and accuracy.
- **vector** – a representation on a digital map or drawing stored by coordinates or a list of vertices. Generally, attributes are associated with and connected to each depicted vector.

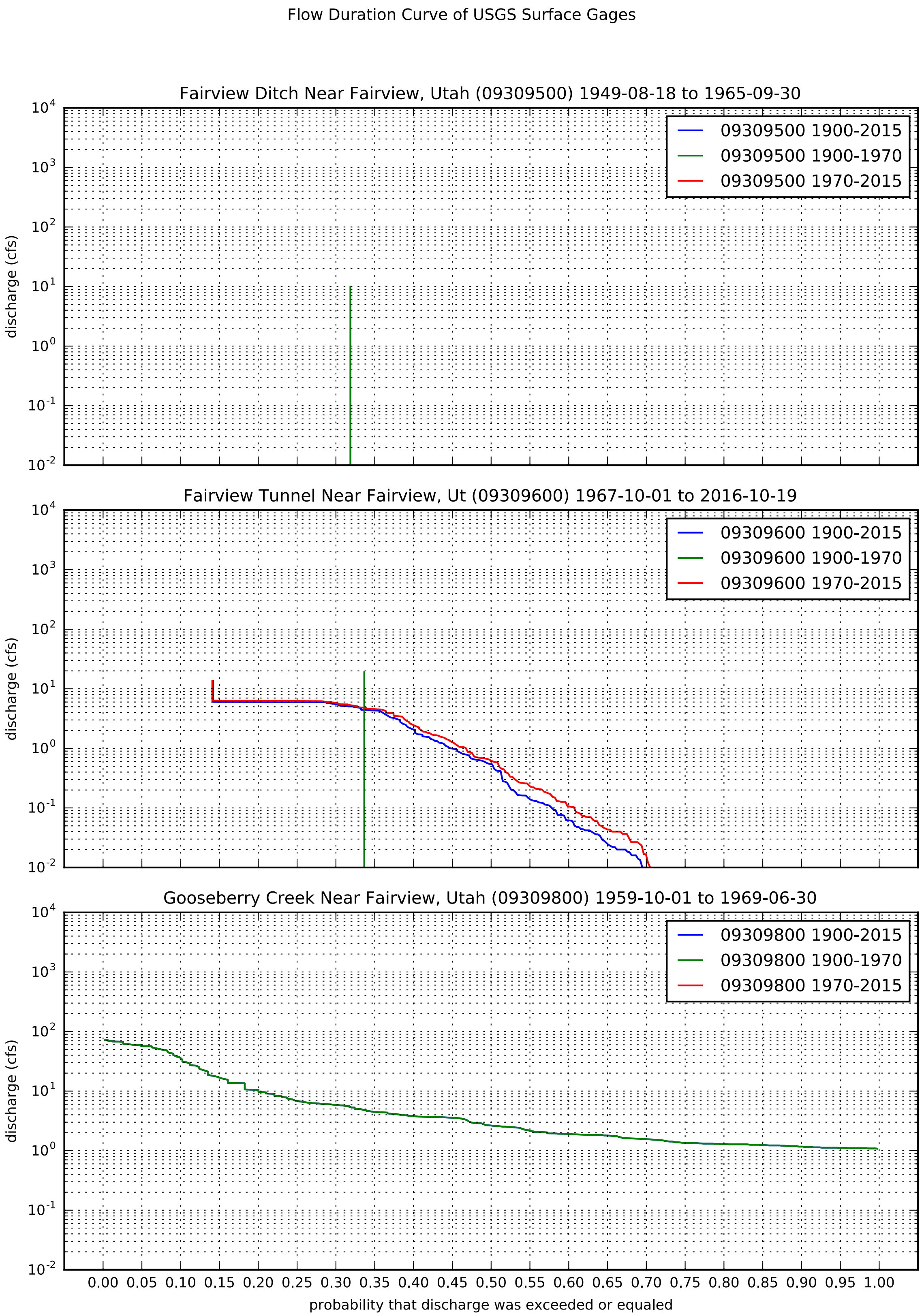
General data hierarchy in ArcGIS from top to bottom:

- geodatabase >> feature dataset >> feature class >> attributes

APPENDIX B

SUMMARY STATISTICS OF CHEMISTRY AND FLOW FOR USGS STATIONS ON THE WASATCH PLATEAU


Gantt Chart Showing Measurement Intervals of USGS Surface Gages near the Wasatch Plateau
Station Name
Sevier Riv Blw San Pitch Riv Nr Gunnison, Ut (10217000)
Twelvemile Creek Near Mayfield, Utah (10216400)
San Pitch River Near Sterling, Utah (10216210)
Manti Creek Blw Dugway Creek, Nr Manti, Ut (10215900)
Oak Creek Near Spring City, Ut (10215700)
Twin Creek Near Mount Pleasant, Utah (10211000)
San Pitch River Near Mt Pleasant, Utah (10210500)
Pleasant Creek Near Mount Pleasant, Utah (10210000)
Oak Creek Nr. Fairview, Utah (10208500)
Sevier River Near Gunnison, Utah (10208000)
Sevier River Below Salina Creek Near Salina, Ut (10206001)
Salina Creek At Salina, Ut (10206000)
Salina Creek Near Emery, Ut (10205030)
Spanish Fork At Thistle, Utah (10148500)
Nebo Creek Near Thistle, Utah (10148400)
Muddy Creek Bl I-70 Nr Emery, Utah (09332100)
Christiansen Wash Near Emery, Utah (09331950)
Quitchupah Creek Near Emery, Utah (09331900)
Convulsion Canyon Near Emery, Utah (09331850)
Muddy Creek Near Emery, Ut (09330500)
Ferron Creek Bl Paradise Ranch Nr Clawson, Ut (09327550)
Ferron Creek Near Castle Dale, Ut (09327500)
Ferron Creek (Upper Station) Near Ferron, Ut (09326500)
Madsen Ditch Near Ephraim, Utah (09326000)
John August Ditch Near Ephraim, Utah (09325500)
San Rafael R Above Ferron Cr Nr Castle Dale, Ut (09325100)
Cottonwood Creek Near Castle Dale, Utah (09325000)
Cottonwood Creek Near Orangeville, Utah (09324500)
Ctnwd C Ab Straight Canyon Nr Orangeville, Ut (09324200)
Seely Creek Near Orangeville, Utah (09324000)
Reeder Ditch Near Spring City, Utah (09323500)
Spring City Tunnel Near Spring City, Ut (09323000)
Cedar Creek Tunnel Near Spring City, Utah (09322500)
Black Canyon Ditch Near Spring City, Utah (09322000)
Twin Creek Tunnel Near Mt Pleasant, Utah (09321500)
Coal Fork Ditch Near Mt Pleasant, Utah (09321000)
Larsen Tunnel Near Ephraim, Utah (09320500)
Horseshoe Tunnel Near Ephraim, Utah (09320000)
Ephraim Tunnel Supplemental Data (09319001)
Ephraim Tunnel Near Ephraim, Ut (09319000)
Huntington Creek Near Castle Dale, Utah (09318500)
Huntington Creek Nr Huntington, Utah (09318000)
Huntington Creek Near Huntington, Ut (09317997)
Tie Fork Canyon Near Huntington, Utah (09317920)
Crandall Canyon At Mouth Nr Huntington, Ut (09317919)
Candland Ditch Near Mt Pleasant, Utah (09317500)
Boulger Creek Near Fairview, Utah (09317000)
Beaver Creek Near Soldier Summit, Utah (09312700)
White R Bl Tabbyune Crk Nr Soldier Summit, Ut (09312600)
Price River Near Soldier Summit, Utah (09311700)
Price River Near Scofield, Utah (09311500)
Mud Crk Bl Winter Quarters Cyn @ Scofield, Ut (09310700)
Eccles Canyon Near Scofield, Utah (09310600)
Boardinghouse Cr. At Mouth South Of Scofield (09310575)
Pontown (Pondtown) Creek, Near Scofield, Ut (09310550)
Fish Creek Above Reservoir, Near Scofield, Ut (09310500)
Gooseberry Creek Near Scofield, Ut (09310000)
Gooseberry Creek Near Fairview, Utah (09309800)
Fairview Tunnel Near Fairview, Ut (09309600)
Fairview Ditch Near Fairview, Utah (09309500)
1904
1924
1944
1964
1984
2004
Date


Flow Duration Curve of USGS Surface Gages
Fairview Ditch Near Fairview, Utah (09309500) 1949-08-18 to 1965-09-30
09309500 1900-2015
09309500 1900-1970
09309500 1970-2015
Fairview Tunnel Near Fairview, Ut (09309600) 1967-10-01 to 2016-10-19
09309600 1900-2015
09309600 1900-1970
09309600 1970-2015
Gooseberry Creek Near Fairview, Utah (09309800) 1959-10-01 to 1969-06-30
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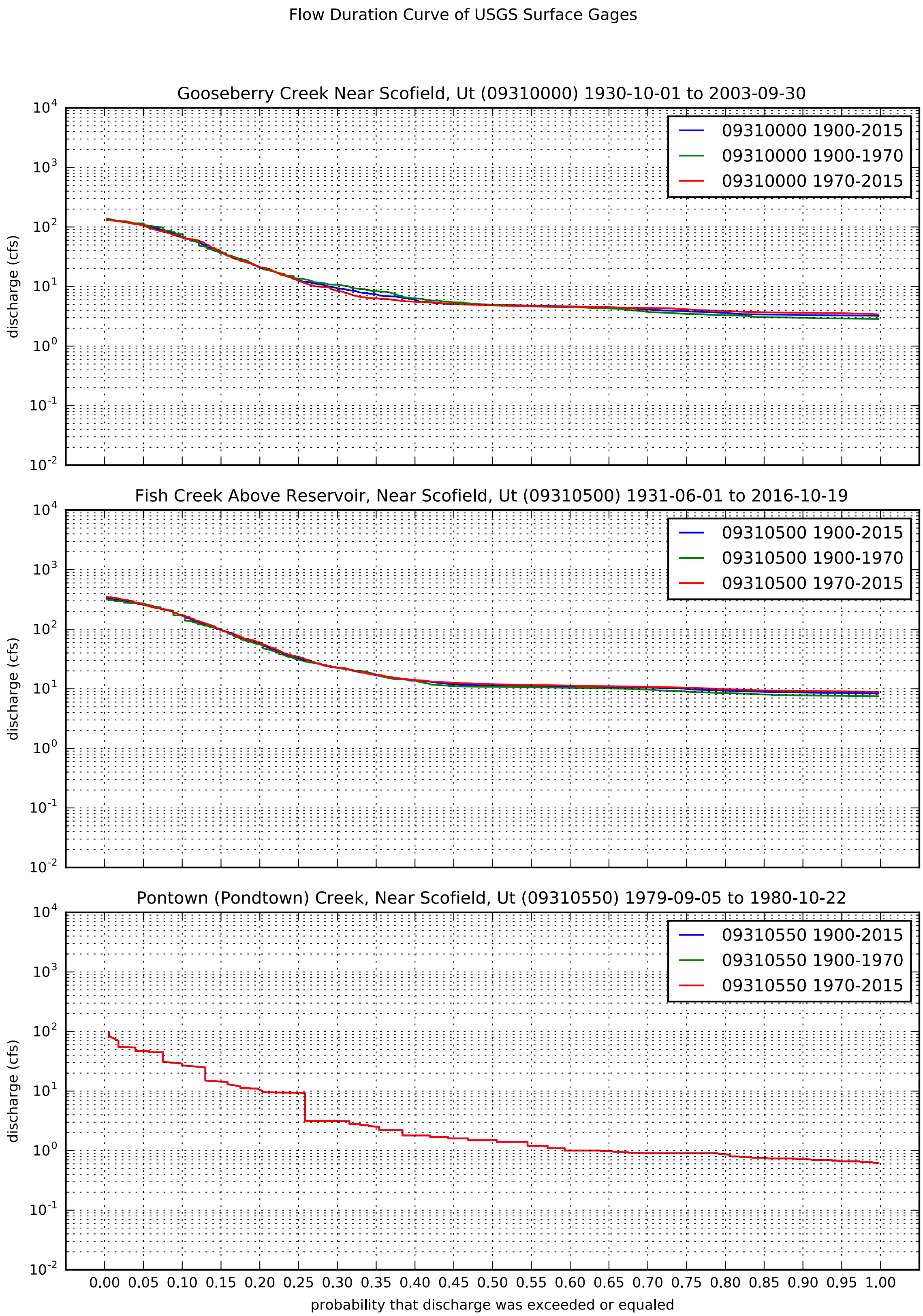
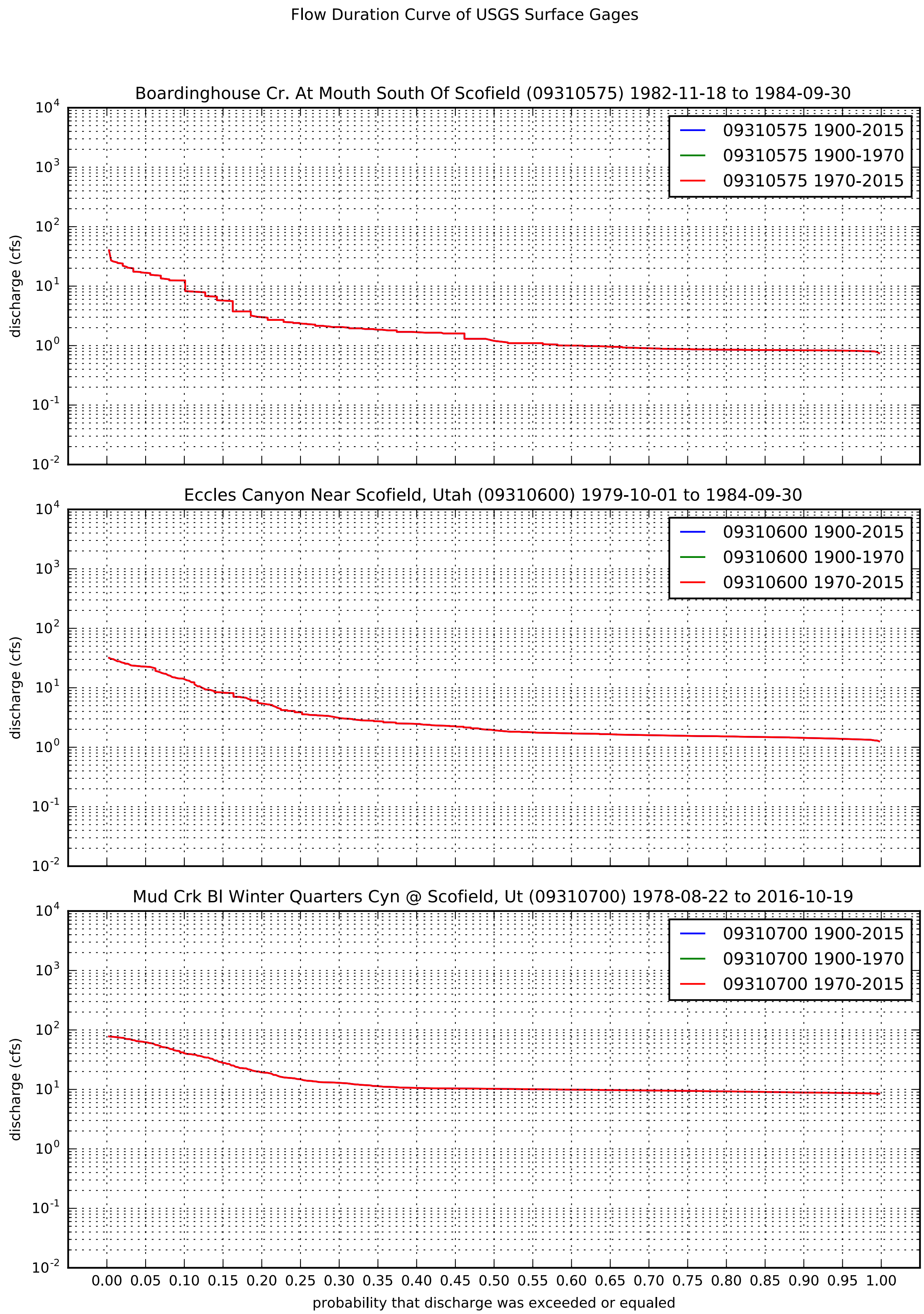
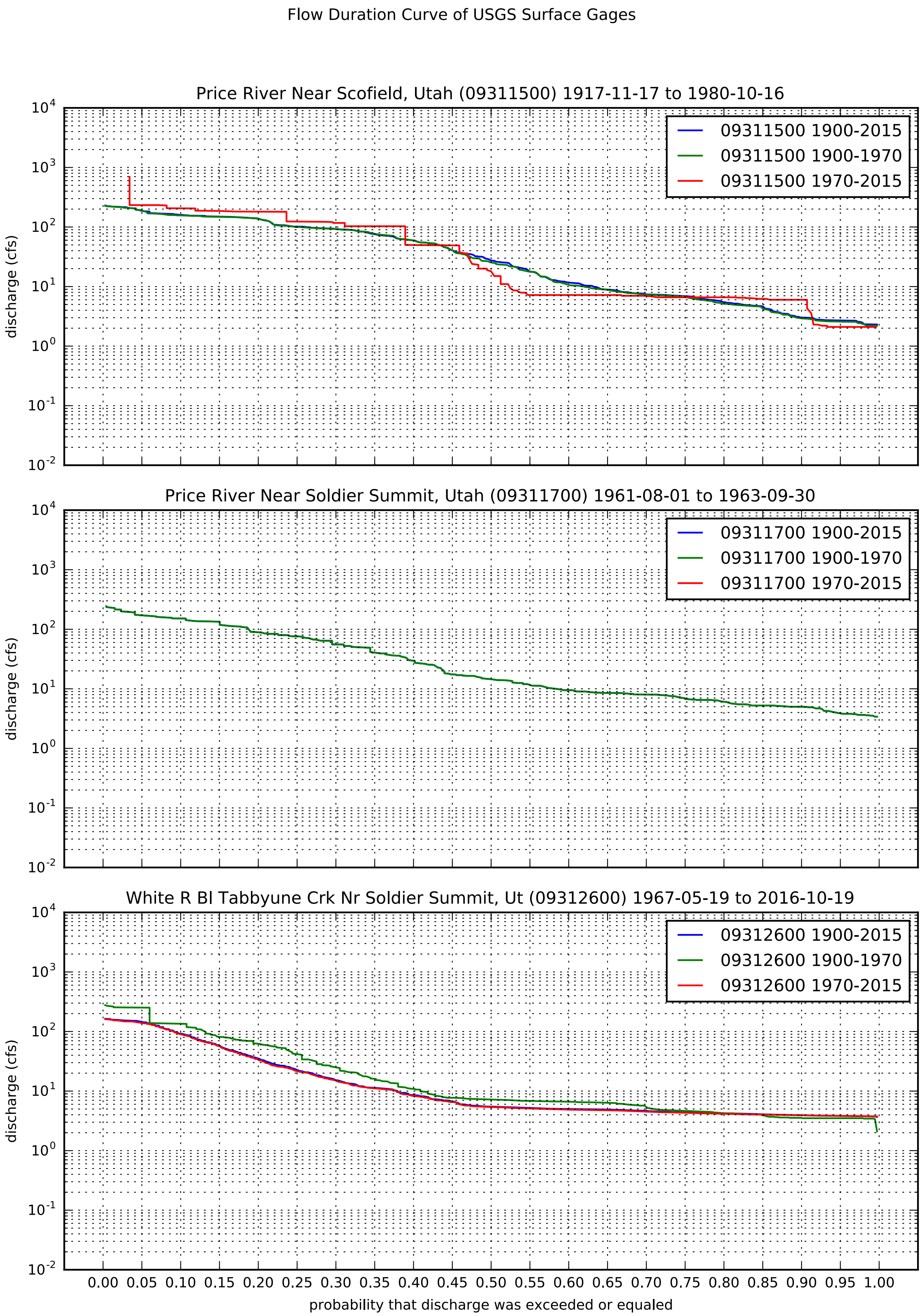
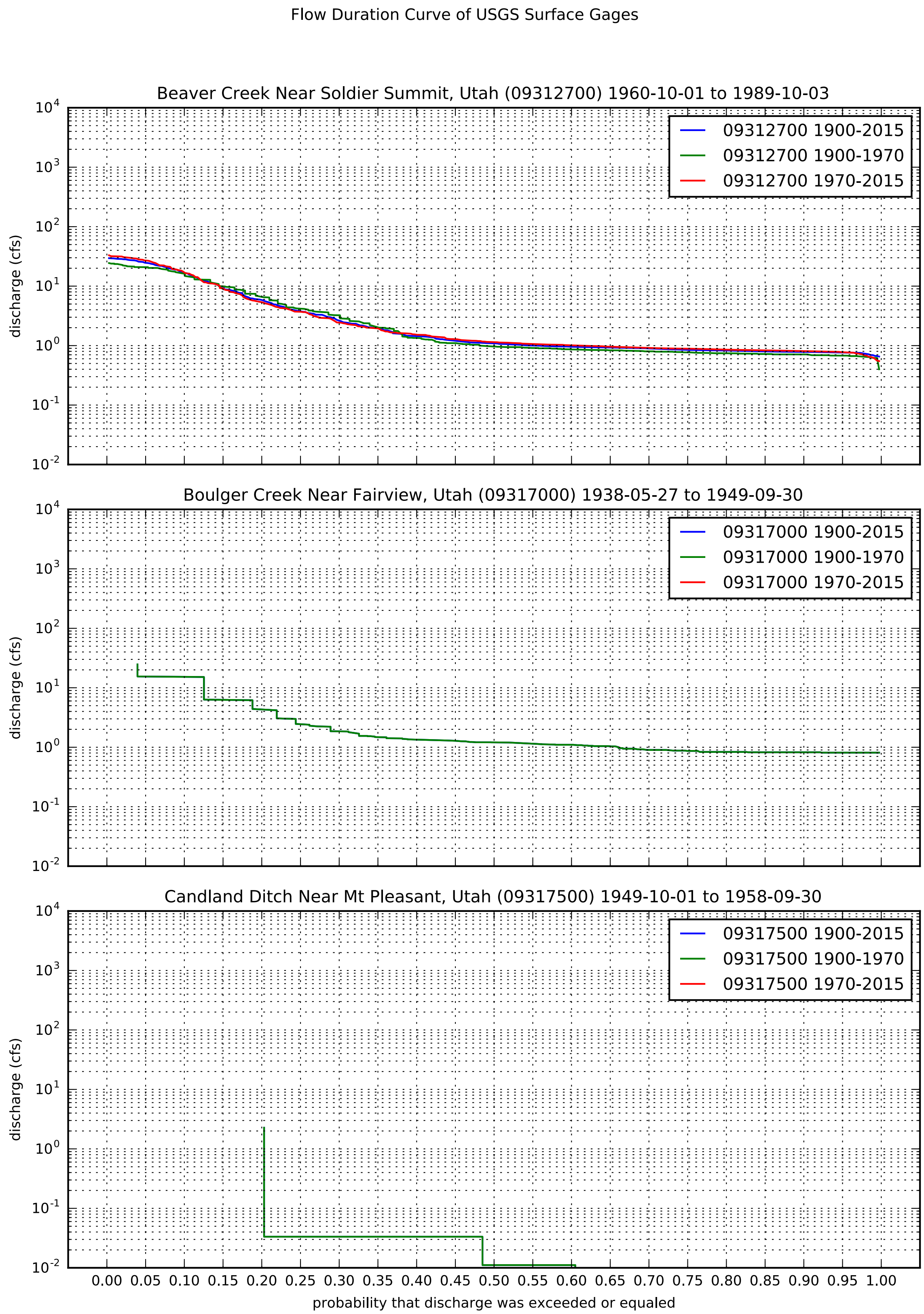
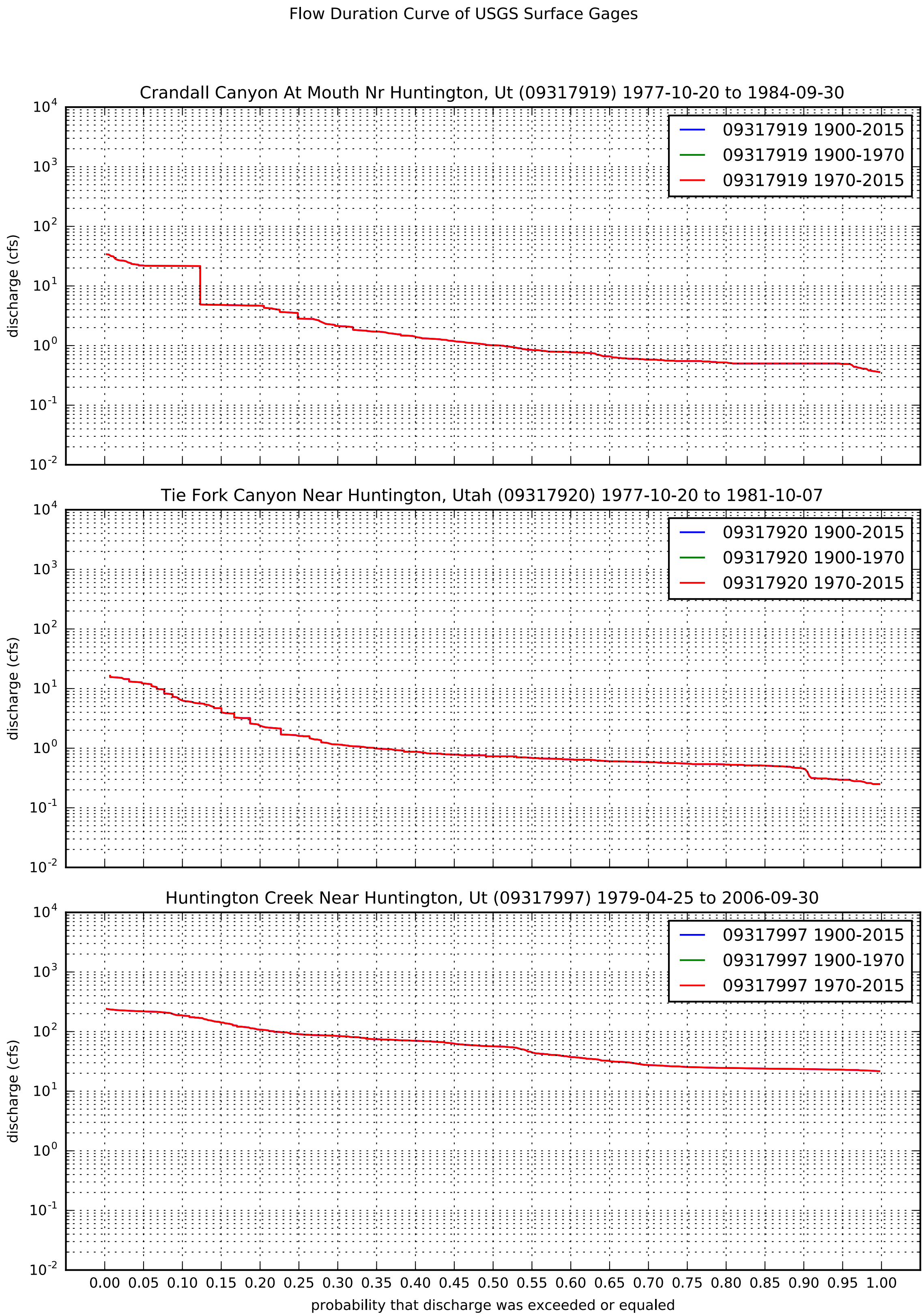
discharge (cfs)
probability that discharge was exceeded or equaled

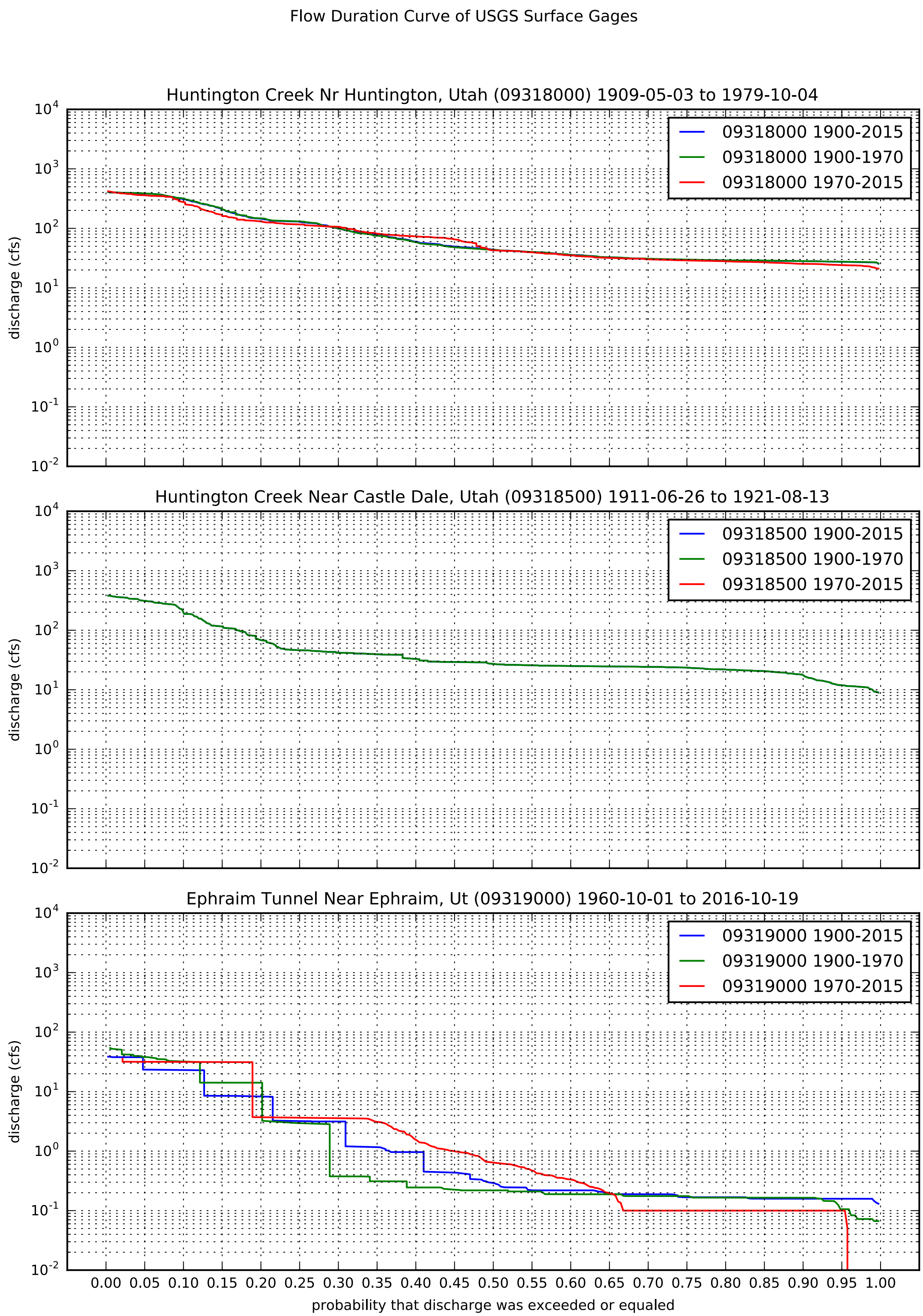

Flow Duration Curve of USGS Surface Gages
Gooseberry Creek Near Scofield, Ut (09310000) 1930-10-01 to 2003-09-30
09310000 1900-2015
09310000 1900-1970
09310000 1970-2015
Fish Creek Above Reservoir, Near Scofield, Ut (09310500) 1931-06-01 to 2016-10-19
09310500 1900-2015
09310500 1900-1970
09310500 1970-2015
Pontown (Pondtown) Creek, Near Scofield, Ut (09310550) 1979-09-05 to 1980-10-22
09310550 1900-2015
09310550 1900-1970
09310550 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}

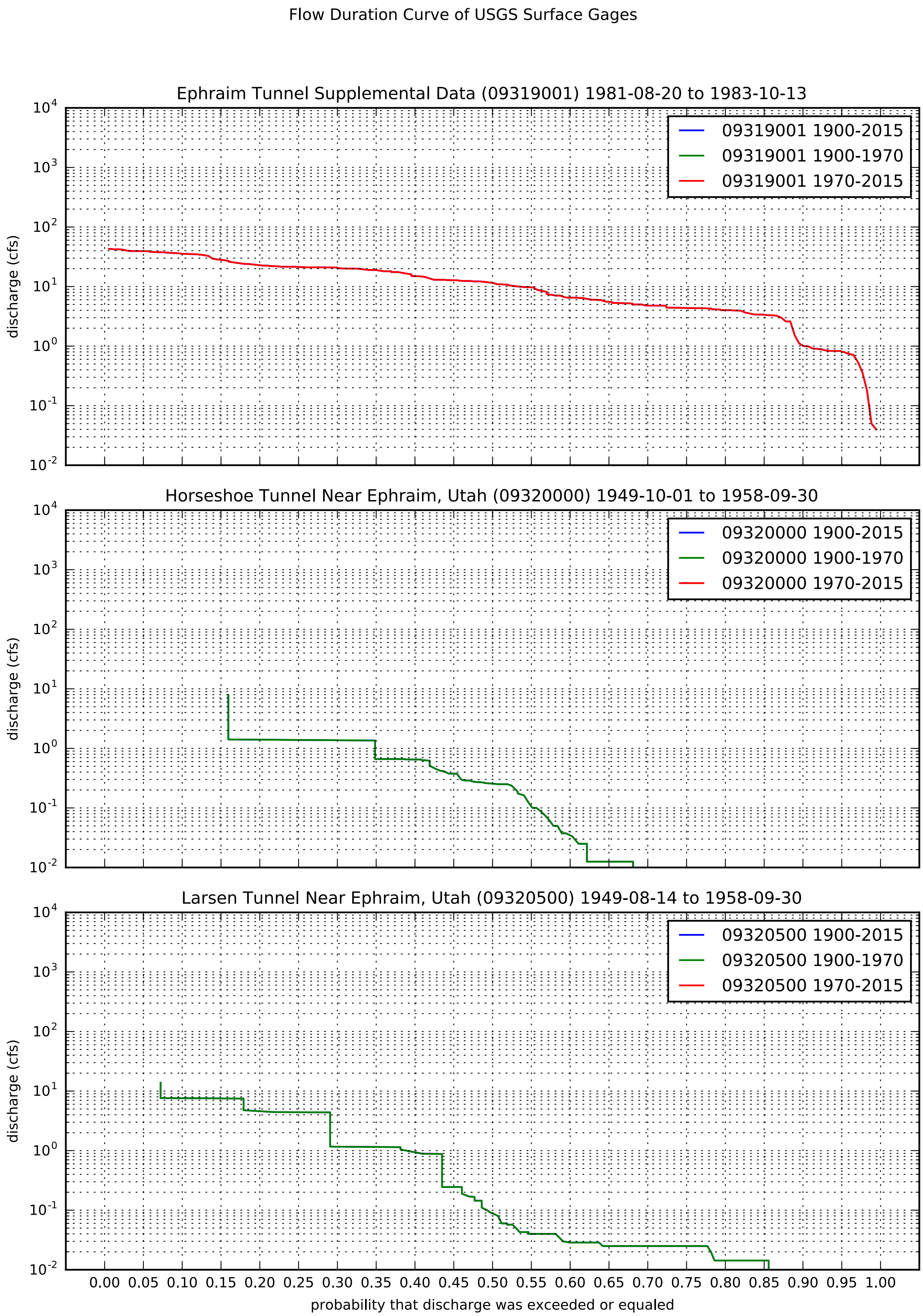

Flow Duration Curve of USGS Surface Gages
Boardinghouse Cr. At Mouth South Of Scofield (09310575) 1982-11-18 to 1984-09-30
09310575 1900-2015
09310575 1900-1970
09310575 1970-2015
Eccles Canyon Near Scofield, Utah (09310600) 1979-10-01 to 1984-09-30
09310600 1900-2015
09310600 1900-1970
09310600 1970-2015
Mud Crk Bl Winter Quarters Cyn @ Scofield, Ut (09310700) 1978-08-22 to 2016-10-19
09310700 1900-2015
09310700 1900-1970
09310700 1970-2015
discharge (cfs)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

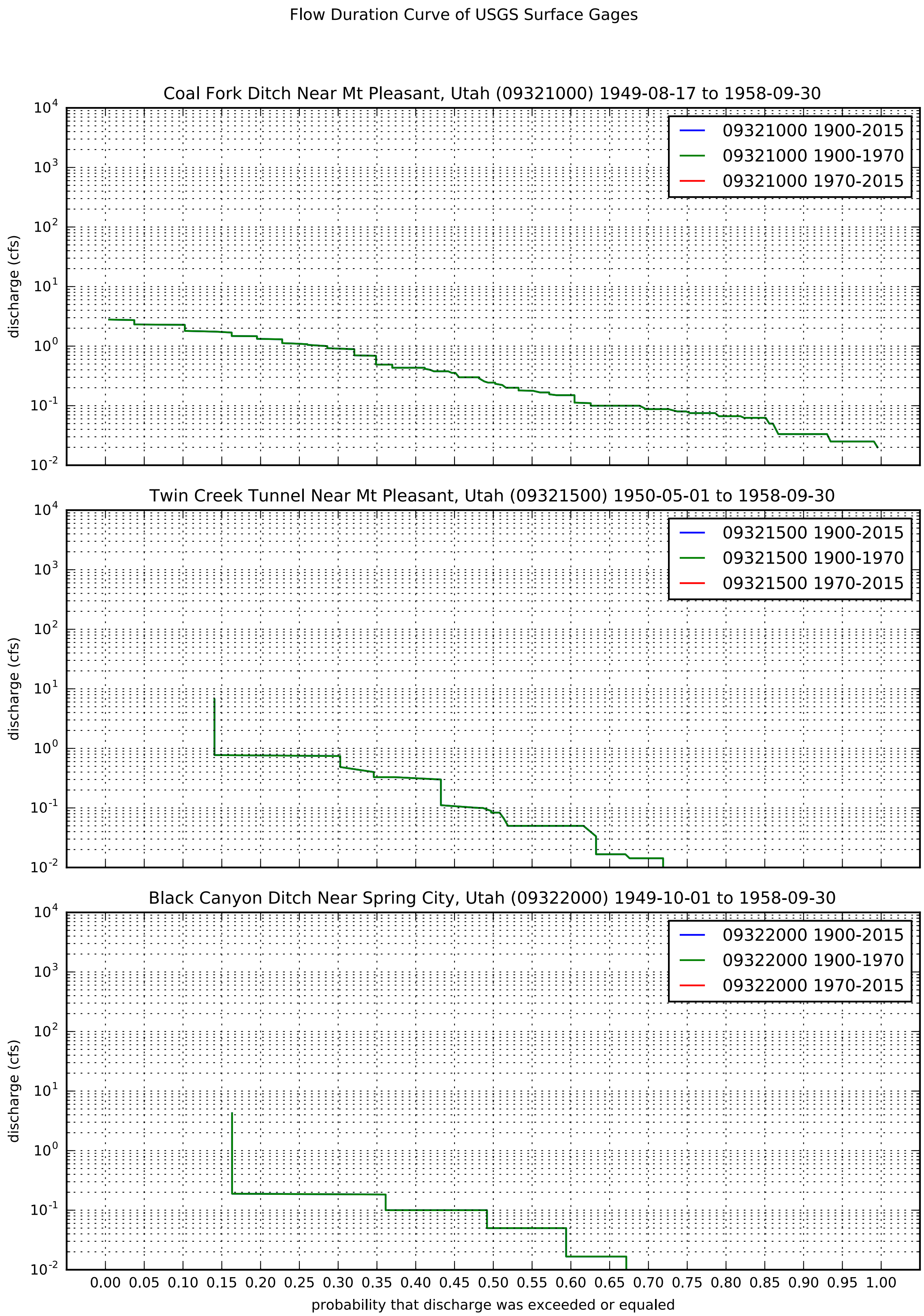

Flow Duration Curve of USGS Surface Gages
Price River Near Scofield, Utah (09311500) 1917-11-17 to 1980-10-16
09311500 1900-2015
09311500 1900-1970
09311500 1970-2015
Price River Near Soldier Summit, Utah (09311700) 1961-08-01 to 1963-09-30
09311700 1900-2015
09311700 1900-1970
09311700 1970-2015
White R Bl Tabbyune Crk Nr Soldier Summit, Ut (09312600) 1967-05-19 to 2016-10-19
09312600 1900-2015
09312600 1900-1970
09312600 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

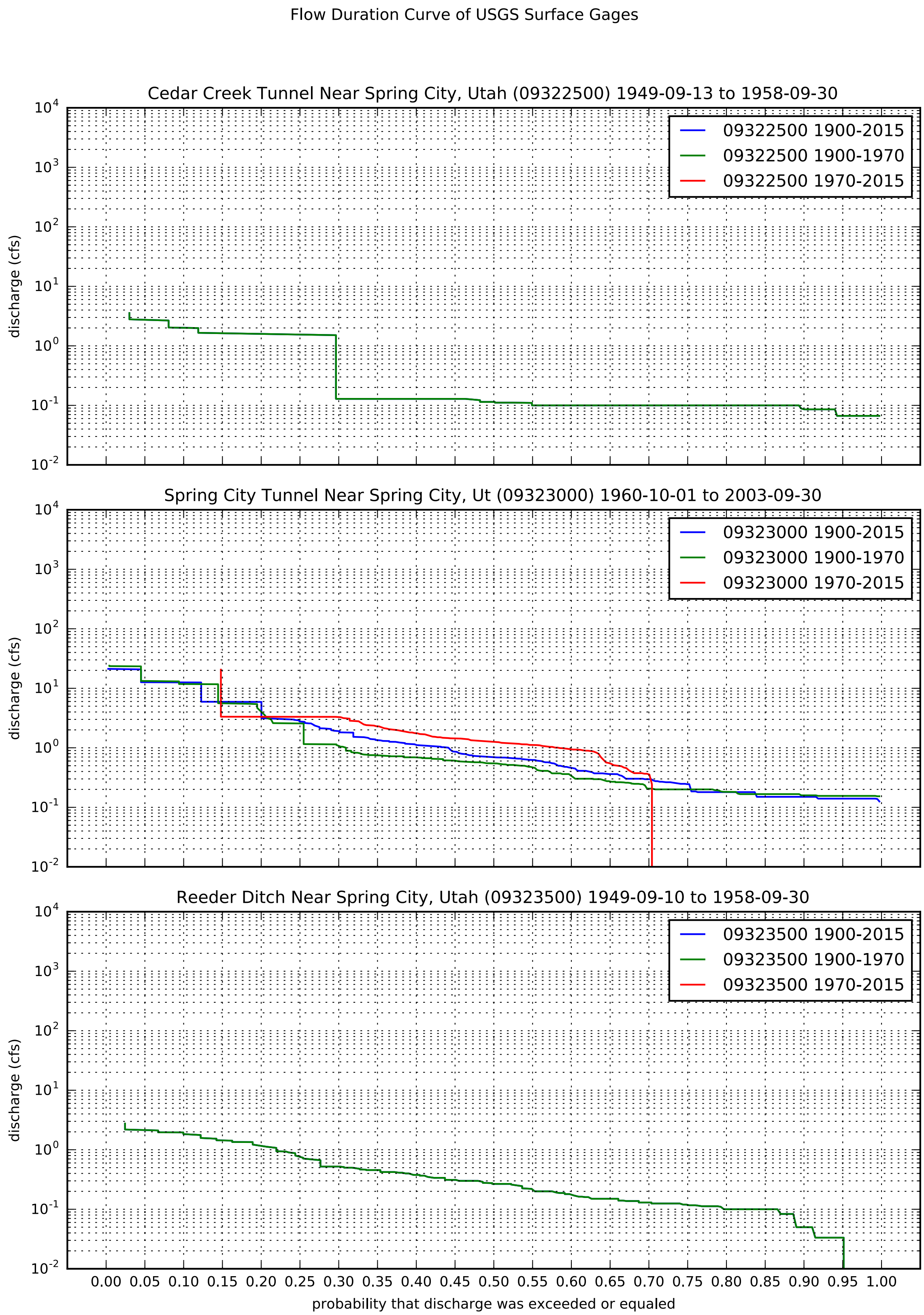

Flow Duration Curve of USGS Surface Gages
Beaver Creek Near Soldier Summit, Utah (09312700) 1960-10-01 to 1989-10-03
09312700 1900-2015
09312700 1900-1970
09312700 1970-2015
Boulger Creek Near Fairview, Utah (09317000) 1938-05-27 to 1949-09-30
09317000 1900-2015
09317000 1900-1970
09317000 1970-2015
Candland Ditch Near Mt Pleasant, Utah (09317500) 1949-10-01 to 1958-09-30
09317500 1900-2015
09317500 1900-1970
09317500 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

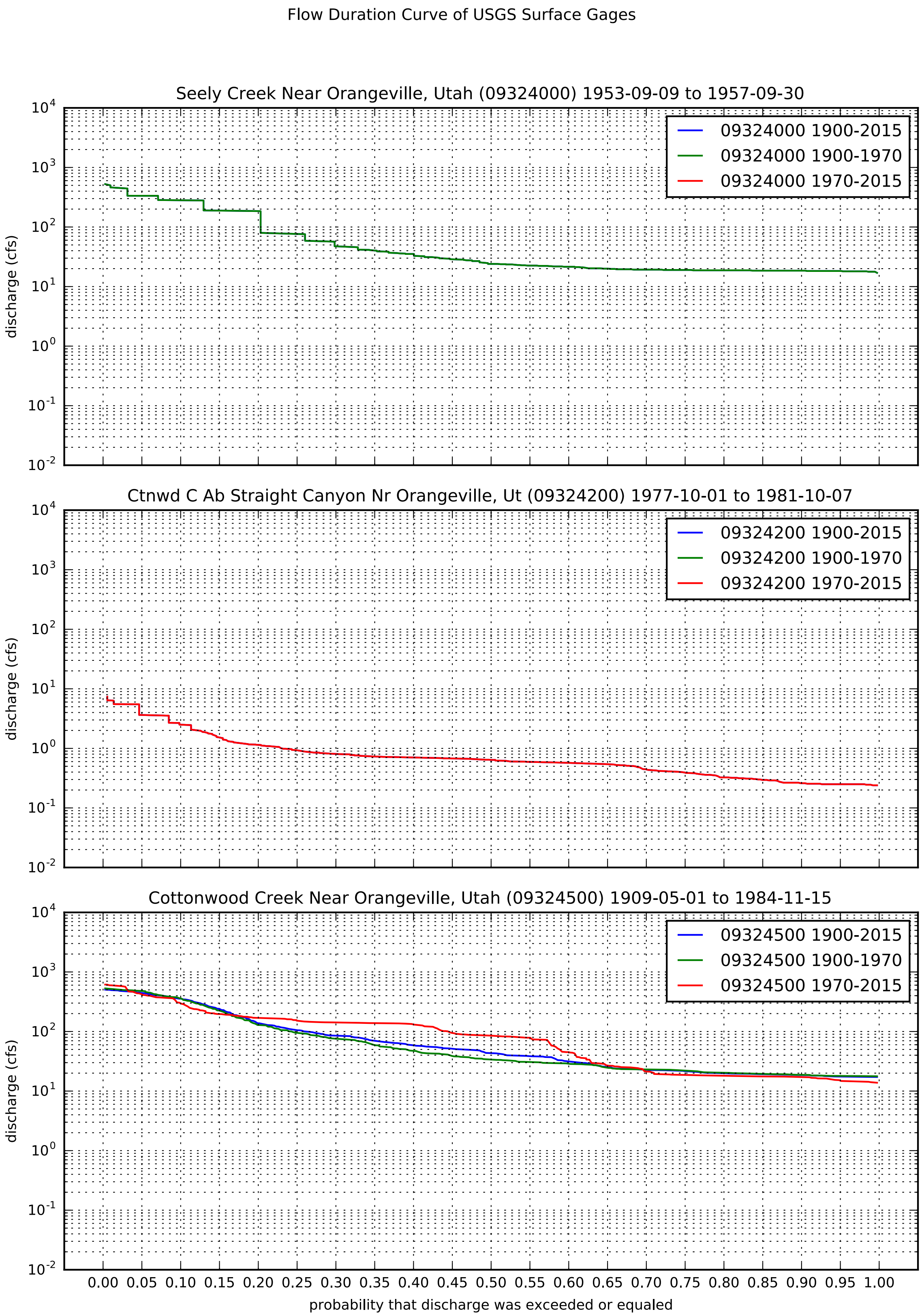

Flow Duration Curve of USGS Surface Gages
Crandall Canyon At Mouth Nr Huntington, Ut (09317919) 1977-10-20 to 1984-09-30
09317919 1900-2015
09317919 1900-1970
09317919 1970-2015
Tie Fork Canyon Near Huntington, Utah (09317920) 1977-10-20 to 1981-10-07
09317920 1900-2015
09317920 1900-1970
09317920 1970-2015
Huntington Creek Near Huntington, Ut (09317997) 1979-04-25 to 2006-09-30
09317997 1900-2015
09317997 1900-1970
09317997 1970-2015
discharge (cfs)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

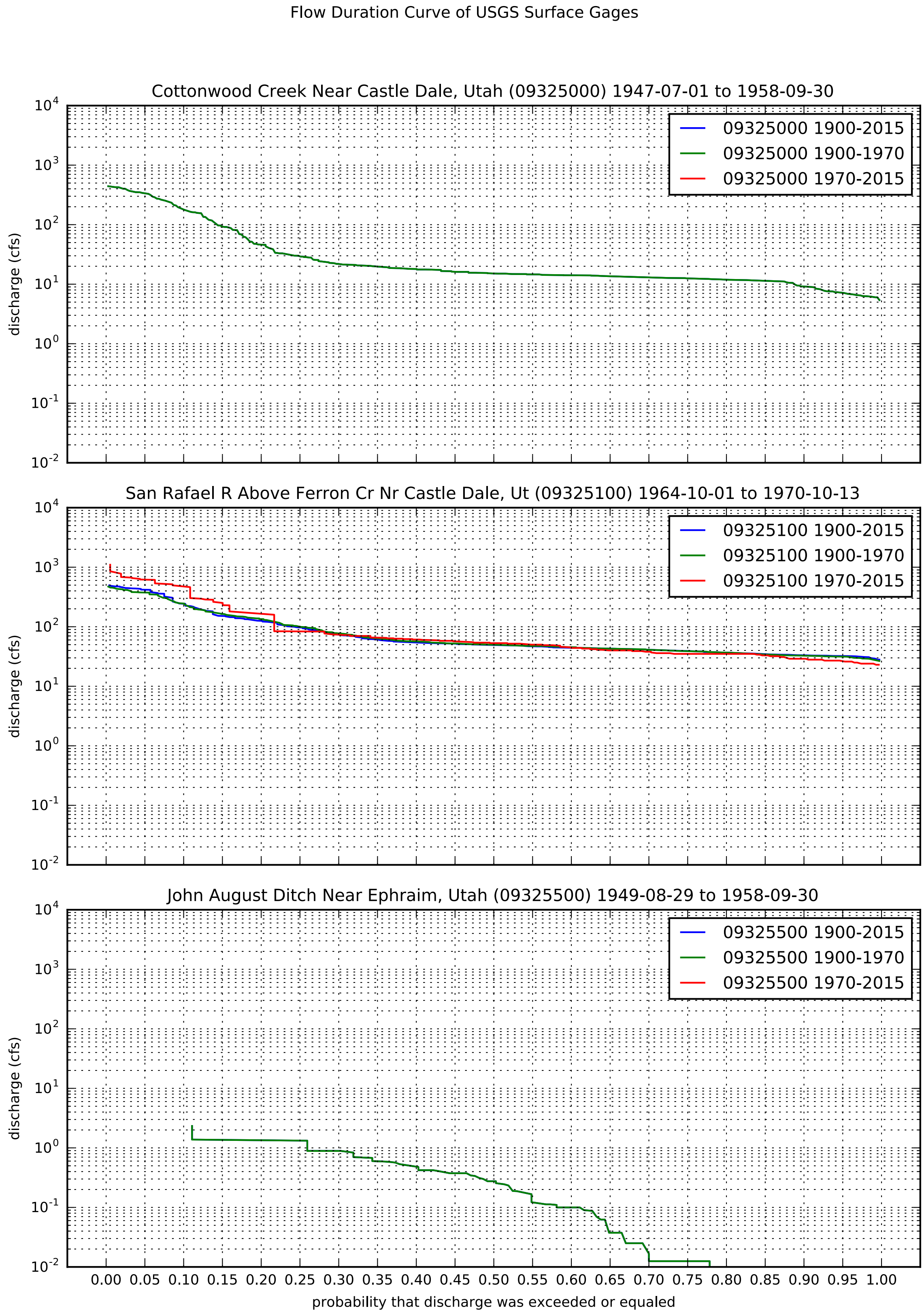

Flow Duration Curve of USGS Surface Gages
Huntington Creek Nr Huntington, Utah (09318000) 1909-05-03 to 1979-10-04
09318000 1900-2015
09318000 1900-1970
09318000 1970-2015
Huntington Creek Near Castle Dale, Utah (09318500) 1911-06-26 to 1921-08-13
09318500 1900-2015
09318500 1900-1970
09318500 1970-2015
Ephraim Tunnel Near Ephraim, Ut (09319000) 1960-10-01 to 2016-10-19
09319000 1900-2015
09319000 1900-1970
09319000 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

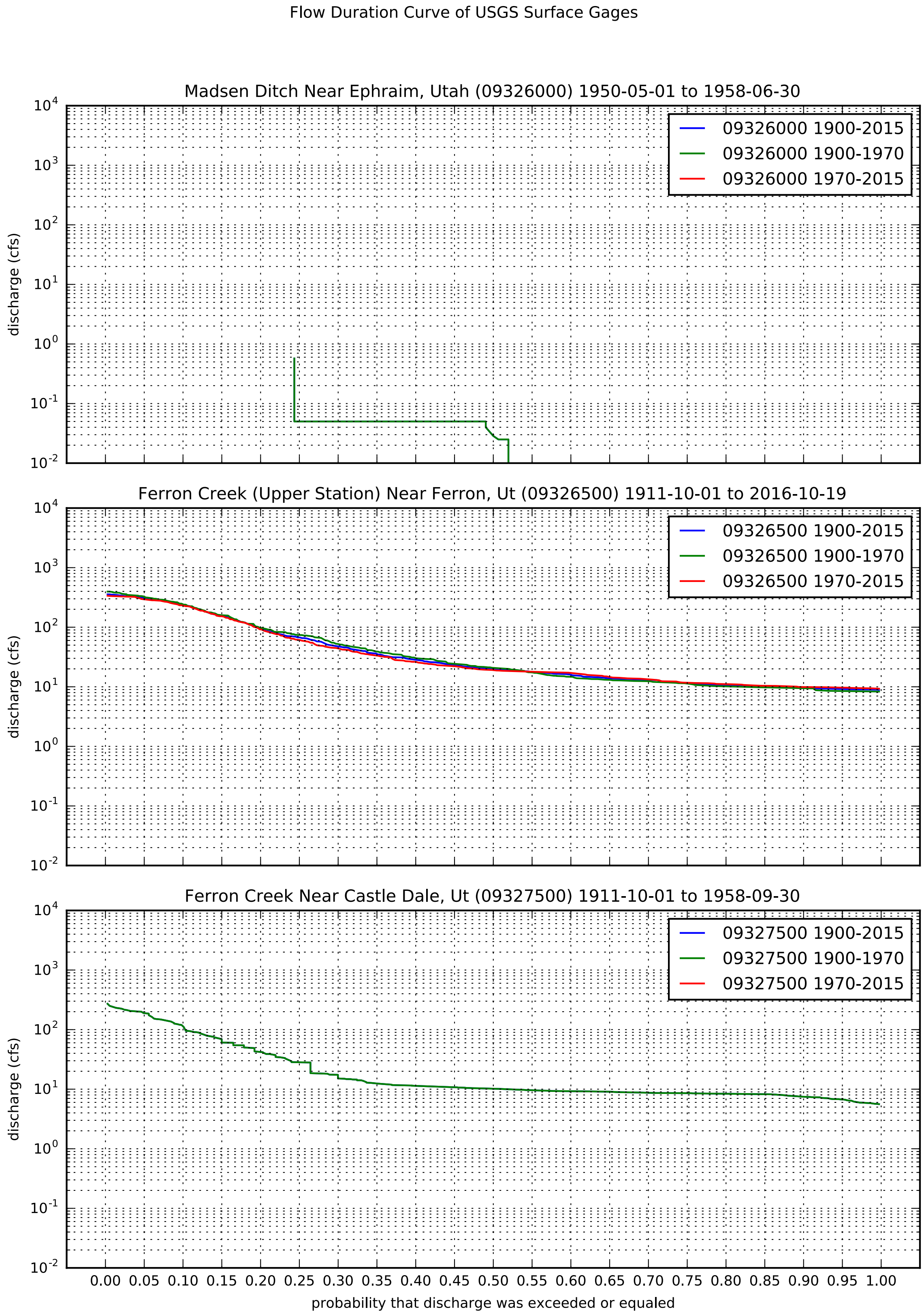

Flow Duration Curve of USGS Surface Gages
Ephraim Tunnel Supplemental Data (09319001) 1981-08-20 to 1983-10-13
09319001 1900-2015
09319001 1900-1970
09319001 1970-2015
Horseshoe Tunnel Near Ephraim, Utah (09320000) 1949-10-01 to 1958-09-30
09320000 1900-2015
09320000 1900-1970
09320000 1970-2015
Larsen Tunnel Near Ephraim, Utah (09320500) 1949-08-14 to 1958-09-30
09320500 1900-2015
09320500 1900-1970
09320500 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

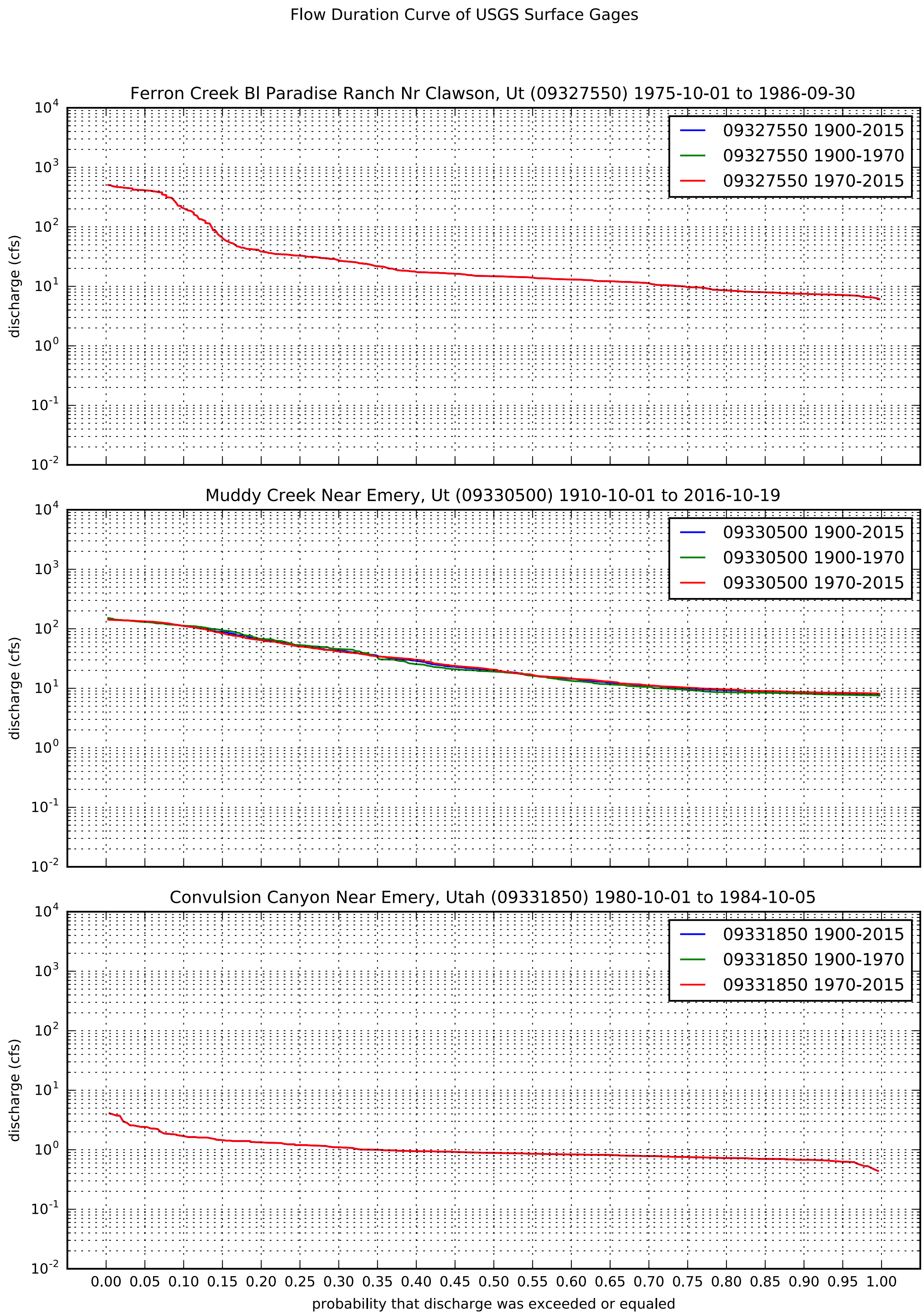

Flow Duration Curve of USGS Surface Gages
Coal Fork Ditch Near Mt Pleasant, Utah (09321000) 1949-08-17 to 1958-09-30
09321000 1900-2015
09321000 1900-1970
09321000 1970-2015
Twin Creek Tunnel Near Mt Pleasant, Utah (09321500) 1950-05-01 to 1958-09-30
09321500 1900-2015
09321500 1900-1970
09321500 1970-2015
Black Canyon Ditch Near Spring City, Utah (09322000) 1949-10-01 to 1958-09-30
09322000 1900-2015
09322000 1900-1970
09322000 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

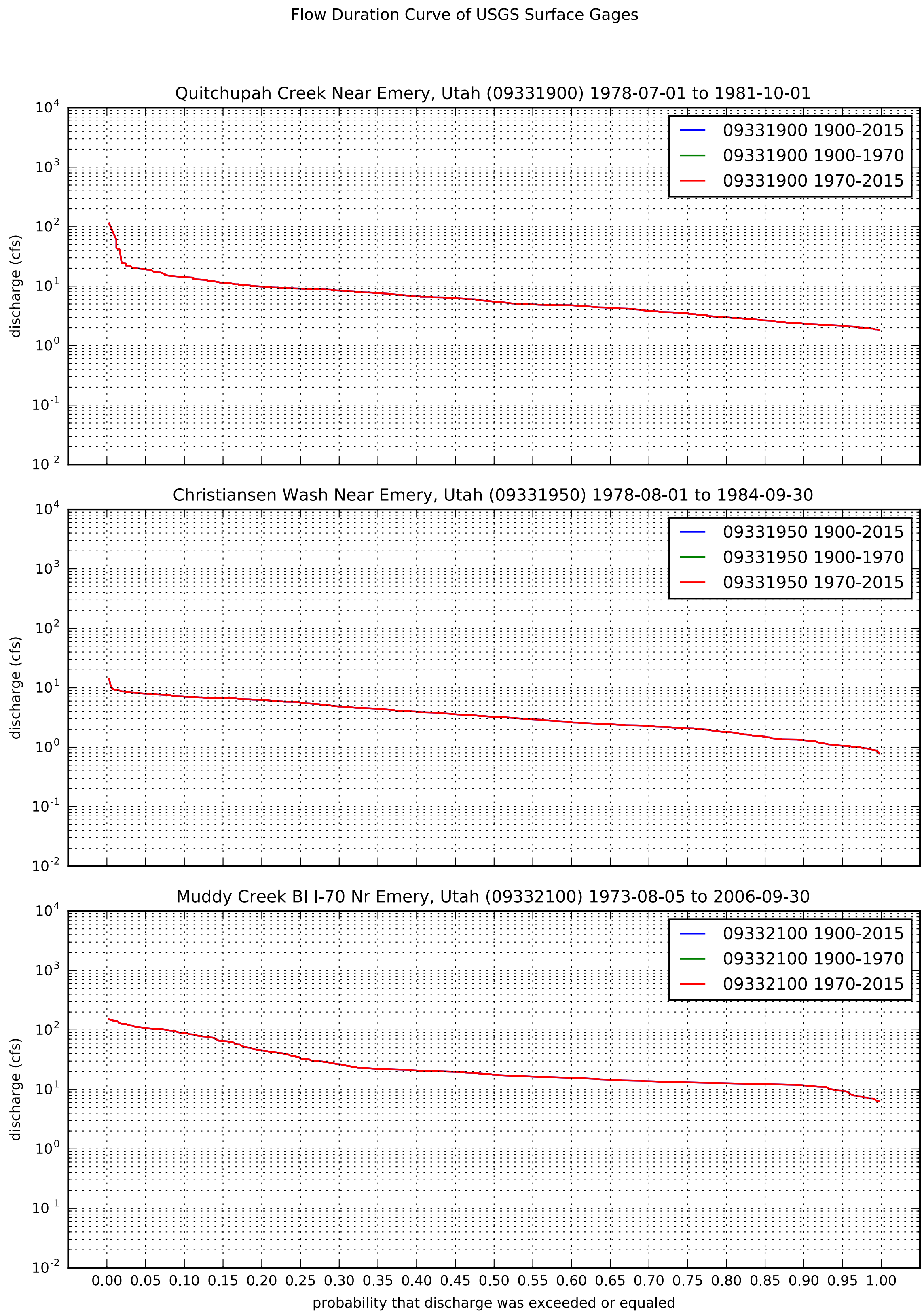

Flow Duration Curve of USGS Surface Gages
Cedar Creek Tunnel Near Spring City, Utah (09322500) 1949-09-13 to 1958-09-30
09322500 1900-2015
09322500 1900-1970
09322500 1970-2015
Spring City Tunnel Near Spring City, Ut (09323000) 1960-10-01 to 2003-09-30
09323000 1900-2015
09323000 1900-1970
09323000 1970-2015
Reeder Ditch Near Spring City, Utah (09323500) 1949-09-10 to 1958-09-30
09323500 1900-2015
09323500 1900-1970
09323500 1970-2015
discharge (cfs)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

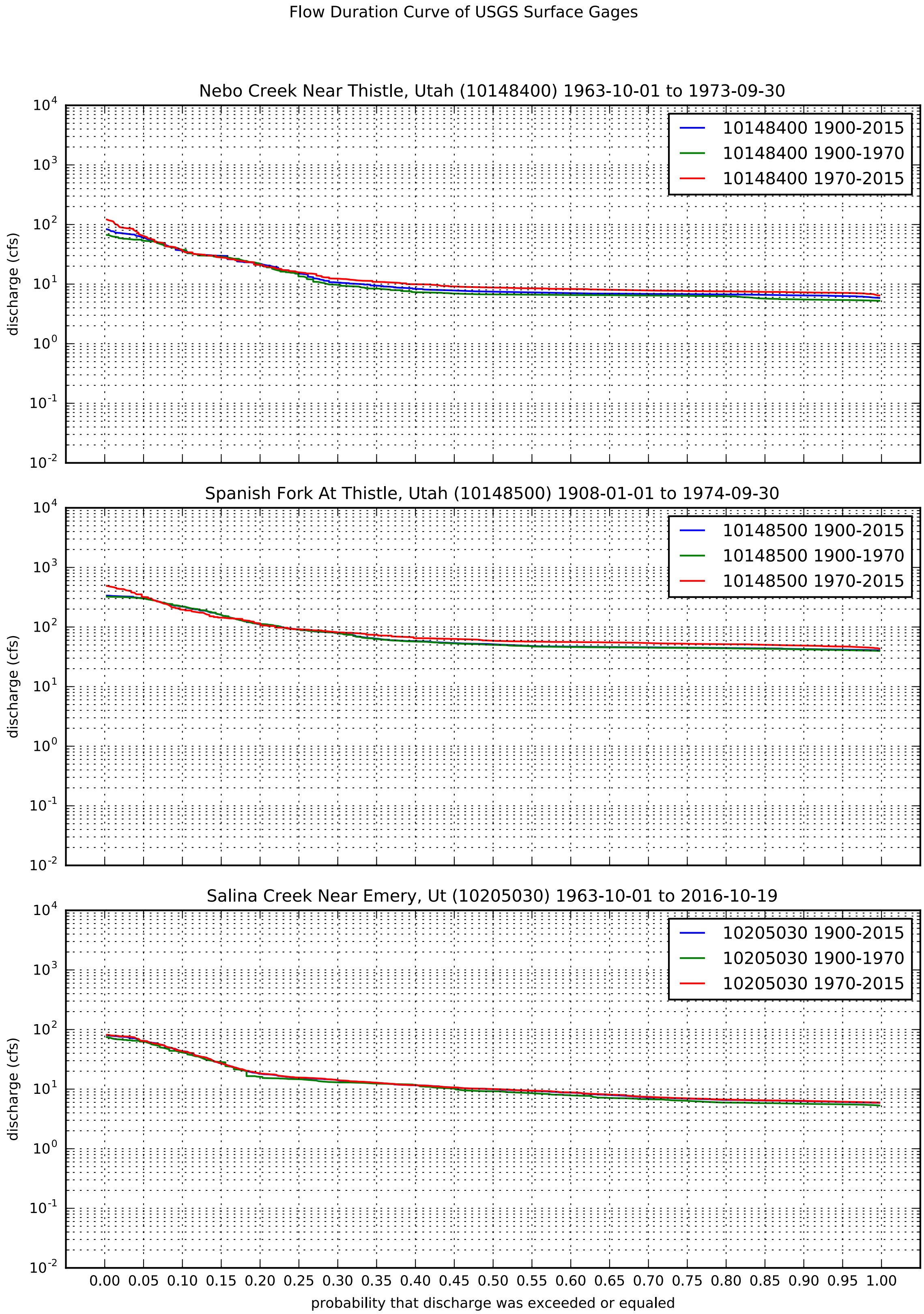

Flow Duration Curve of USGS Surface Gages
Seely Creek Near Orangeville, Utah (09324000) 1953-09-09 to 1957-09-30
09324000 1900-2015
09324000 1900-1970
09324000 1970-2015
discharge (cfs)
Ctnwd C Ab Straight Canyon Nr Orangeville, Ut (09324200) 1977-10-01 to 1981-10-07
09324200 1900-2015
09324200 1900-1970
09324200 1970-2015
discharge (cfs)
Cottonwood Creek Near Orangeville, Utah (09324500) 1909-05-01 to 1984-11-15
09324500 1900-2015
09324500 1900-1970
09324500 1970-2015
discharge (cfs)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

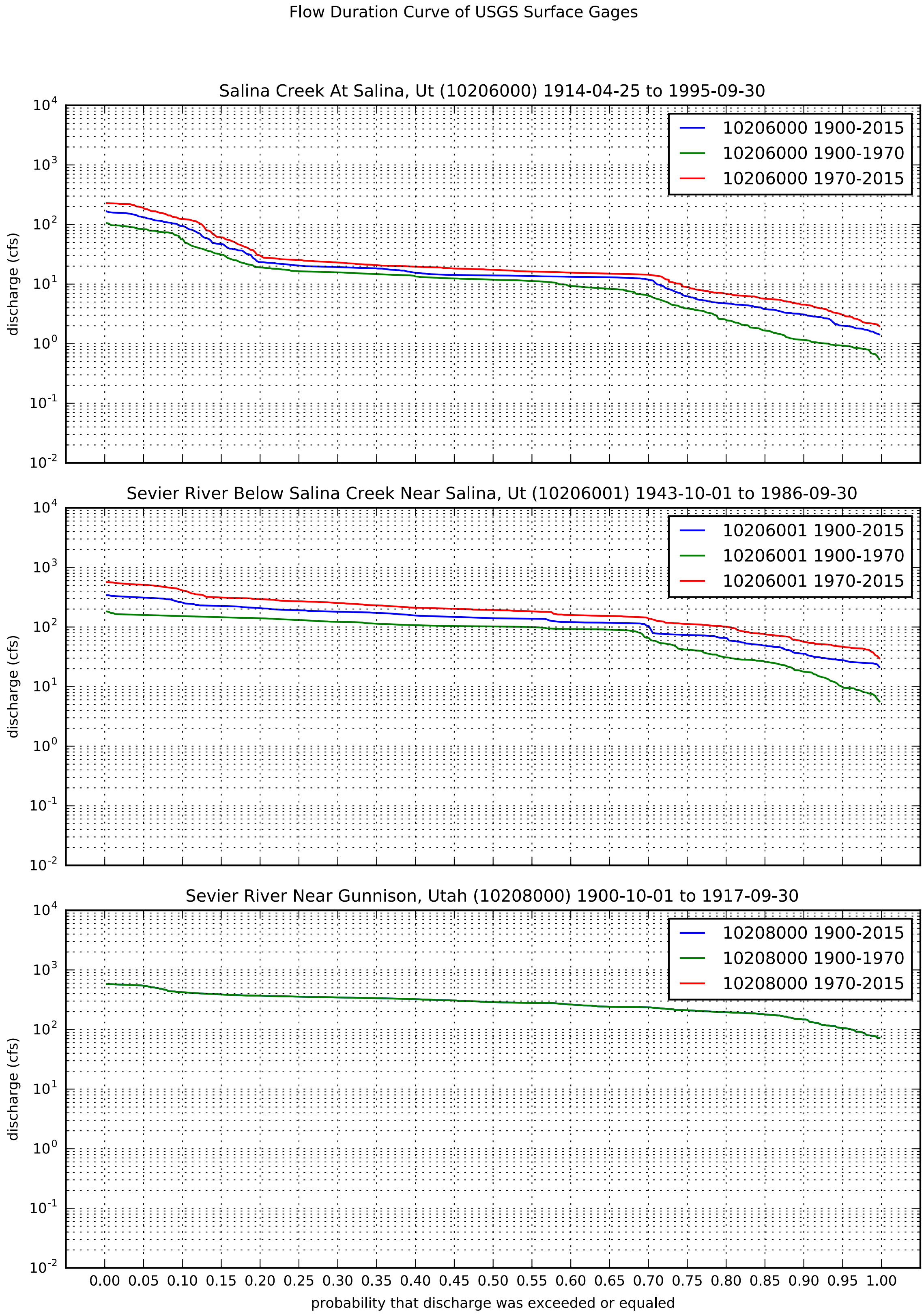

Flow Duration Curve of USGS Surface Gages
Cottonwood Creek Near Castle Dale, Utah (09325000) 1947-07-01 to 1958-09-30
09325000 1900-2015
09325000 1900-1970
09325000 1970-2015
San Rafael R Above Ferron Cr Nr Castle Dale, Ut (09325100) 1964-10-01 to 1970-10-13
09325100 1900-2015
09325100 1900-1970
09325100 1970-2015
John August Ditch Near Ephraim, Utah (09325500) 1949-08-29 to 1958-09-30
09325500 1900-2015
09325500 1900-1970
09325500 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00

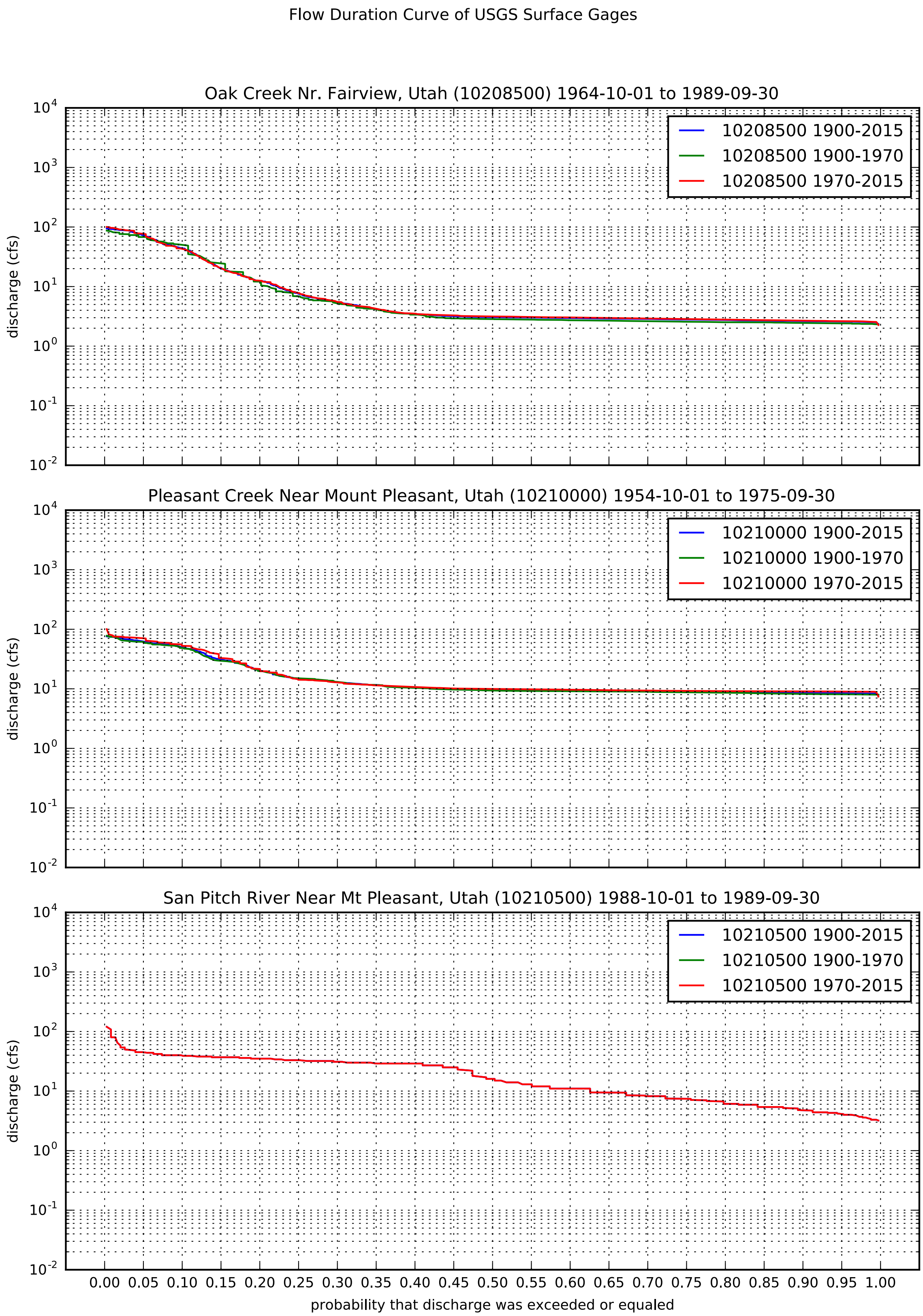

Flow Duration Curve of USGS Surface Gages
Madsen Ditch Near Ephraim, Utah (09326000) 1950-05-01 to 1958-06-30
09326000 1900-2015
09326000 1900-1970
09326000 1970-2015
Ferron Creek (Upper Station) Near Ferron, Ut (09326500) 1911-10-01 to 2016-10-19
09326500 1900-2015
09326500 1900-1970
09326500 1970-2015
Ferron Creek Near Castle Dale, Ut (09327500) 1911-10-01 to 1958-09-30
09327500 1900-2015
09327500 1900-1970
09327500 1970-2015
discharge (cfs)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

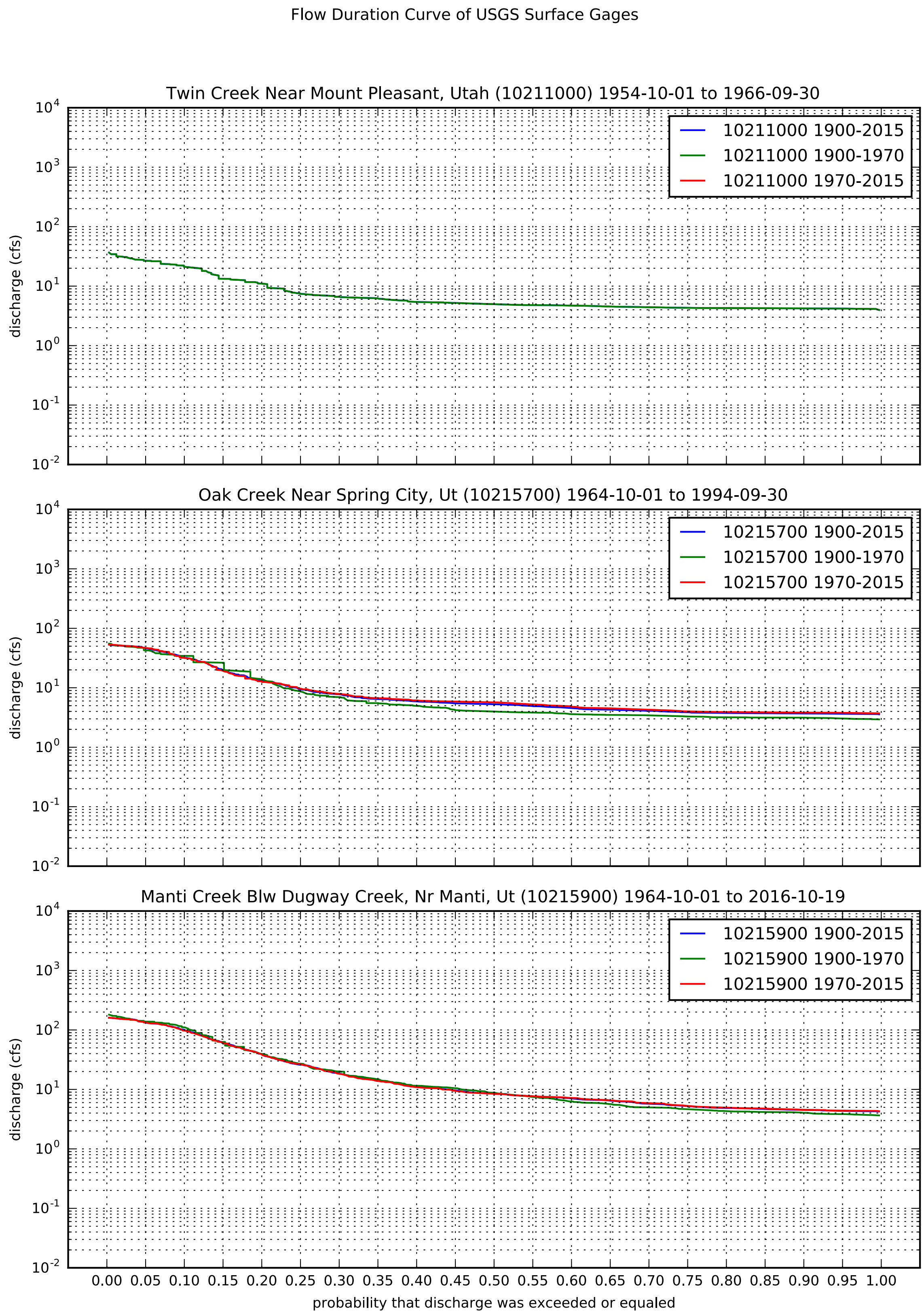

Flow Duration Curve of USGS Surface Gages
Ferron Creek Bl Paradise Ranch Nr Clawson, Ut (09327550) 1975-10-01 to 1986-09-30
09327550 1900-2015
09327550 1900-1970
09327550 1970-2015
discharge (cfs)
Muddy Creek Near Emery, Ut (09330500) 1910-10-01 to 2016-10-19
09330500 1900-2015
09330500 1900-1970
09330500 1970-2015
discharge (cfs)
Convulsion Canyon Near Emery, Utah (09331850) 1980-10-01 to 1984-10-05
09331850 1900-2015
09331850 1900-1970
09331850 1970-2015
discharge (cfs)
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00
probability that discharge was exceeded or equaled

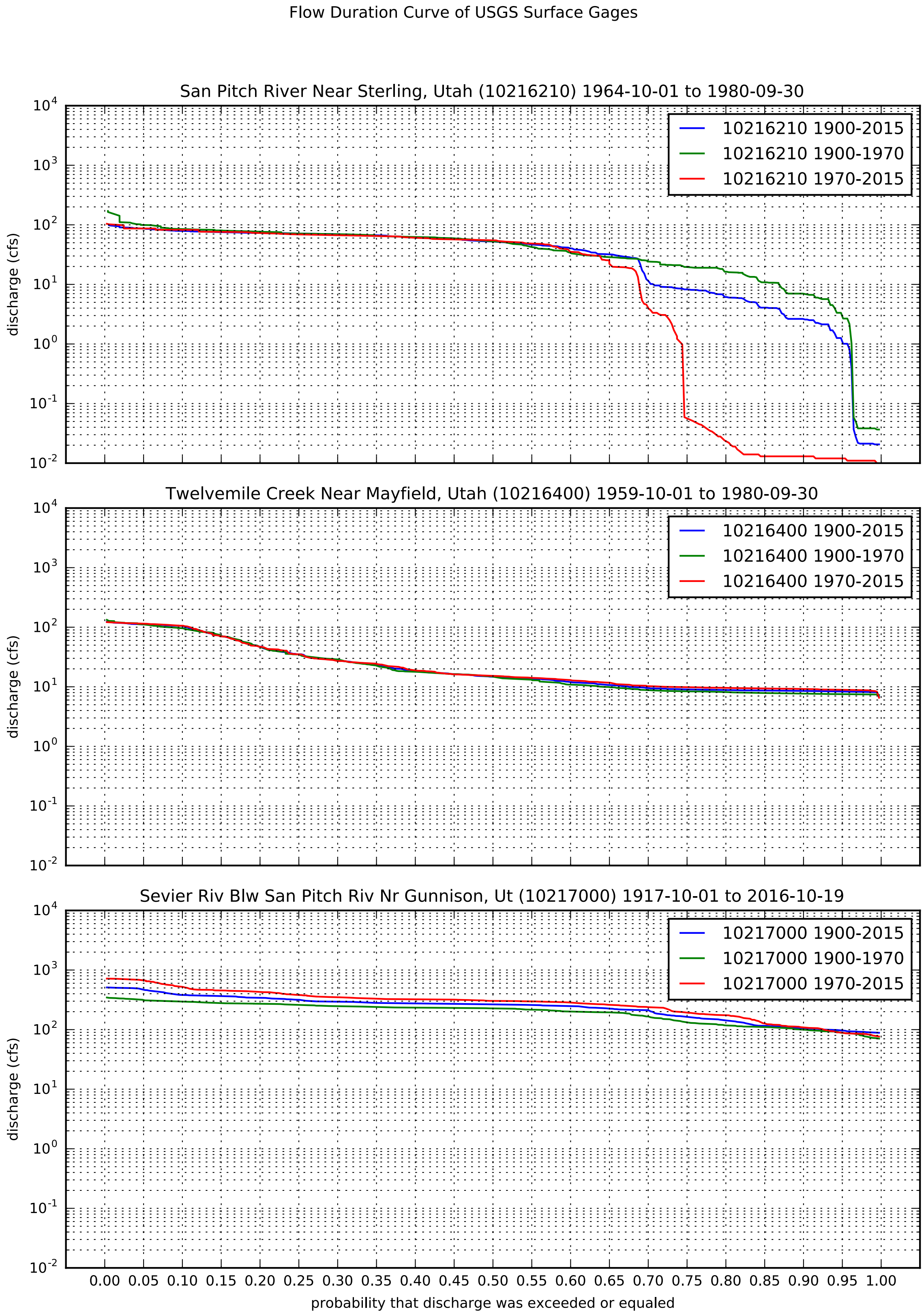

Flow Duration Curve of USGS Surface Gages
Quitchupah Creek Near Emery, Utah (09331900) 1978-07-01 to 1981-10-01
09331900 1900-2015
09331900 1900-1970
09331900 1970-2015
Christiansen Wash Near Emery, Utah (09331950) 1978-08-01 to 1984-09-30
09331950 1900-2015
09331950 1900-1970
09331950 1970-2015
Muddy Creek Bl I-70 Nr Emery, Utah (09332100) 1973-08-05 to 2006-09-30
09332100 1900-2015
09332100 1900-1970
09332100 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

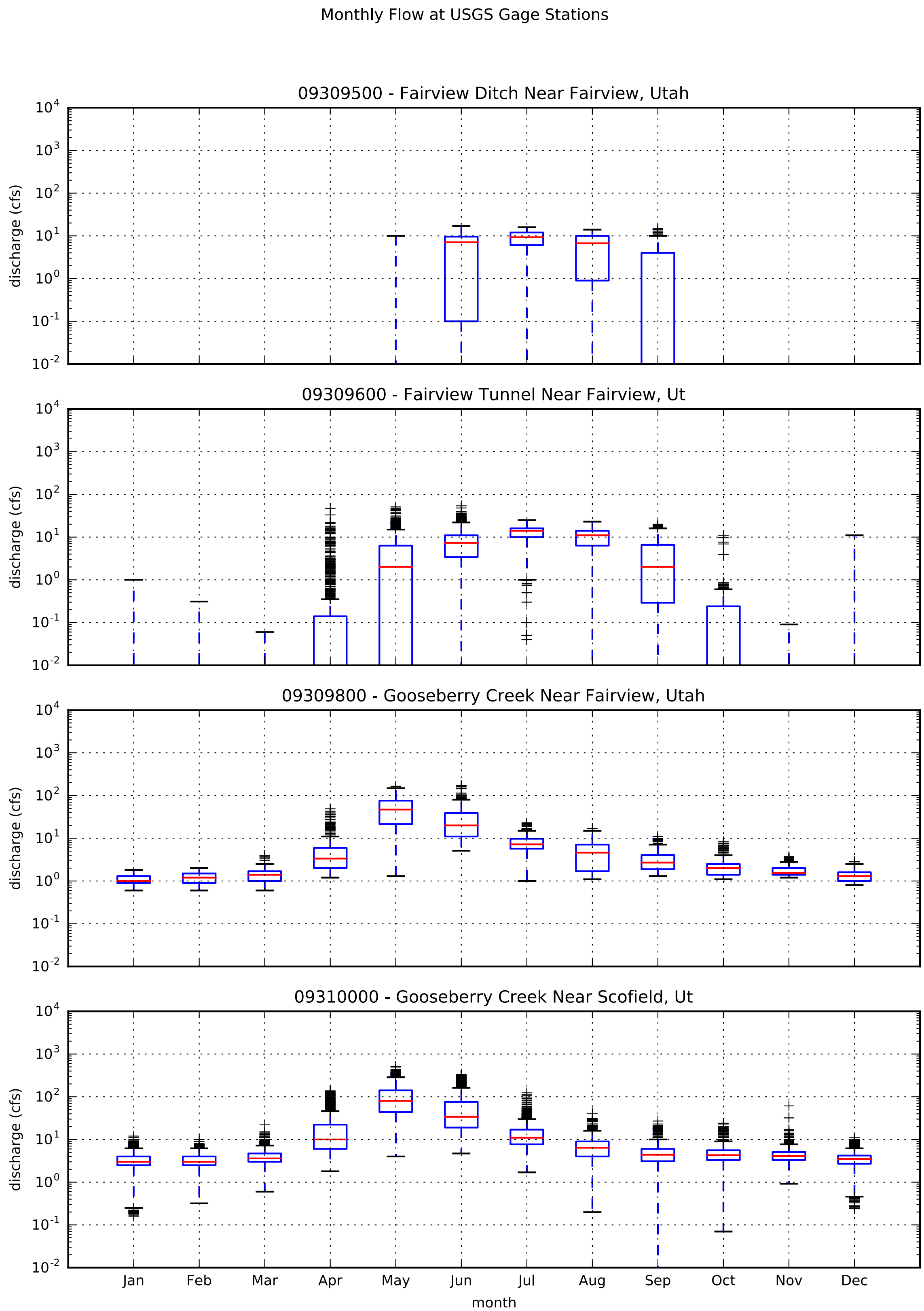

Flow Duration Curve of USGS Surface Gages
Nebo Creek Near Thistle, Utah (10148400) 1963-10-01 to 1973-09-30
10148400 1900-2015
10148400 1900-1970
10148400 1970-2015
Spanish Fork At Thistle, Utah (10148500) 1908-01-01 to 1974-09-30
10148500 1900-2015
10148500 1900-1970
10148500 1970-2015
Salina Creek Near Emery, Ut (10205030) 1963-10-01 to 2016-10-19
10205030 1900-2015
10205030 1900-1970
10205030 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

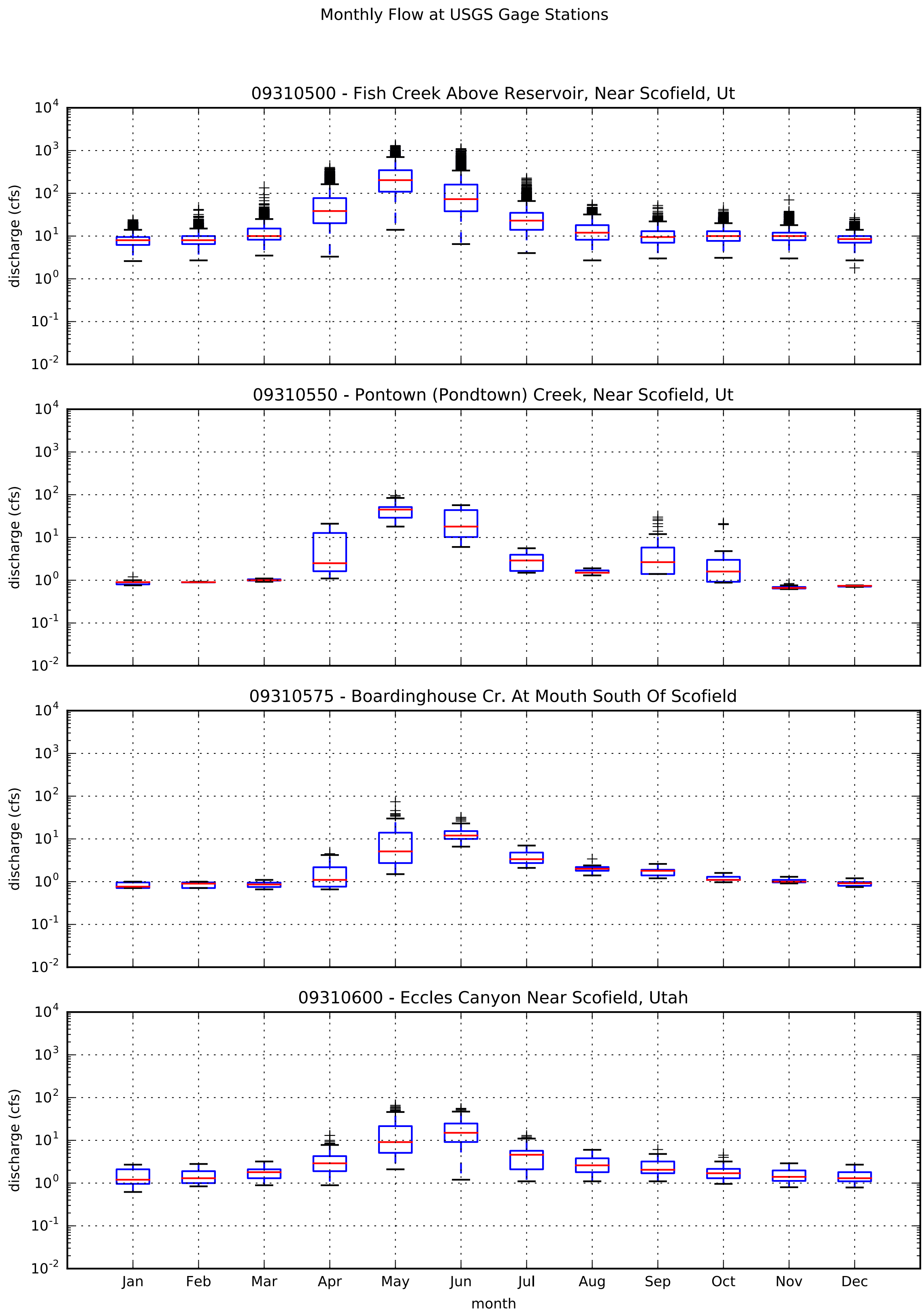

Flow Duration Curve of USGS Surface Gages
Salina Creek At Salina, Ut (10206000) 1914-04-25 to 1995-09-30
10206000 1900-2015
10206000 1900-1970
10206000 1970-2015
Sevier River Below Salina Creek Near Salina, Ut (10206001) 1943-10-01 to 1986-09-30
10206001 1900-2015
10206001 1900-1970
10206001 1970-2015
Sevier River Near Gunnison, Utah (10208000) 1900-10-01 to 1917-09-30
10208000 1900-2015
10208000 1900-1970
10208000 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

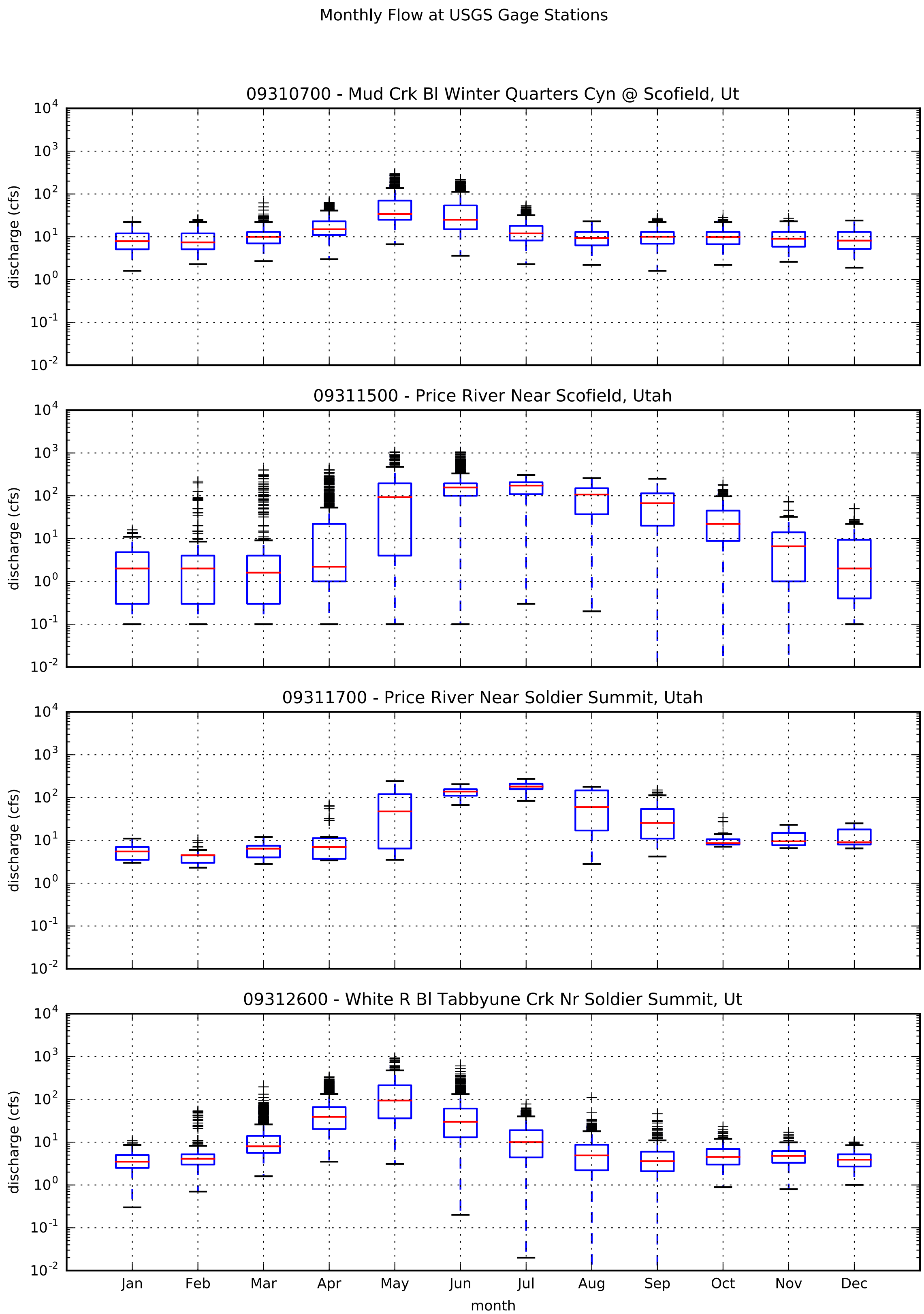

Flow Duration Curve of USGS Surface Gages
Oak Creek Nr. Fairview, Utah (10208500) 1964-10-01 to 1989-09-30
10208500 1900-2015
10208500 1900-1970
10208500 1970-2015
Pleasant Creek Near Mount Pleasant, Utah (10210000) 1954-10-01 to 1975-09-30
10210000 1900-2015
10210000 1900-1970
10210000 1970-2015
San Pitch River Near Mt Pleasant, Utah (10210500) 1988-10-01 to 1989-09-30
10210500 1900-2015
10210500 1900-1970
10210500 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70 0.75 0.80 0.85 0.90 0.95 1.00

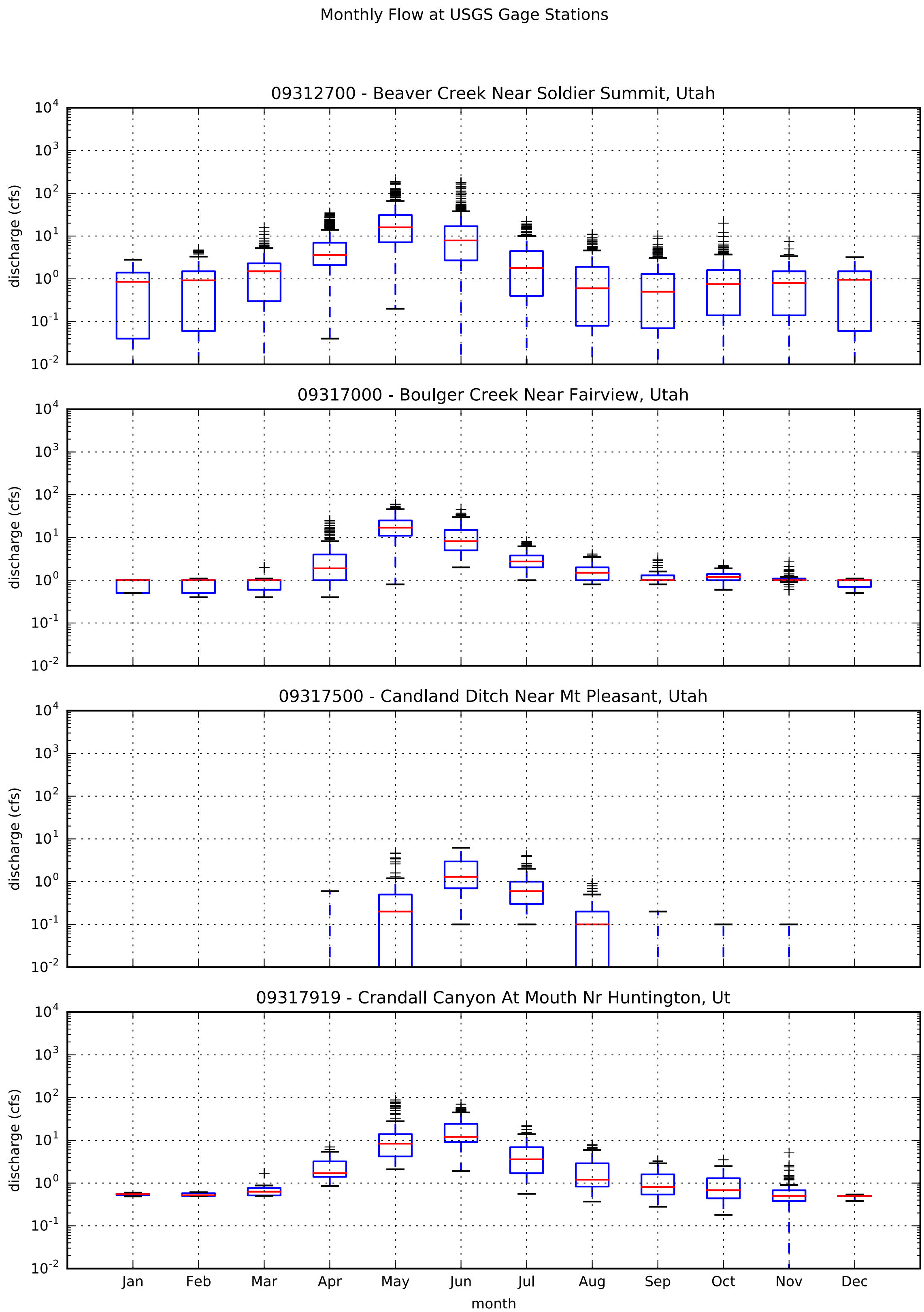

Flow Duration Curve of USGS Surface Gages
Twin Creek Near Mount Pleasant, Utah (10211000) 1954-10-01 to 1966-09-30
10211000 1900-2015
10211000 1900-1970
10211000 1970-2015
Oak Creek Near Spring City, Ut (10215700) 1964-10-01 to 1994-09-30
10215700 1900-2015
10215700 1900-1970
10215700 1970-2015
Manti Creek Blw Dugway Creek, Nr Manti, Ut (10215900) 1964-10-01 to 2016-10-19
10215900 1900-2015
10215900 1900-1970
10215900 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

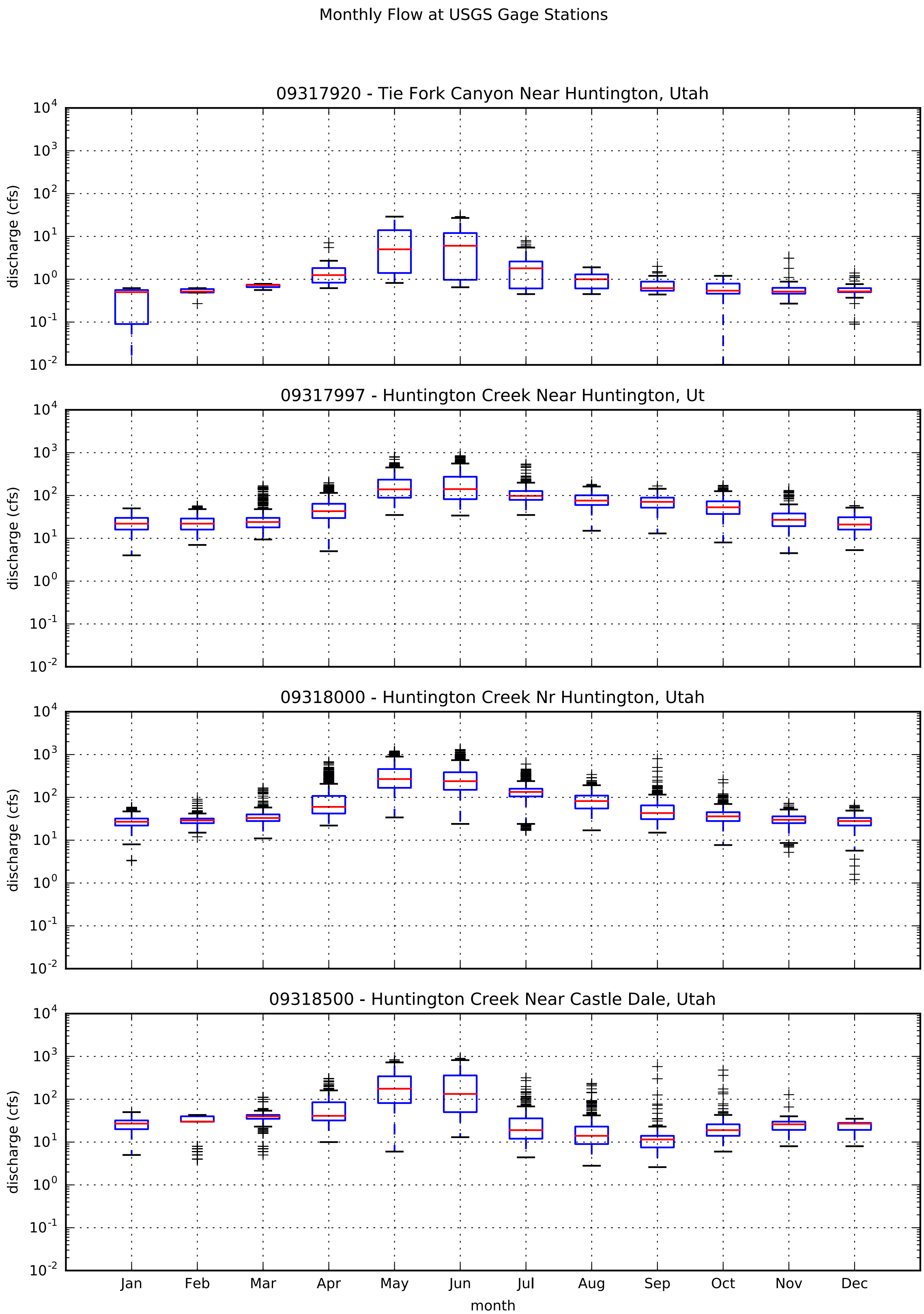

Flow Duration Curve of USGS Surface Gages
San Pitch River Near Sterling, Utah (10216210) 1964-10-01 to 1980-09-30
10216210 1900-2015
10216210 1900-1970
10216210 1970-2015
Twelvemile Creek Near Mayfield, Utah (10216400) 1959-10-01 to 1980-09-30
10216400 1900-2015
10216400 1900-1970
10216400 1970-2015
Sevier Riv Blw San Pitch Riv Nr Gunnison, Ut (10217000) 1917-10-01 to 2016-10-19
10217000 1900-2015
10217000 1900-1970
10217000 1970-2015
discharge (cfs)
probability that discharge was exceeded or equaled

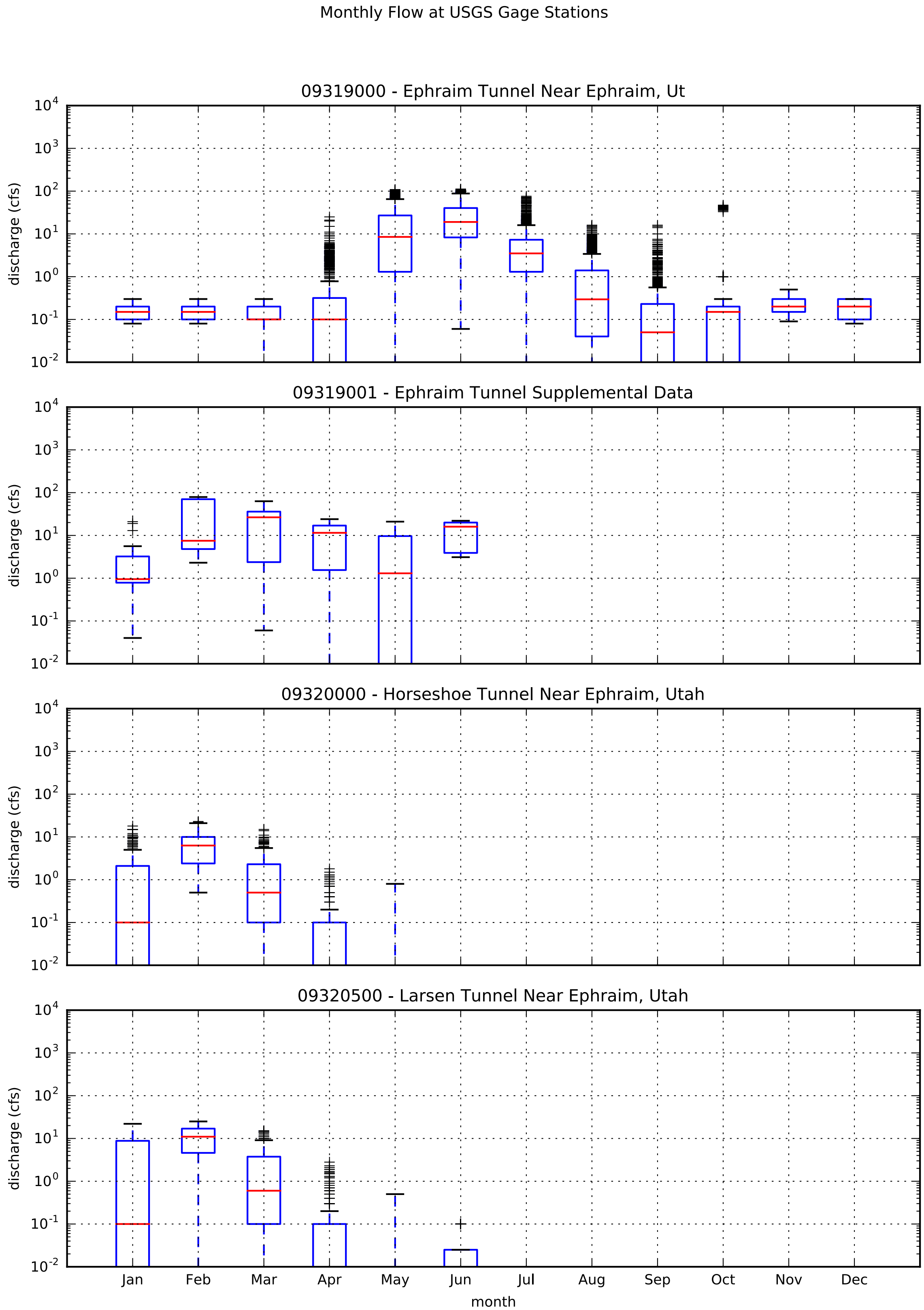

Monthly Flow at USGS Gage Stations
09309500 - Fairview Ditch Near Fairview, Utah
09309600 - Fairview Tunnel Near Fairview, Ut
09309800 - Gooseberry Creek Near Fairview, Utah
09310000 - Gooseberry Creek Near Scofield, Ut
discharge (cfs)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

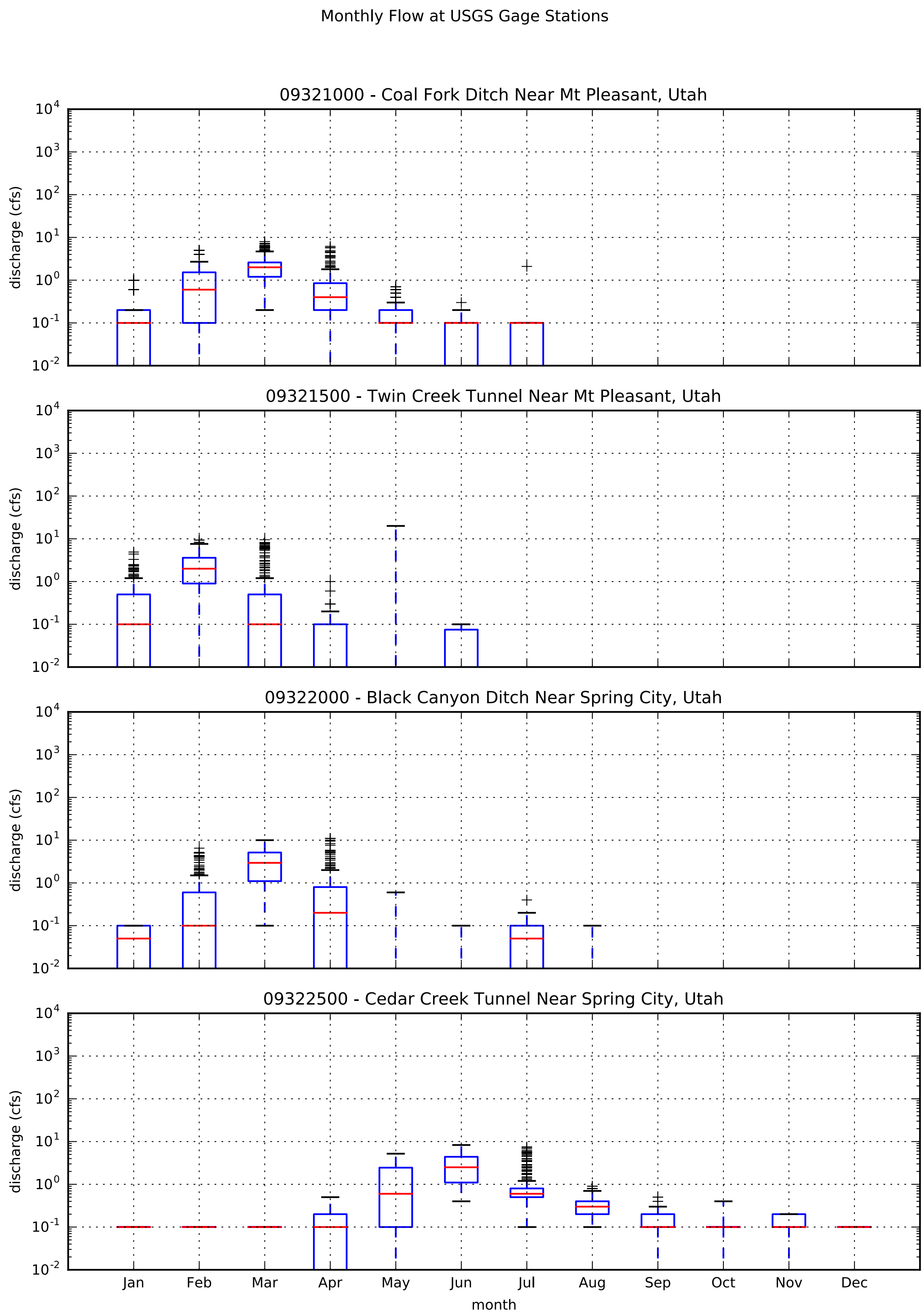

Monthly Flow at USGS Gage Stations
09310500 - Fish Creek Above Reservoir, Near Scofield, Ut
09310550 - Pontown (Pondtown) Creek, Near Scofield, Ut
09310575 - Boardinghouse Cr. At Mouth South Of Scofield
09310600 - Eccles Canyon Near Scofield, Utah
discharge (cfs)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
month


Monthly Flow at USGS Gage Stations
09310700 - Mud Crk Bl Winter Quarters Cyn @ Scofield, Ut
09311500 - Price River Near Scofield, Utah
09311700 - Price River Near Soldier Summit, Utah
09312600 - White R Bl Tabbyune Crk Nr Soldier Summit, Ut
discharge (cfs)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

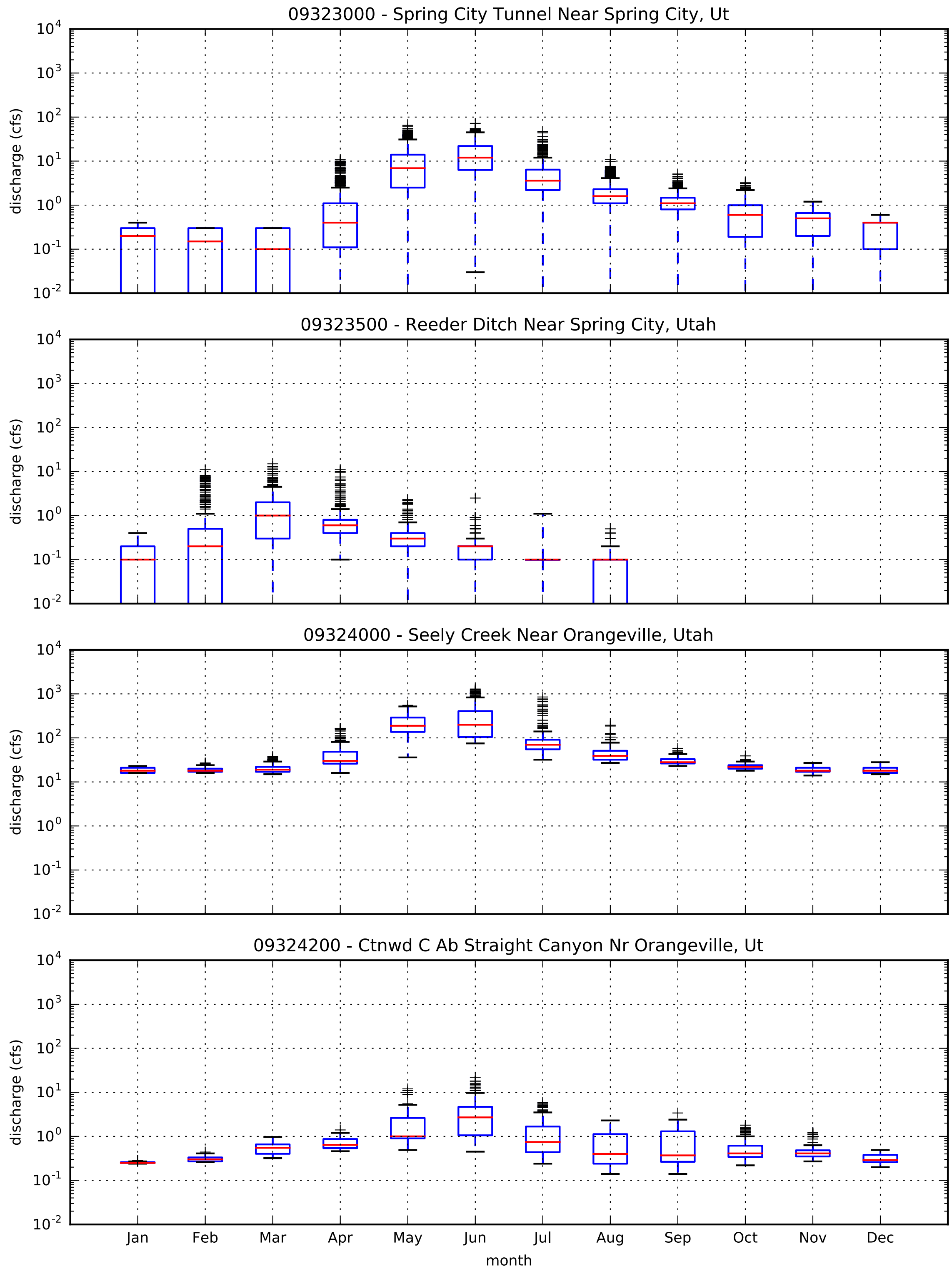

Monthly Flow at USGS Gage Stations
09312700 - Beaver Creek Near Soldier Summit, Utah
09317000 - Boulger Creek Near Fairview, Utah
09317500 - Candland Ditch Near Mt Pleasant, Utah
09317919 - Crandall Canyon At Mouth Nr Huntington, Ut
discharge (cfs)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

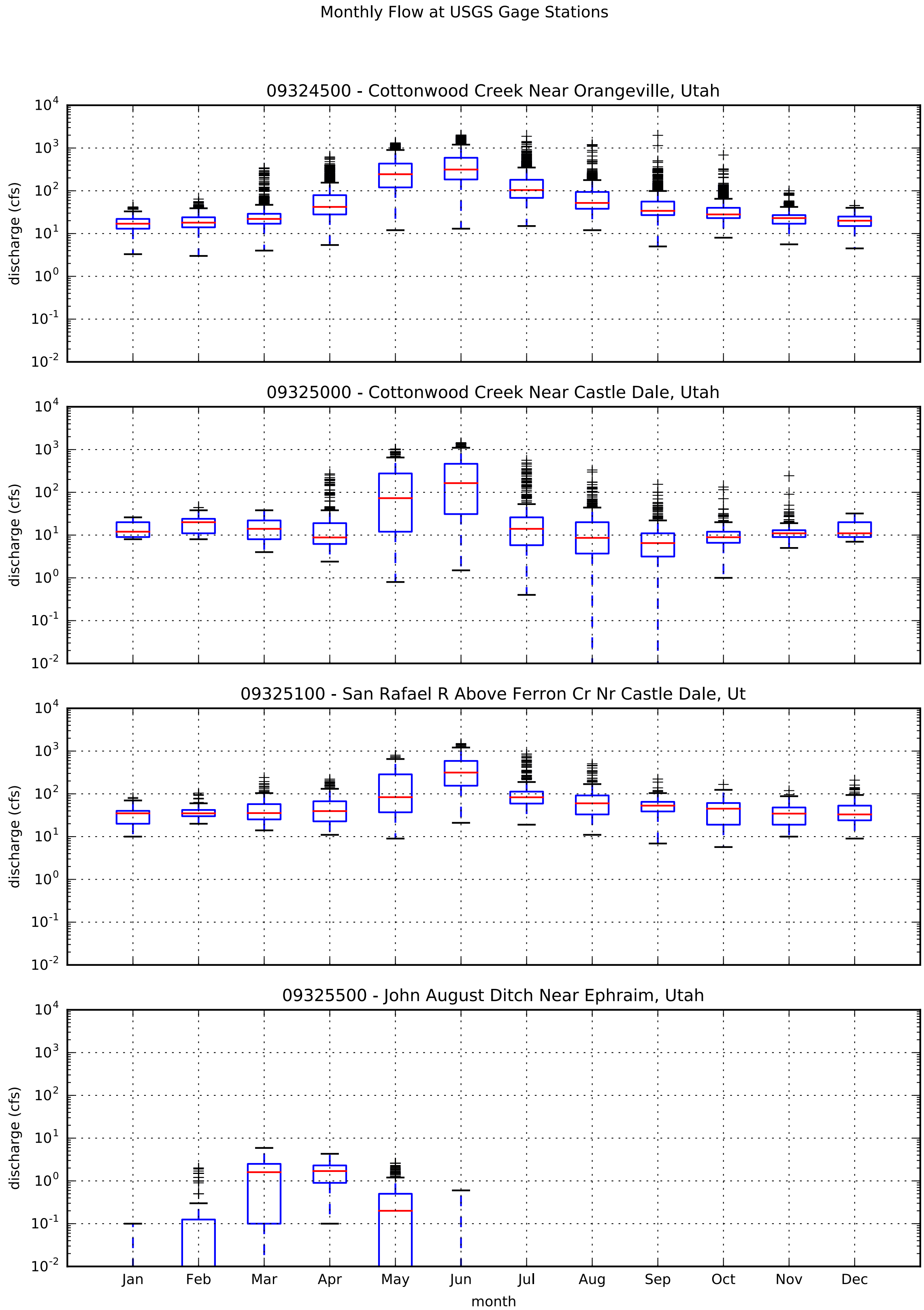

Monthly Flow at USGS Gage Stations
09317920 - Tie Fork Canyon Near Huntington, Utah
09317997 - Huntington Creek Near Huntington, Ut
09318000 - Huntington Creek Nr Huntington, Utah
09318500 - Huntington Creek Near Castle Dale, Utah
discharge (cfs)
month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

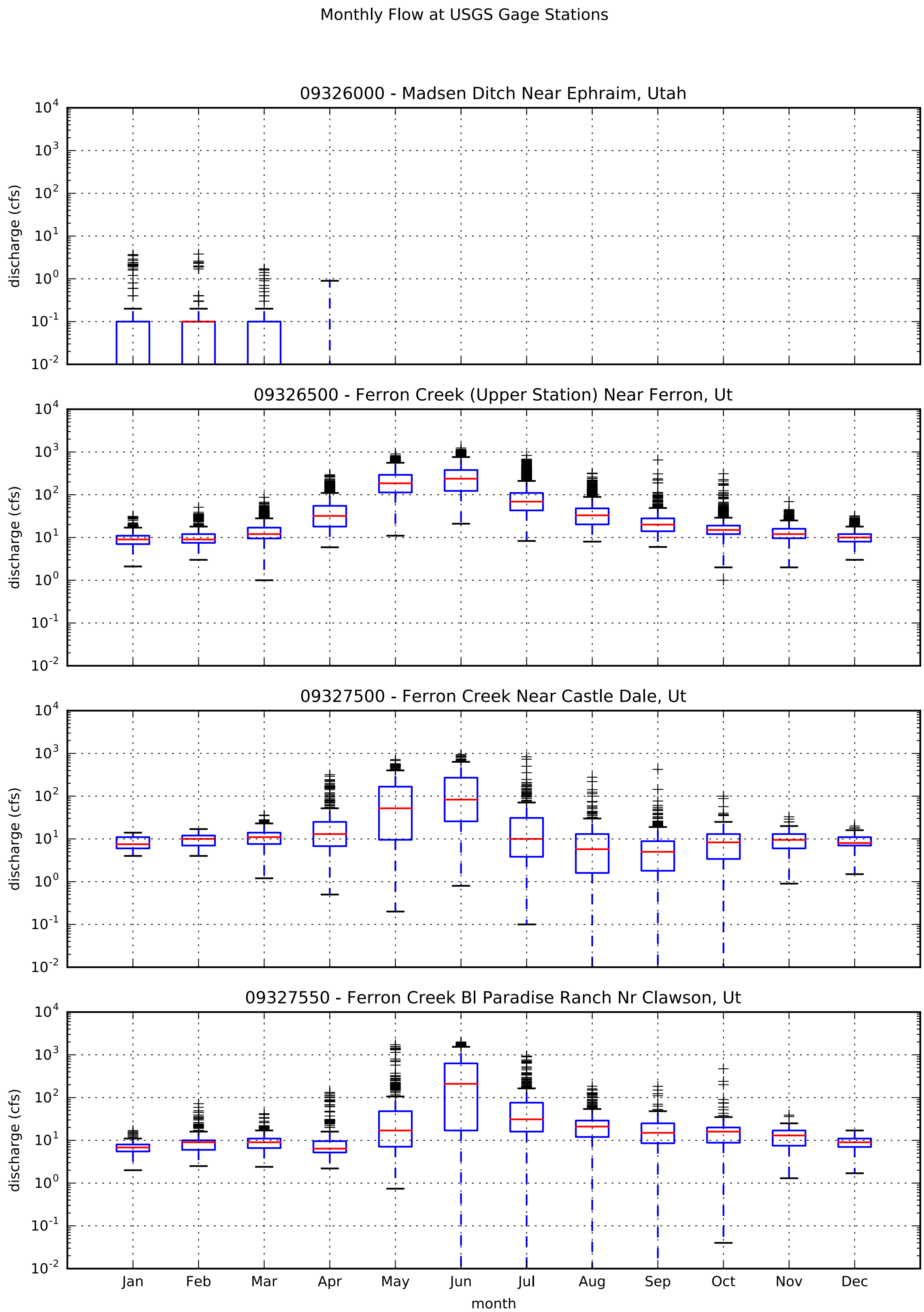

Monthly Flow at USGS Gage Stations
09319000 - Ephraim Tunnel Near Ephraim, Ut
09319001 - Ephraim Tunnel Supplemental Data
09320000 - Horseshoe Tunnel Near Ephraim, Utah
09320500 - Larsen Tunnel Near Ephraim, Utah
discharge (cfs)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

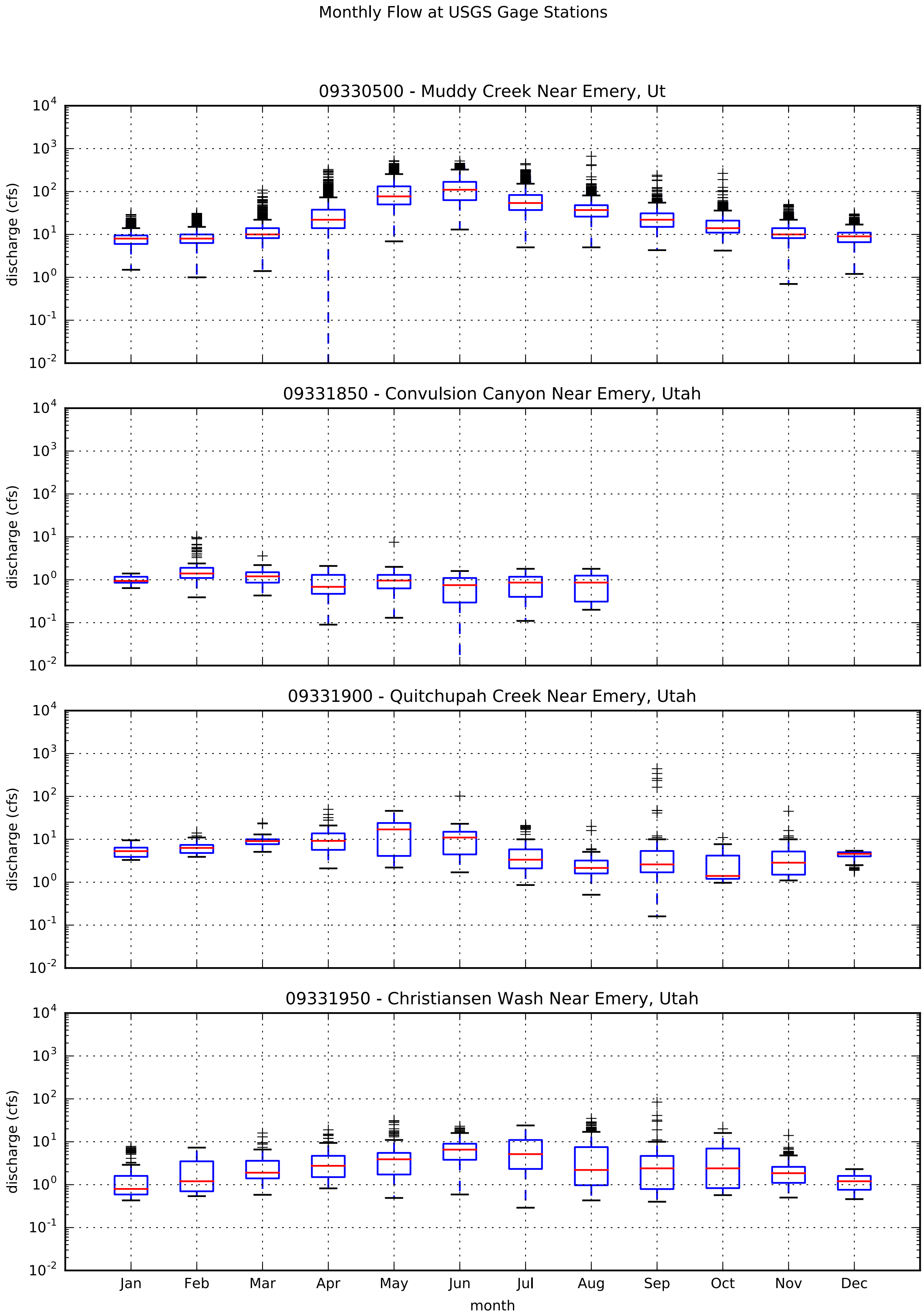

Monthly Flow at USGS Gage Stations
09321000 - Coal Fork Ditch Near Mt Pleasant, Utah
09321500 - Twin Creek Tunnel Near Mt Pleasant, Utah
09322000 - Black Canyon Ditch Near Spring City, Utah
09322500 - Cedar Creek Tunnel Near Spring City, Utah
discharge (cfs)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
month

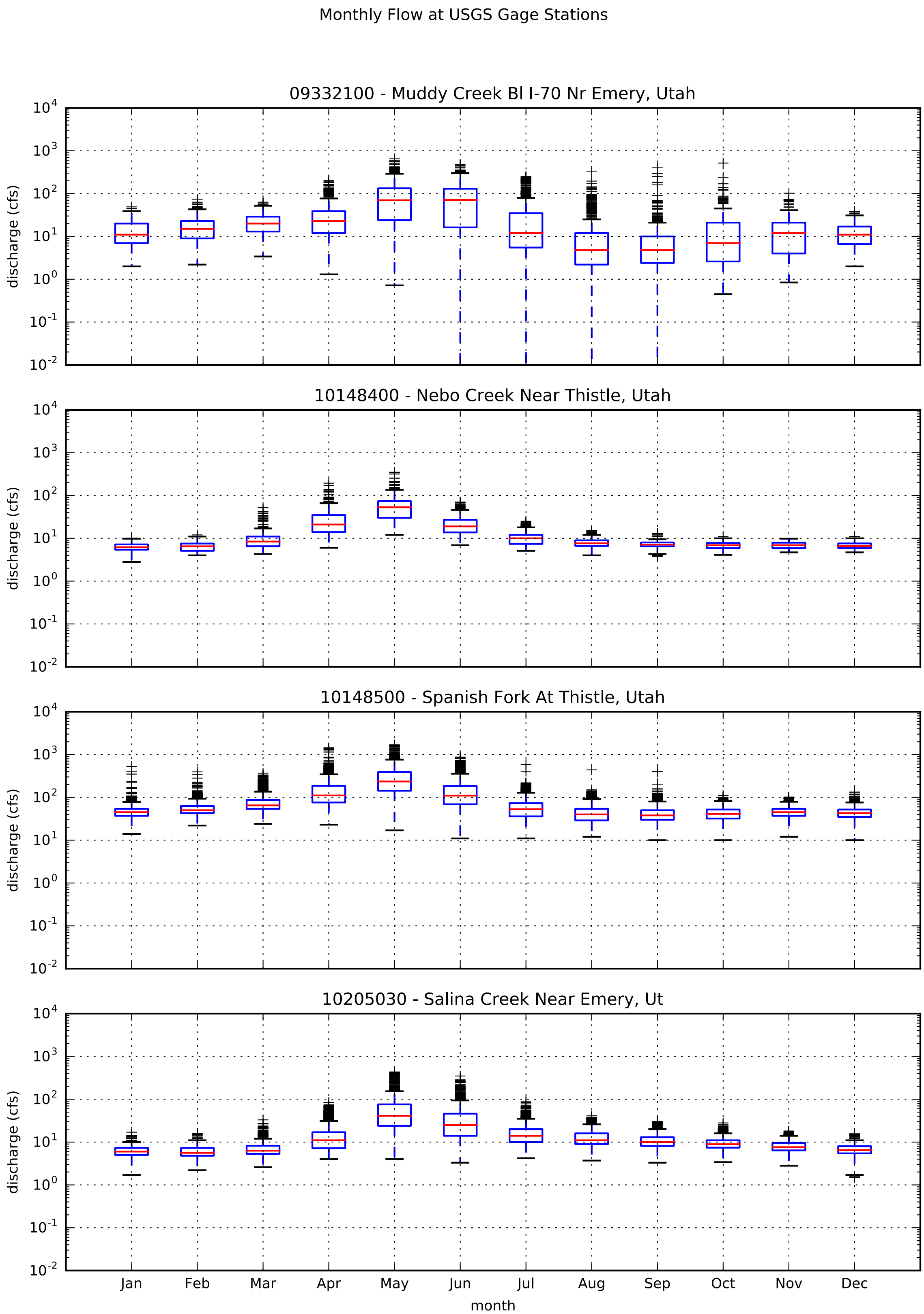
Monthly Flow at USGS Gage Stations

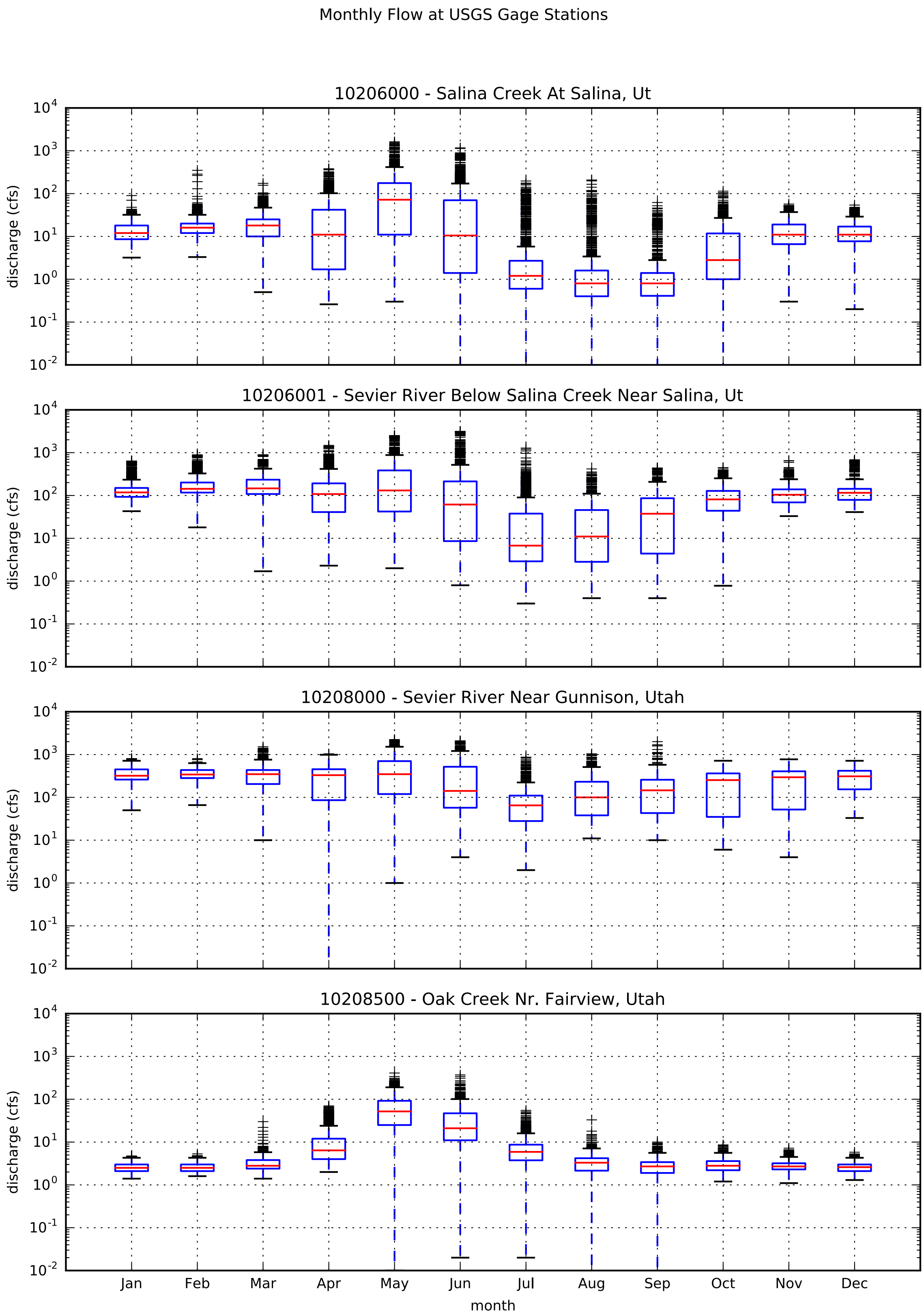



Monthly Flow at USGS Gage Stations
09324500 - Cottonwood Creek Near Orangeville, Utah
09325000 - Cottonwood Creek Near Castle Dale, Utah
09325100 - San Rafael R Above Ferron Cr Nr Castle Dale, Ut
09325500 - John August Ditch Near Ephraim, Utah
discharge (cfs)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

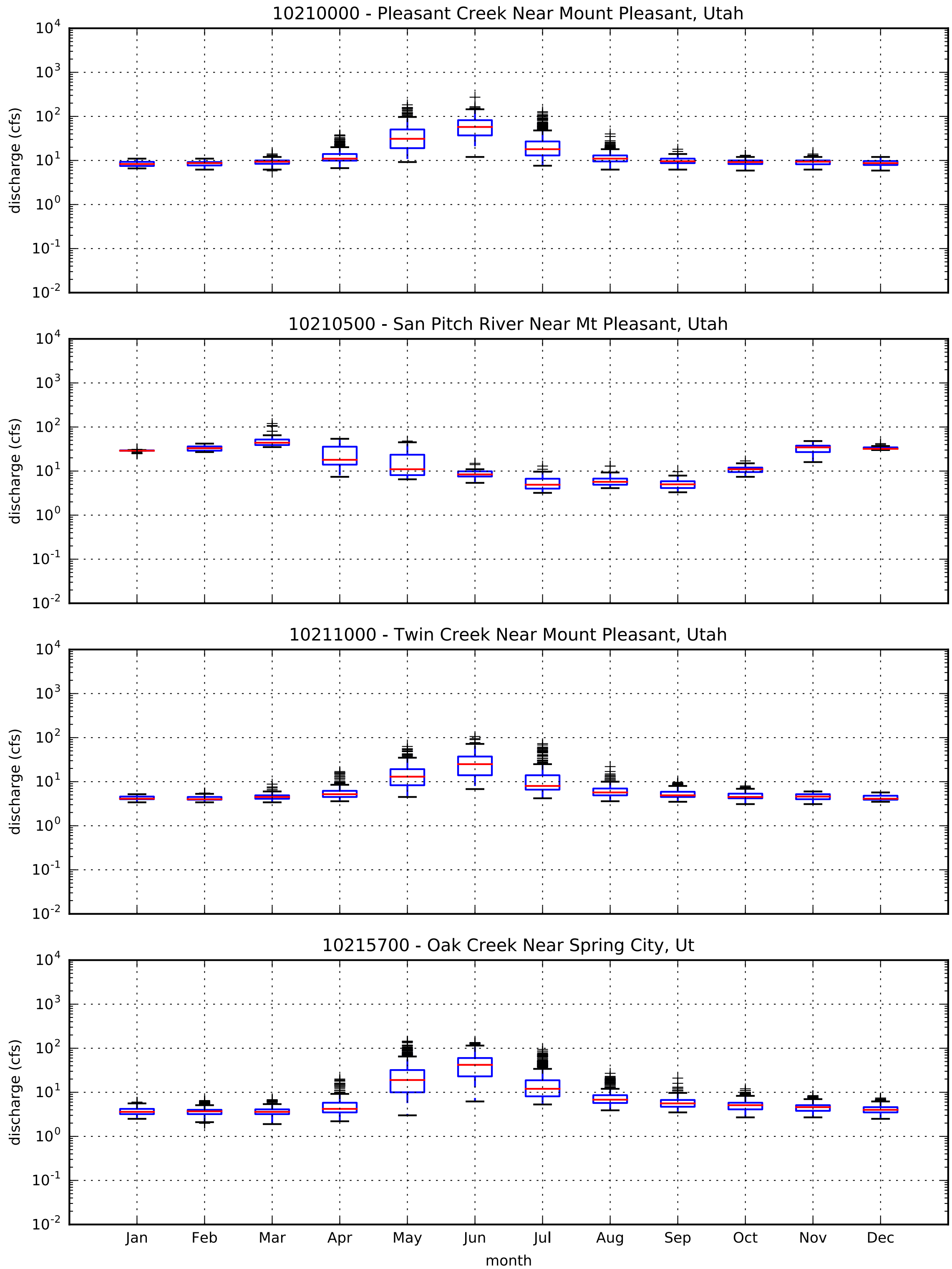

Monthly Flow at USGS Gage Stations
09326000 - Madsen Ditch Near Ephraim, Utah
09326500 - Ferron Creek (Upper Station) Near Ferron, Ut
09327500 - Ferron Creek Near Castle Dale, Ut
09327550 - Ferron Creek Bl Paradise Ranch Nr Clawson, Ut
discharge (cfs)
10^-2
10^-1
10^0
10^1
10^2
10^3
10^4
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

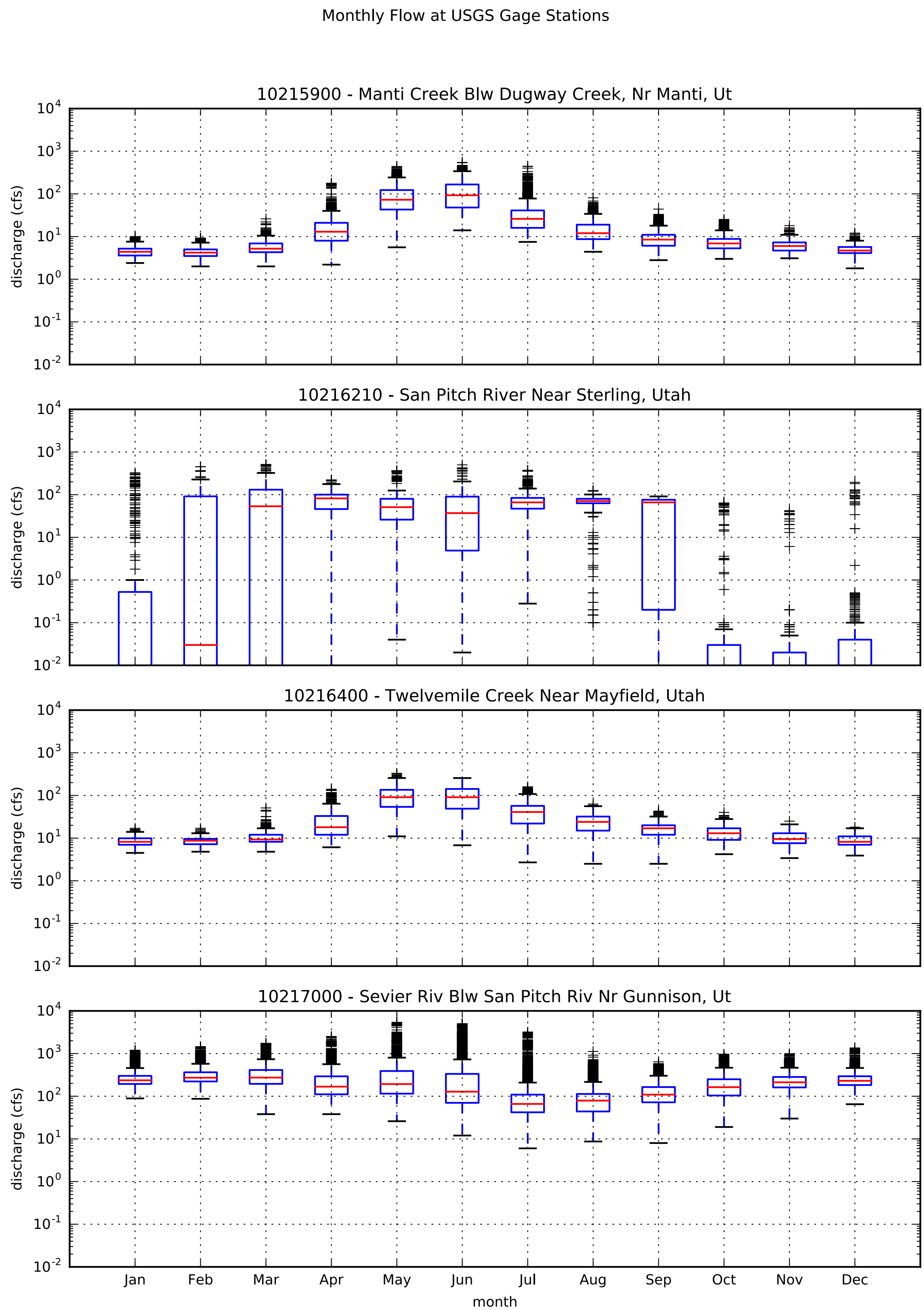

Monthly Flow at USGS Gage Stations
09330500 - Muddy Creek Near Emery, Ut
09331850 - Convulsion Canyon Near Emery, Utah
09331900 - Quitchupah Creek Near Emery, Utah
09331950 - Christiansen Wash Near Emery, Utah
discharge (cfs)
month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Monthly Flow at USGS Gage Stations
09332100 - Muddy Creek Bl I-70 Nr Emery, Utah
10148400 - Nebo Creek Near Thistle, Utah
10148500 - Spanish Fork At Thistle, Utah
10205030 - Salina Creek Near Emery, Ut
discharge (cfs)
10^4
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
month

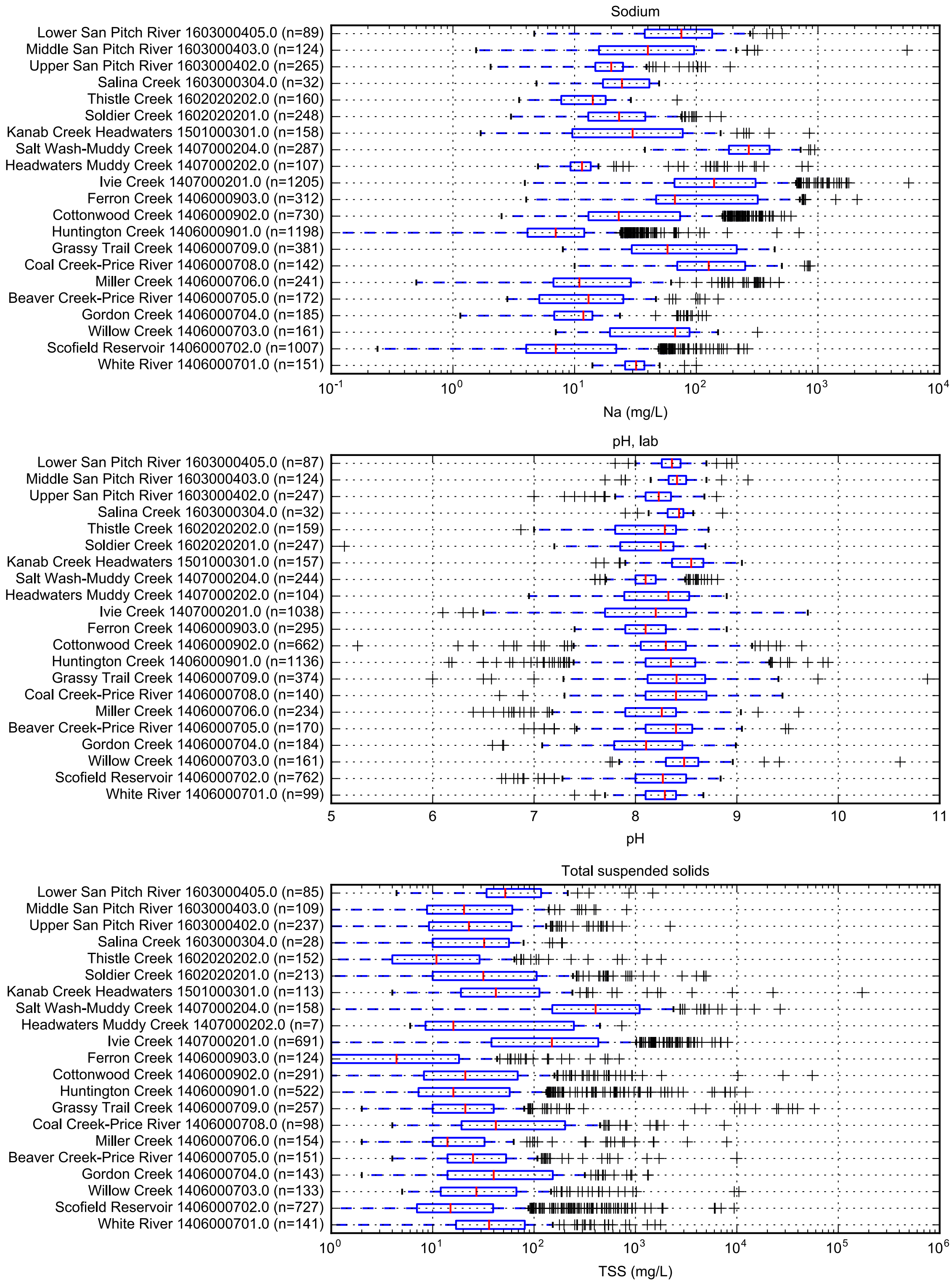

Monthly Flow at USGS Gage Stations
10206000 - Salina Creek At Salina, Ut
10206001 - Sevier River Below Salina Creek Near Salina, Ut
10208000 - Sevier River Near Gunnison, Utah
10208500 - Oak Creek Nr. Fairview, Utah
discharge (cfs)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
month

Monthly Flow at USGS Gage Stations

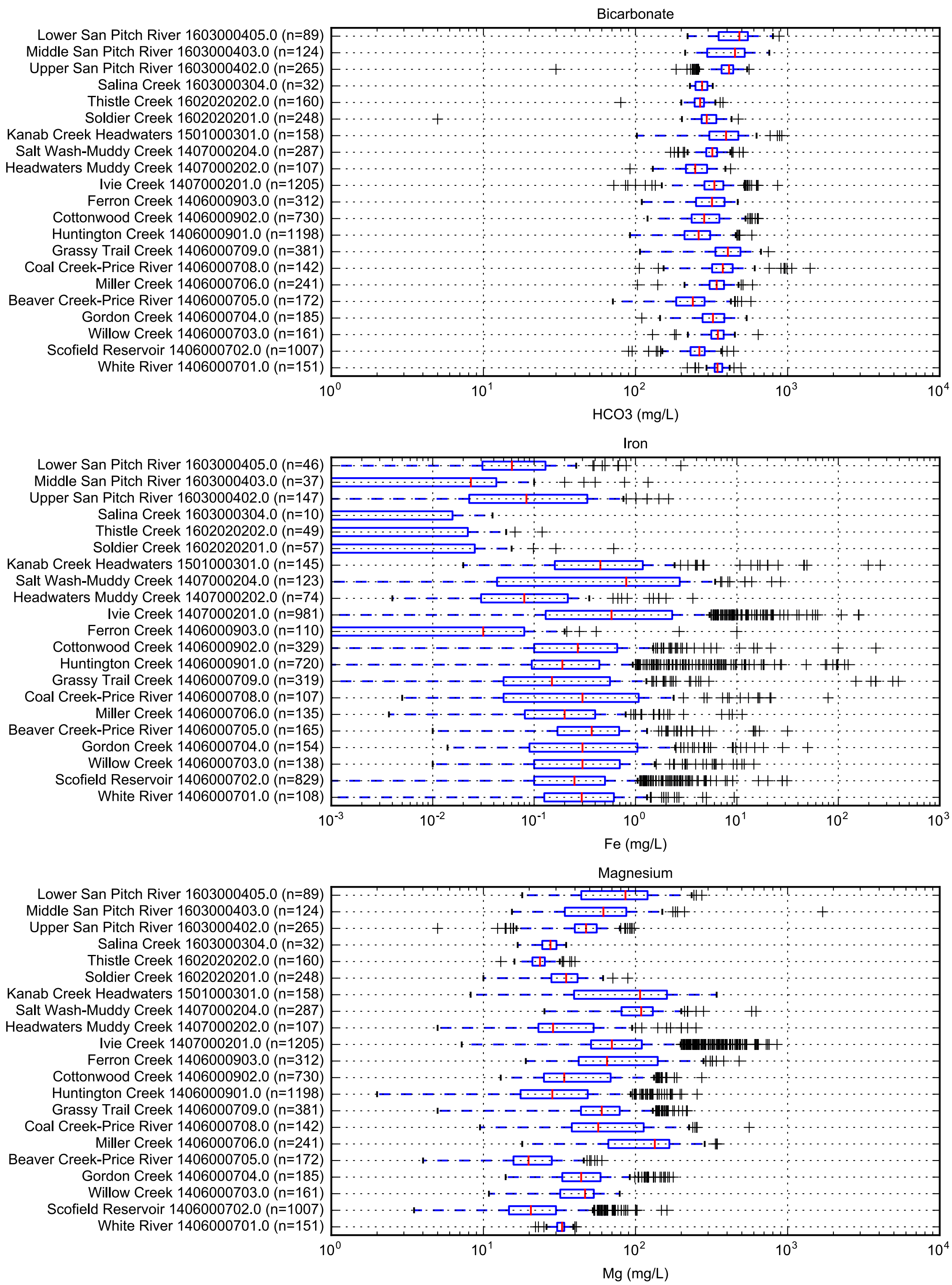


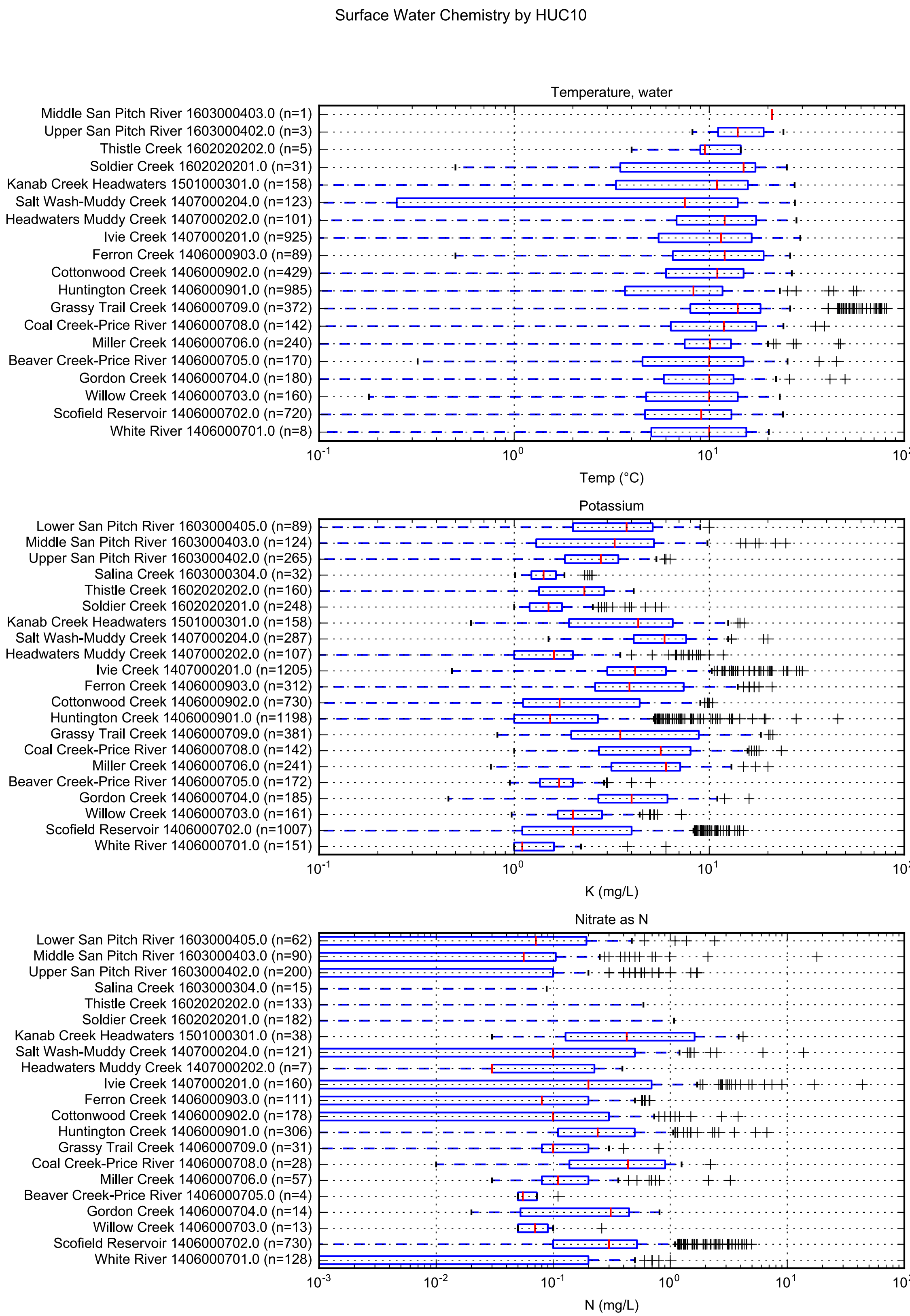

Monthly Flow at USGS Gage Stations
10215900 - Manti Creek Blw Dugway Creek, Nr Manti, Ut
10216210 - San Pitch River Near Sterling, Utah
10216400 - Twelvemile Creek Near Mayfield, Utah
10217000 - Sevier Riv Blw San Pitch Riv Nr Gunnison, Ut
discharge (cfs)
month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Surface Water Chemistry by HUC10

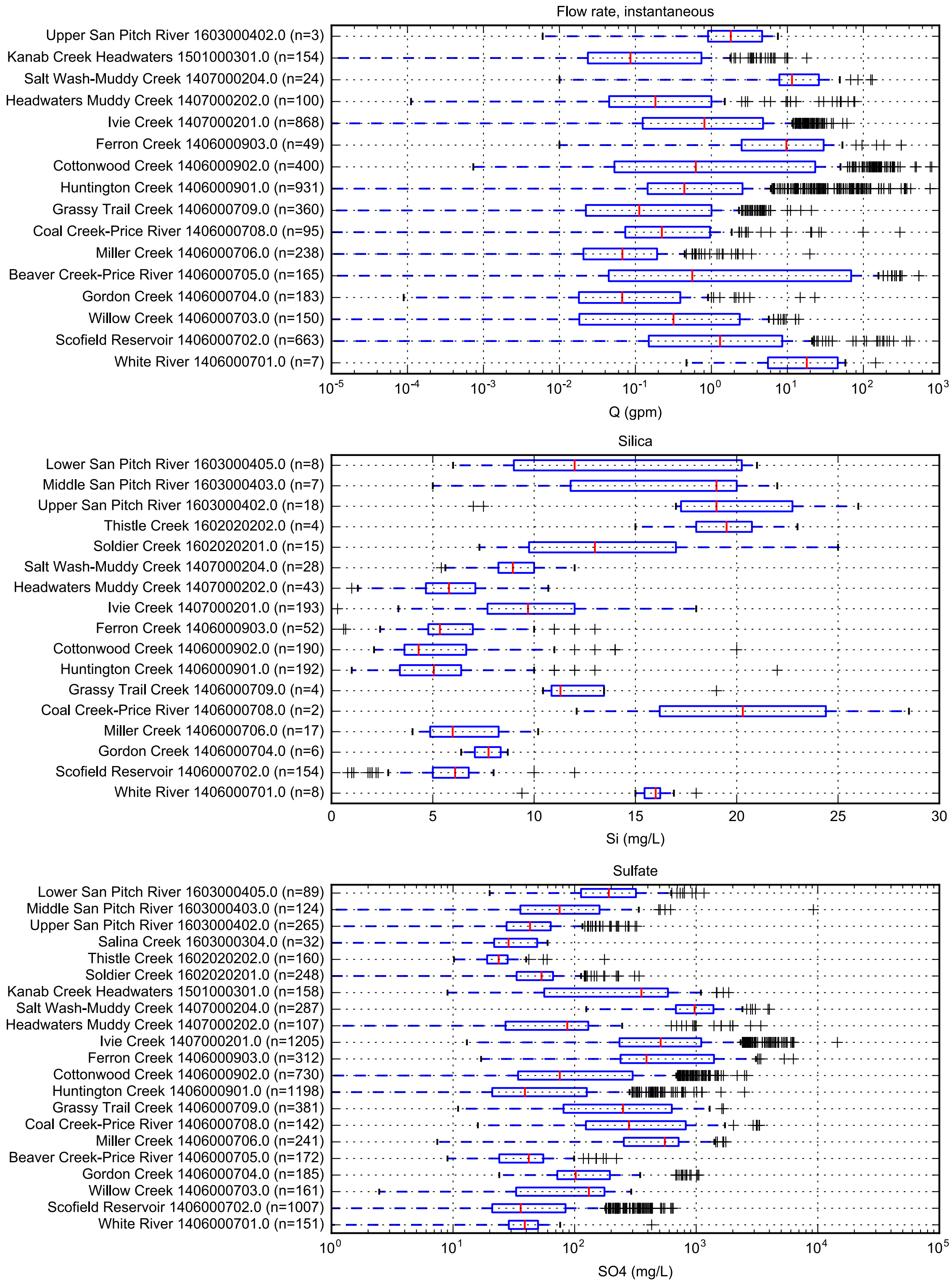


Surface Water Chemistry by HUC10

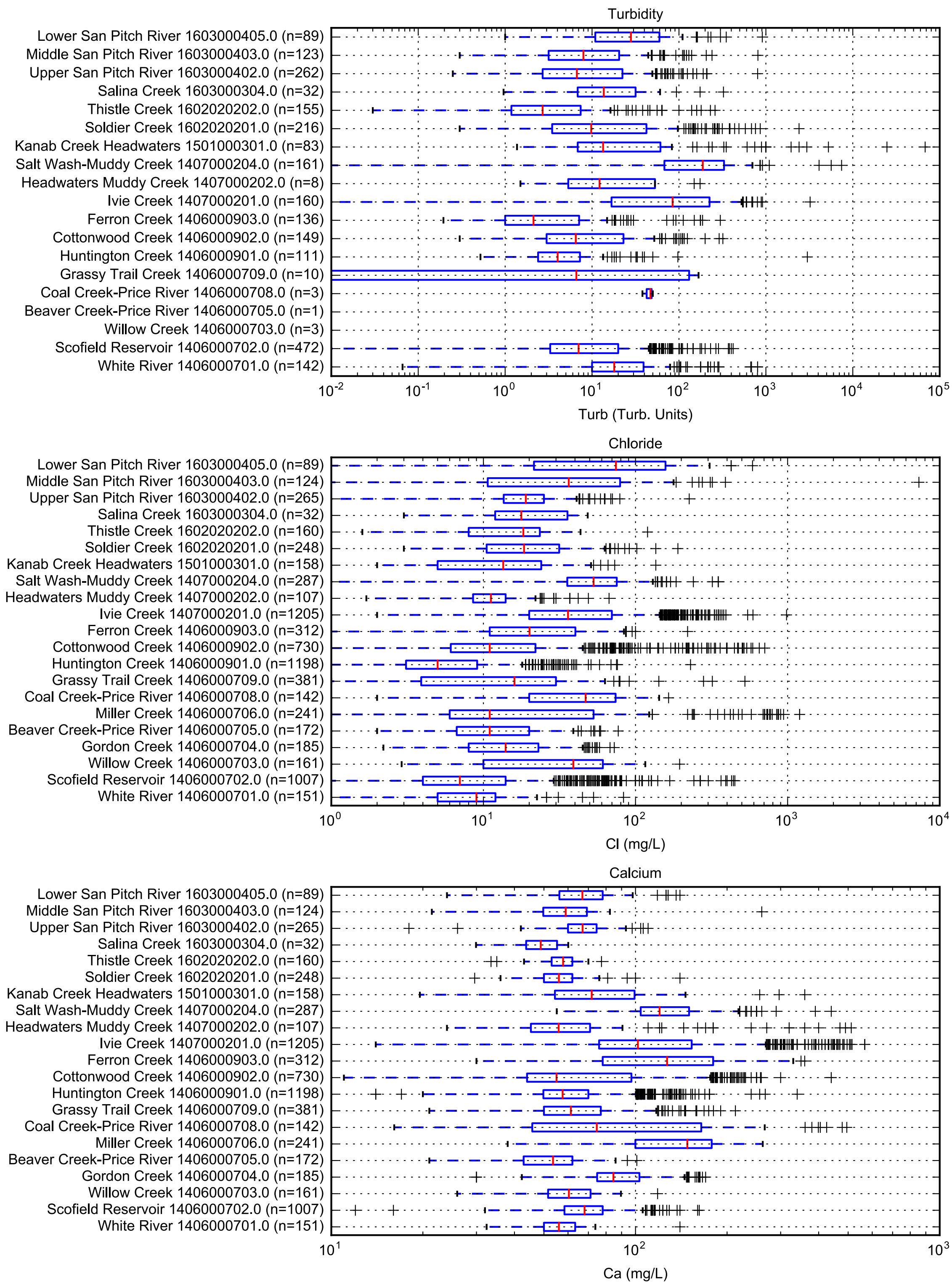


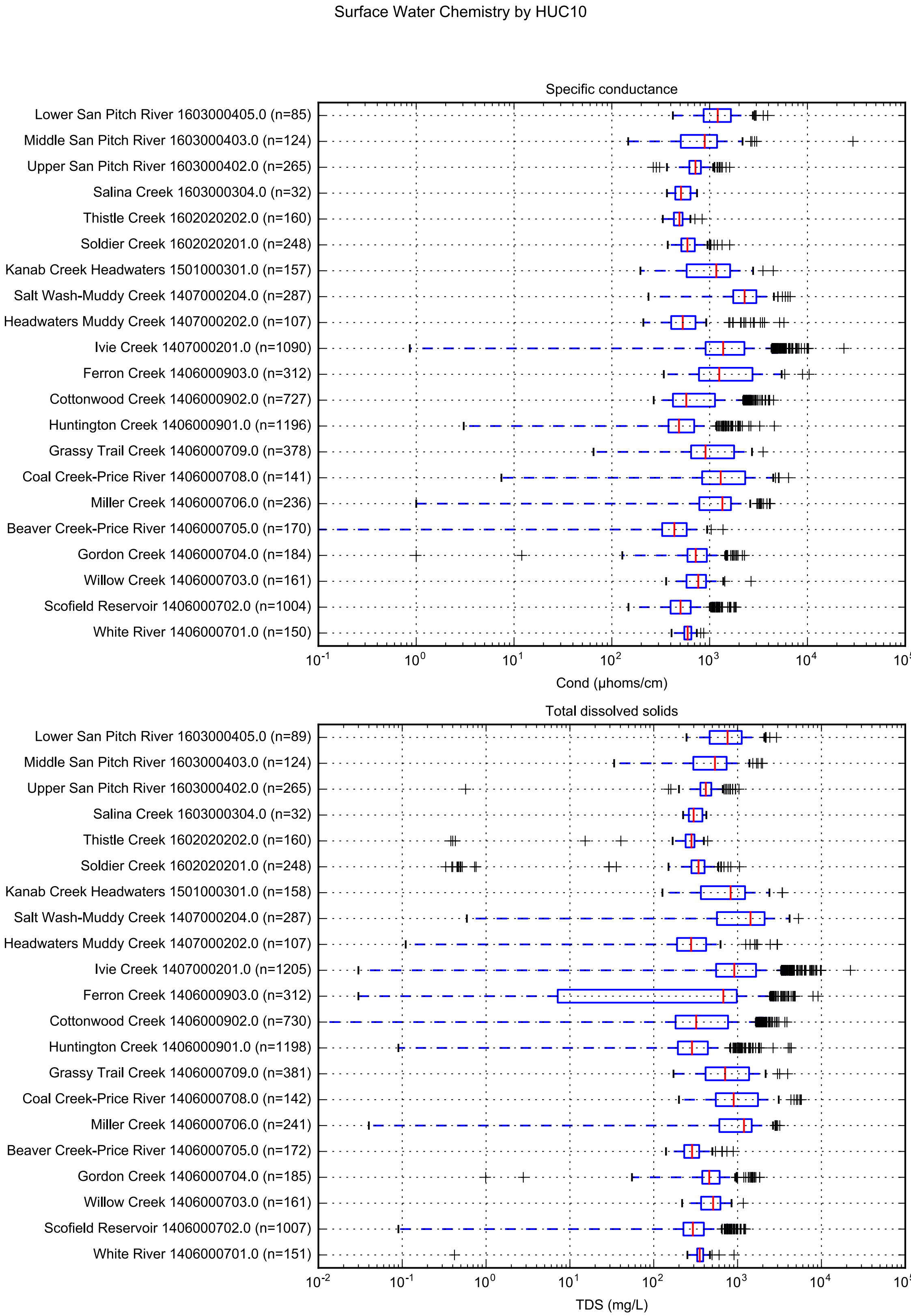

Surface Water Chemistry by HUC10
Temperature, water
Middle San Pitch River 1603000403.0 (n=1)
Upper San Pitch River 1603000402.0 (n=3)
Thistle Creek 1602020202.0 (n=5)
Soldier Creek 1602020201.0 (n=31)
Kanab Creek Headwaters 1501000301.0 (n=158)
Salt Wash-Muddy Creek 1407000204.0 (n=123)
Headwaters Muddy Creek 1407000202.0 (n=101)
Ivie Creek 1407000201.0 (n=925)
Ferron Creek 1406000903.0 (n=89)
Cottonwood Creek 1406000902.0 (n=429)
Huntington Creek 1406000901.0 (n=985)
Grassy Trail Creek 1406000709.0 (n=372)
Coal Creek-Price River 1406000708.0 (n=142)
Miller Creek 1406000706.0 (n=240)
Beaver Creek-Price River 1406000705.0 (n=170)
Gordon Creek 1406000704.0 (n=180)
Willow Creek 1406000703.0 (n=160)
Scofield Reservoir 1406000702.0 (n=720)
White River 1406000701.0 (n=8)
10^{-1}
10^{0}
10^{1}
10^{2}
Temp (°C)
Potassium
Lower San Pitch River 1603000405.0 (n=89)
Middle San Pitch River 1603000403.0 (n=124)
Upper San Pitch River 1603000402.0 (n=265)
Salina Creek 1603000304.0 (n=32)
Thistle Creek 1602020202.0 (n=160)
Soldier Creek 1602020201.0 (n=248)
Kanab Creek Headwaters 1501000301.0 (n=158)
Salt Wash-Muddy Creek 1407000204.0 (n=287)
Headwaters Muddy Creek 1407000202.0 (n=107)
Ivie Creek 1407000201.0 (n=1205)
Ferron Creek 1406000903.0 (n=312)
Cottonwood Creek 1406000902.0 (n=730)
Huntington Creek 1406000901.0 (n=1198)
Grassy Trail Creek 1406000709.0 (n=381)
Coal Creek-Price River 1406000708.0 (n=142)
Miller Creek 1406000706.0 (n=241)
Beaver Creek-Price River 1406000705.0 (n=172)
Gordon Creek 1406000704.0 (n=185)
Willow Creek 1406000703.0 (n=161)
Scofield Reservoir 1406000702.0 (n=1007)
White River 1406000701.0 (n=151)
10^{-1}
10^{0}
10^{1}
10^{2}
K (mg/L)
Nitrate as N
Lower San Pitch River 1603000405.0 (n=62)
Middle San Pitch River 1603000403.0 (n=90)
Upper San Pitch River 1603000402.0 (n=200)
Salina Creek 1603000304.0 (n=15)
Thistle Creek 1602020202.0 (n=133)
Soldier Creek 1602020201.0 (n=182)
Kanab Creek Headwaters 1501000301.0 (n=38)
Salt Wash-Muddy Creek 1407000204.0 (n=121)
Headwaters Muddy Creek 1407000202.0 (n=7)
Ivie Creek 1407000201.0 (n=160)
Ferron Creek 1406000903.0 (n=111)
Cottonwood Creek 1406000902.0 (n=178)
Huntington Creek 1406000901.0 (n=306)
Grassy Trail Creek 1406000709.0 (n=31)
Coal Creek-Price River 1406000708.0 (n=28)
Miller Creek 1406000706.0 (n=57)
Beaver Creek-Price River 1406000705.0 (n=4)
Gordon Creek 1406000704.0 (n=14)
Willow Creek 1406000703.0 (n=13)
Scofield Reservoir 1406000702.0 (n=730)
White River 1406000701.0 (n=128)
10^{-3}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
N (mg/L)

Surface Water Chemistry by HUC10

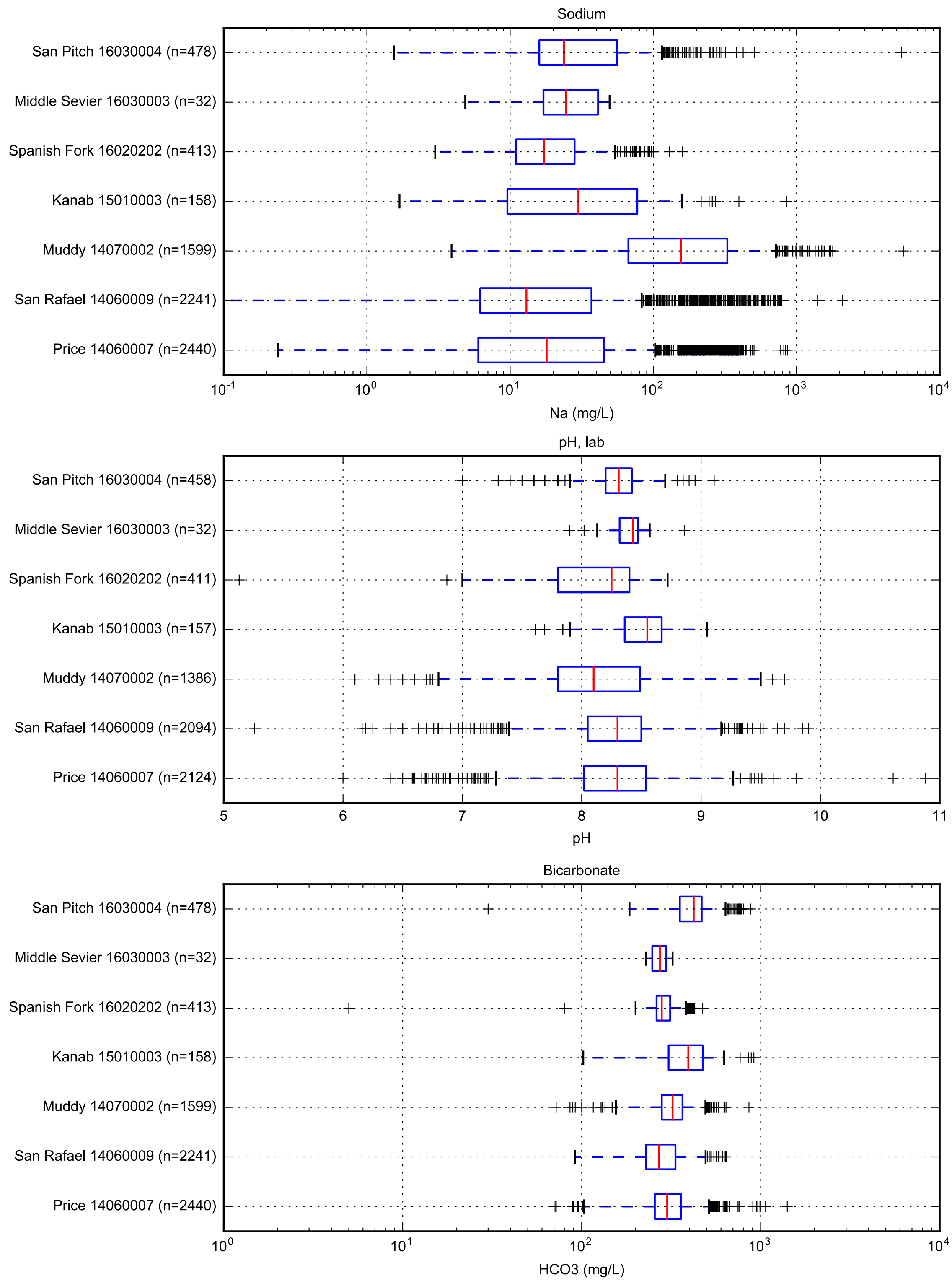


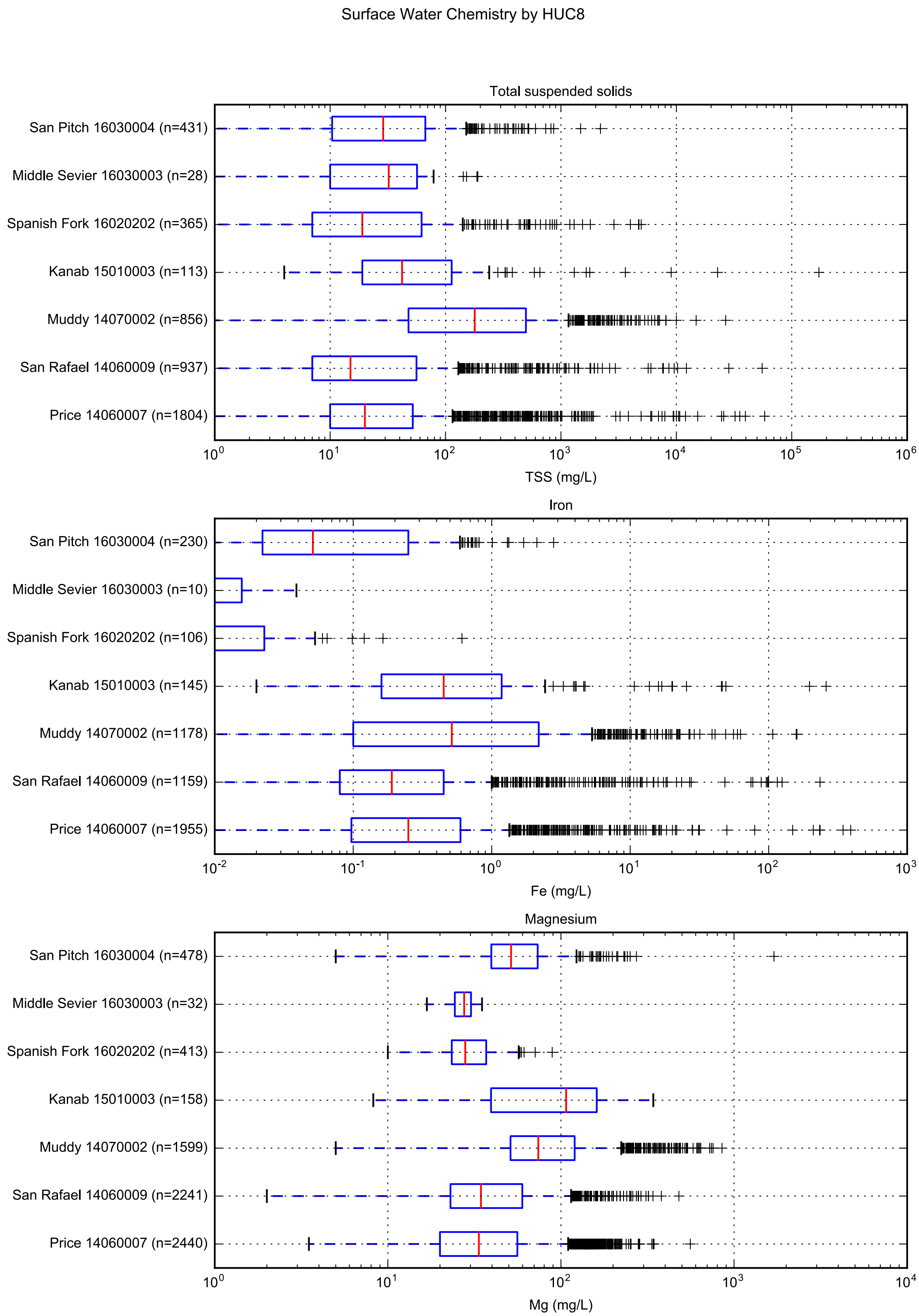
Surface Water Chemistry by HUC10




Surface Water Chemistry by HUC10
Specific conductance
Lower San Pitch River 1603000405.0 (n=85)
Middle San Pitch River 1603000403.0 (n=124)
Upper San Pitch River 1603000402.0 (n=265)
Salina Creek 1603000304.0 (n=32)
Thistle Creek 1602020202.0 (n=160)
Soldier Creek 1602020201.0 (n=248)
Kanab Creek Headwaters 1501000301.0 (n=157)
Salt Wash-Muddy Creek 1407000204.0 (n=287)
Headwaters Muddy Creek 1407000202.0 (n=107)
Ivie Creek 1407000201.0 (n=1090)
Ferron Creek 1406000903.0 (n=312)
Cottonwood Creek 1406000902.0 (n=727)
Huntington Creek 1406000901.0 (n=1196)
Grassy Trail Creek 1406000709.0 (n=378)
Coal Creek-Price River 1406000708.0 (n=141)
Miller Creek 1406000706.0 (n=236)
Beaver Creek-Price River 1406000705.0 (n=170)
Gordon Creek 1406000704.0 (n=184)
Willow Creek 1406000703.0 (n=161)
Scofield Reservoir 1406000702.0 (n=1004)
White River 1406000701.0 (n=150)
10-1
100
101
102
103
104
105
Cond (µhoms/cm)
Total dissolved solids
Lower San Pitch River 1603000405.0 (n=89)
Middle San Pitch River 1603000403.0 (n=124)
Upper San Pitch River 1603000402.0 (n=265)
Salina Creek 1603000304.0 (n=32)
Thistle Creek 1602020202.0 (n=160)
Soldier Creek 1602020201.0 (n=248)
Kanab Creek Headwaters 1501000301.0 (n=158)
Salt Wash-Muddy Creek 1407000204.0 (n=287)
Headwaters Muddy Creek 1407000202.0 (n=107)
Ivie Creek 1407000201.0 (n=1205)
Ferron Creek 1406000903.0 (n=312)
Cottonwood Creek 1406000902.0 (n=730)
Huntington Creek 1406000901.0 (n=1198)
Grassy Trail Creek 1406000709.0 (n=381)
Coal Creek-Price River 1406000708.0 (n=142)
Miller Creek 1406000706.0 (n=241)
Beaver Creek-Price River 1406000705.0 (n=172)
Gordon Creek 1406000704.0 (n=185)
Willow Creek 1406000703.0 (n=161)
Scofield Reservoir 1406000702.0 (n=1007)
White River 1406000701.0 (n=151)
10-2
10-1
100
101
102
103
104
105
TDS (mg/L)

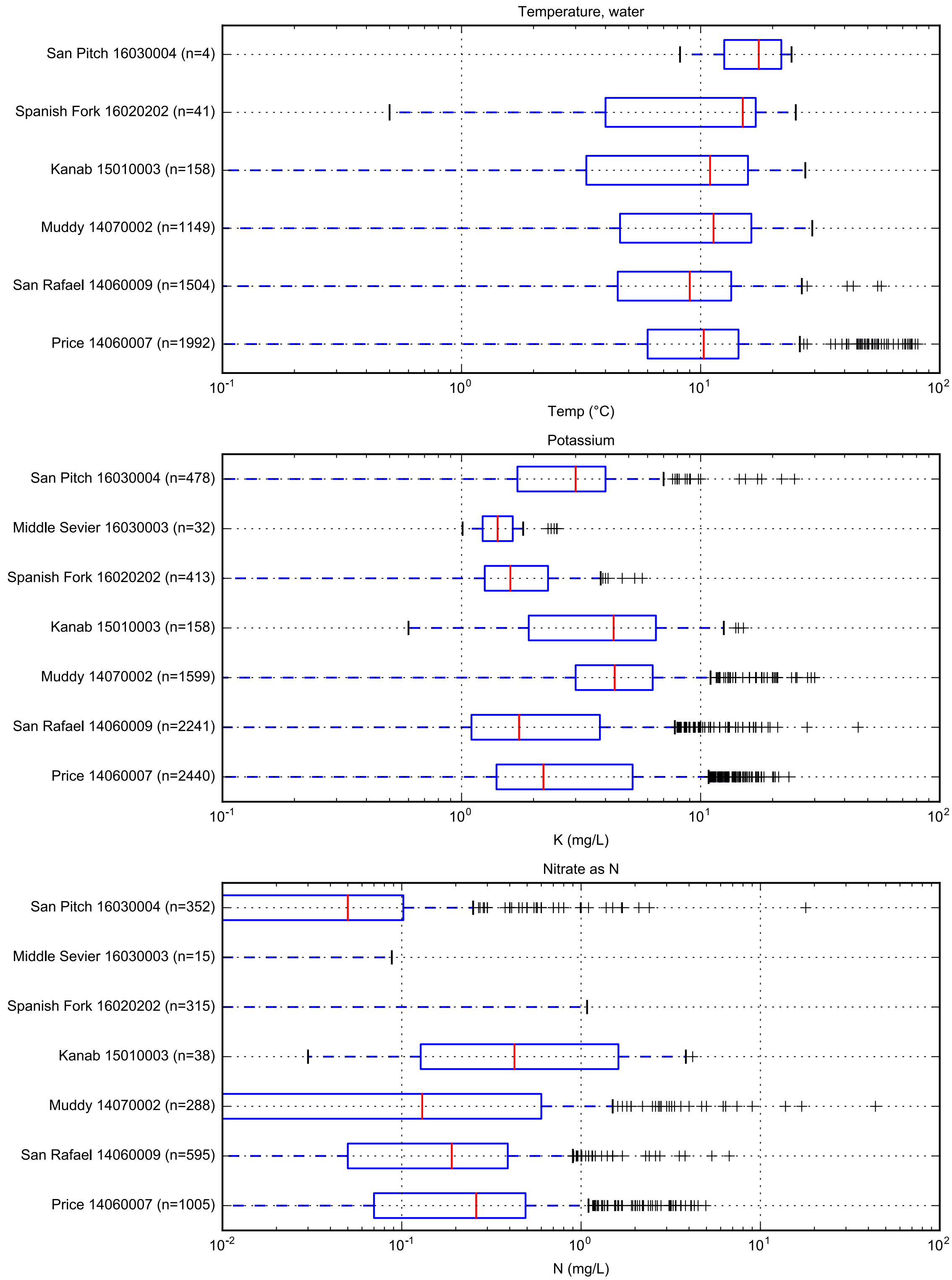
Surface Water Chemistry by HUC8

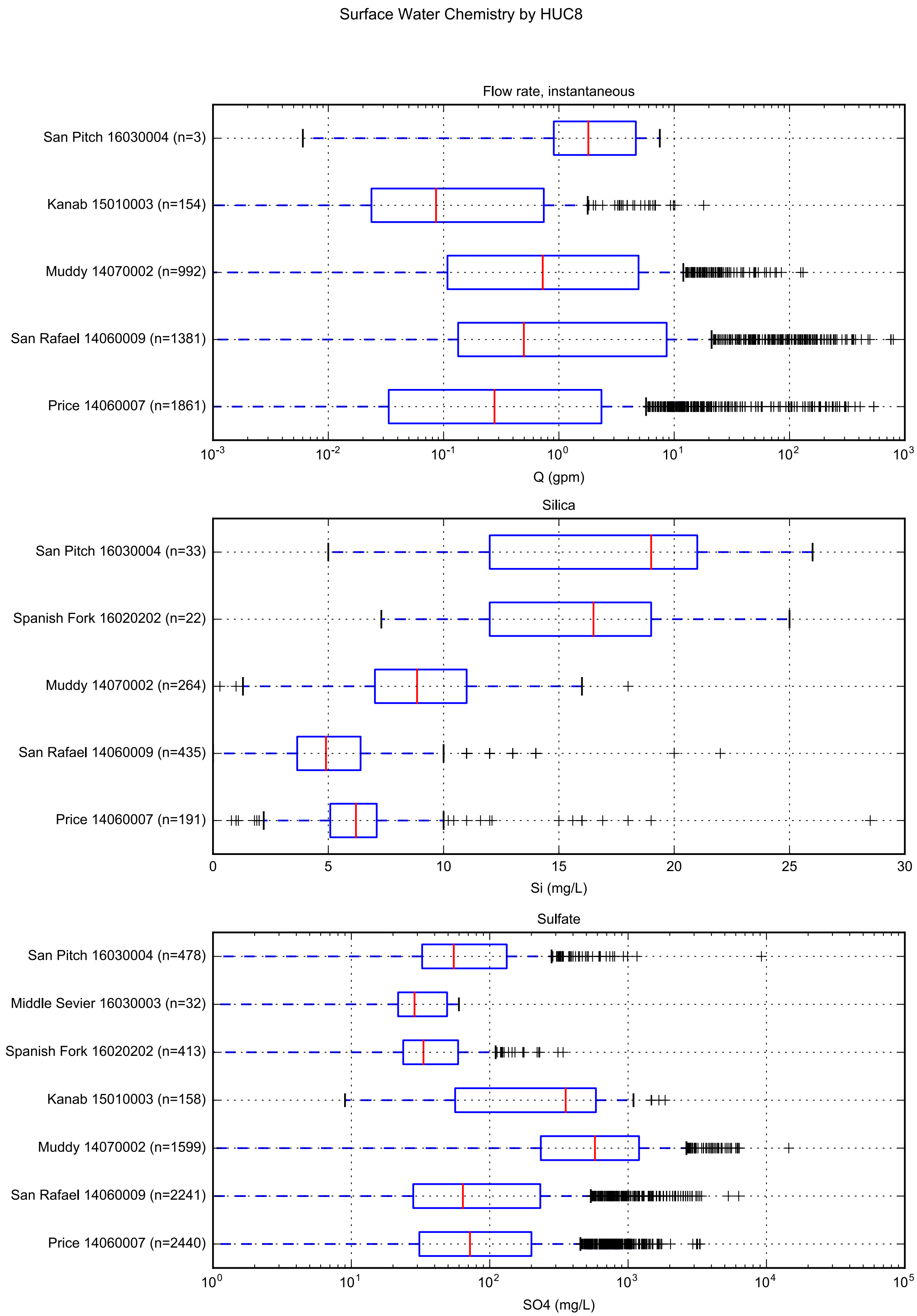




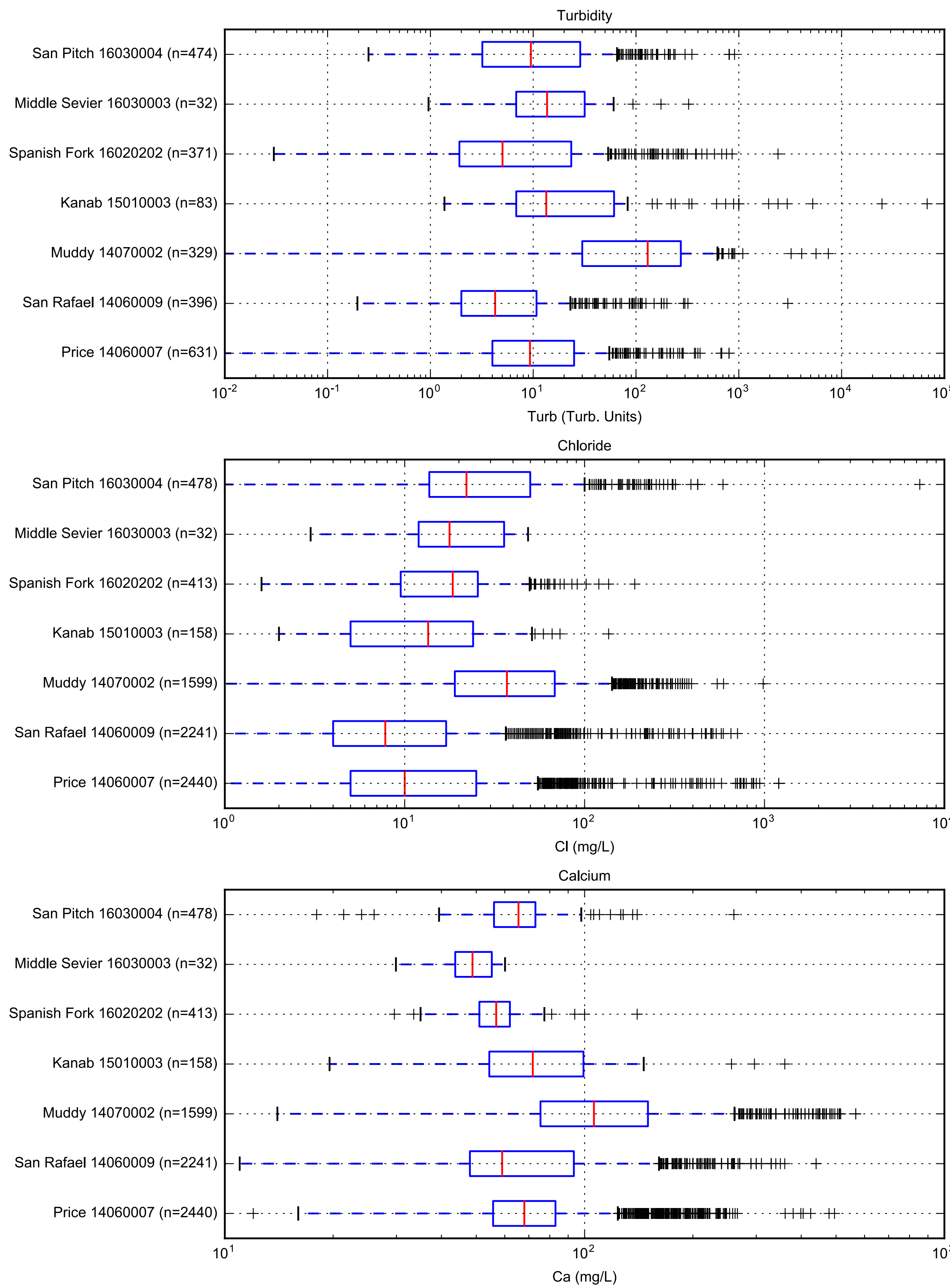
Surface Water Chemistry by HUC8
Total suspended solids
San Pitch 16030004 (n=431)
Middle Sevier 16030003 (n=28)
Spanish Fork 16020202 (n=365)
Kanab 15010003 (n=113)
Muddy 14070002 (n=856)
San Rafael 14060009 (n=937)
Price 14060007 (n=1804)
TSS (mg/L)
Iron
San Pitch 16030004 (n=230)
Middle Sevier 16030003 (n=10)
Spanish Fork 16020202 (n=106)
Kanab 15010003 (n=145)
Muddy 14070002 (n=1178)
San Rafael 14060009 (n=1159)
Price 14060007 (n=1955)
Fe (mg/L)
Magnesium
San Pitch 16030004 (n=478)
Middle Sevier 16030003 (n=32)
Spanish Fork 16020202 (n=413)
Kanab 15010003 (n=158)
Muddy 14070002 (n=1599)
San Rafael 14060009 (n=2241)
Price 14060007 (n=2440)
Mg (mg/L)

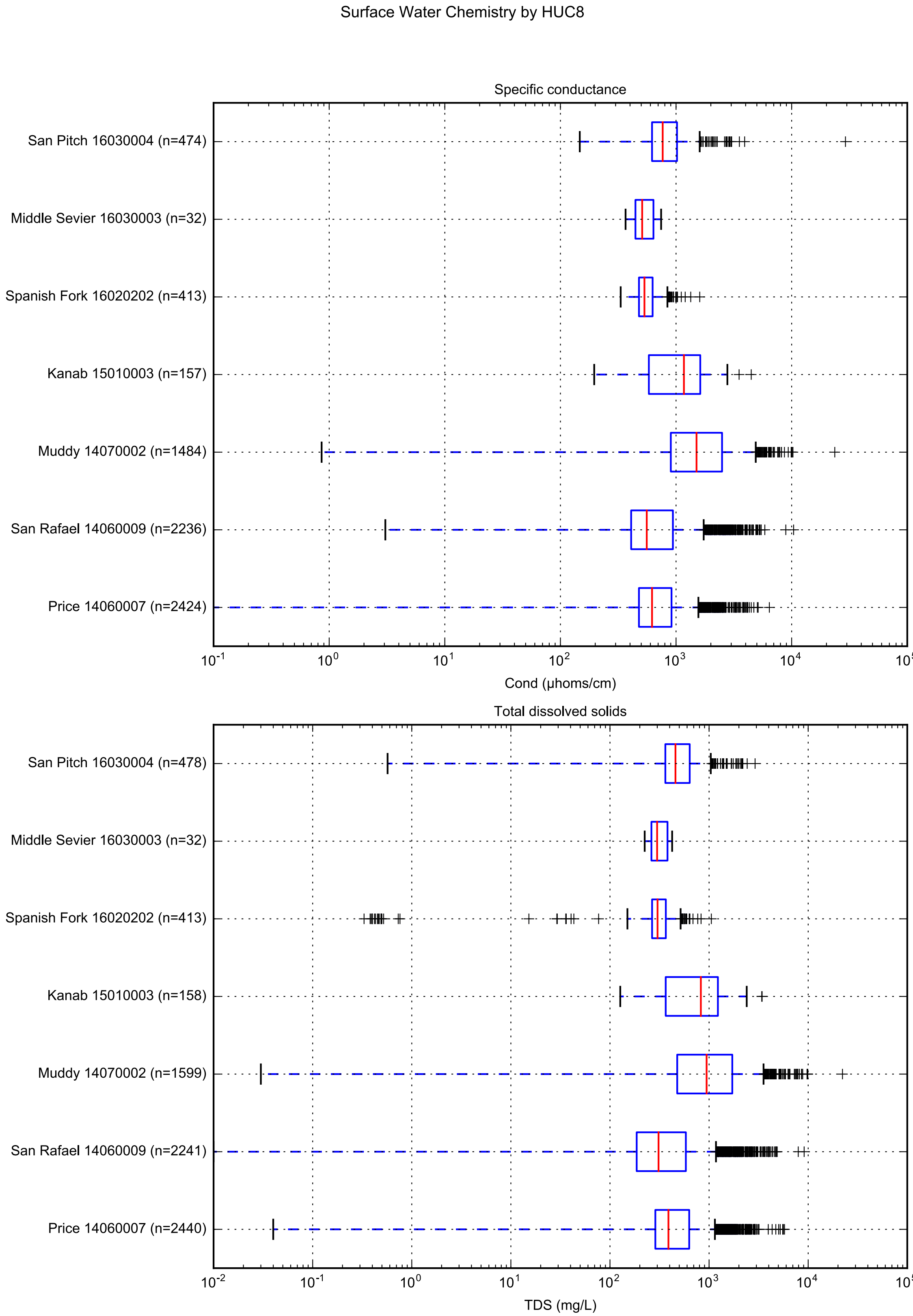
Surface Water Chemistry by HUC8

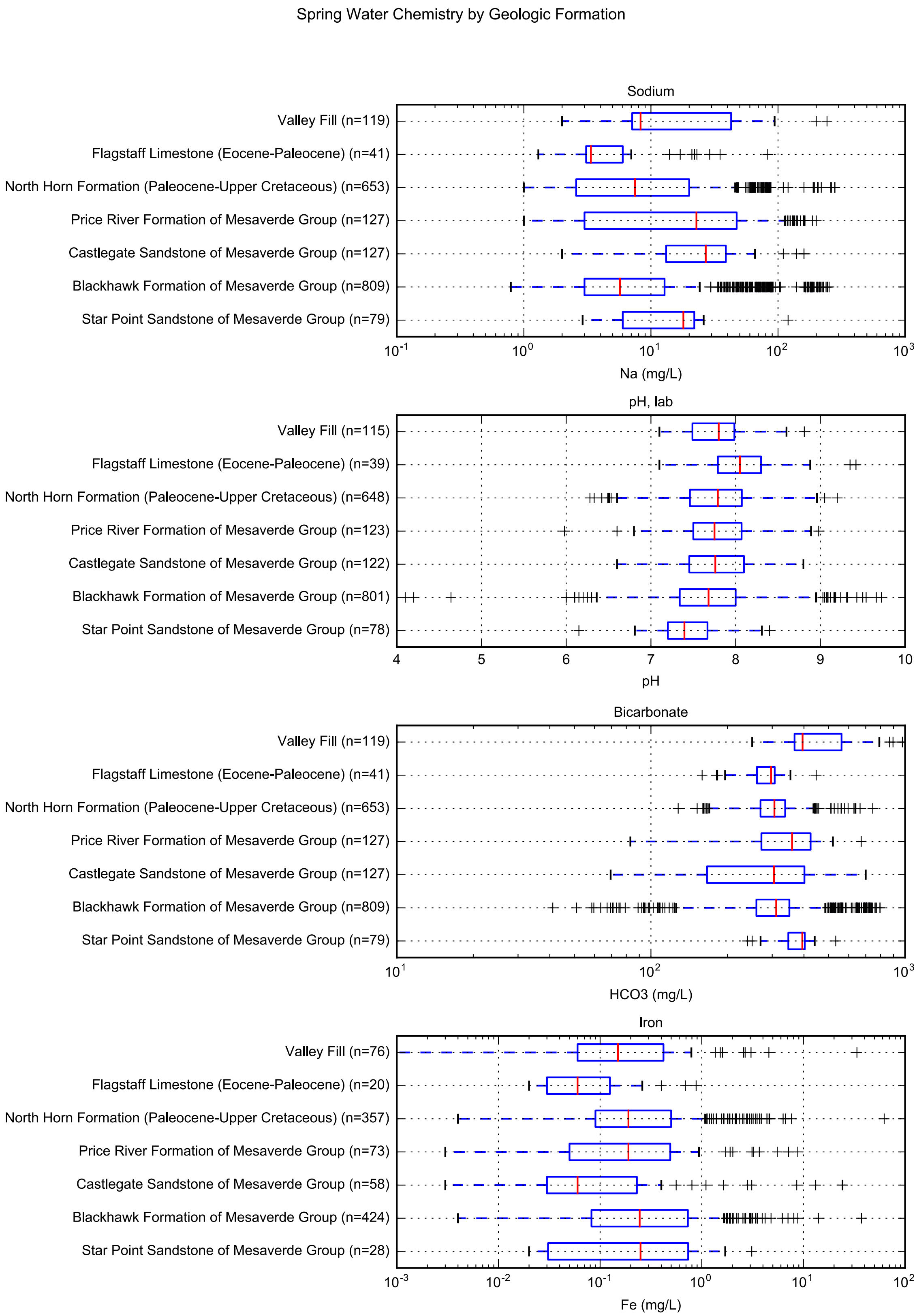


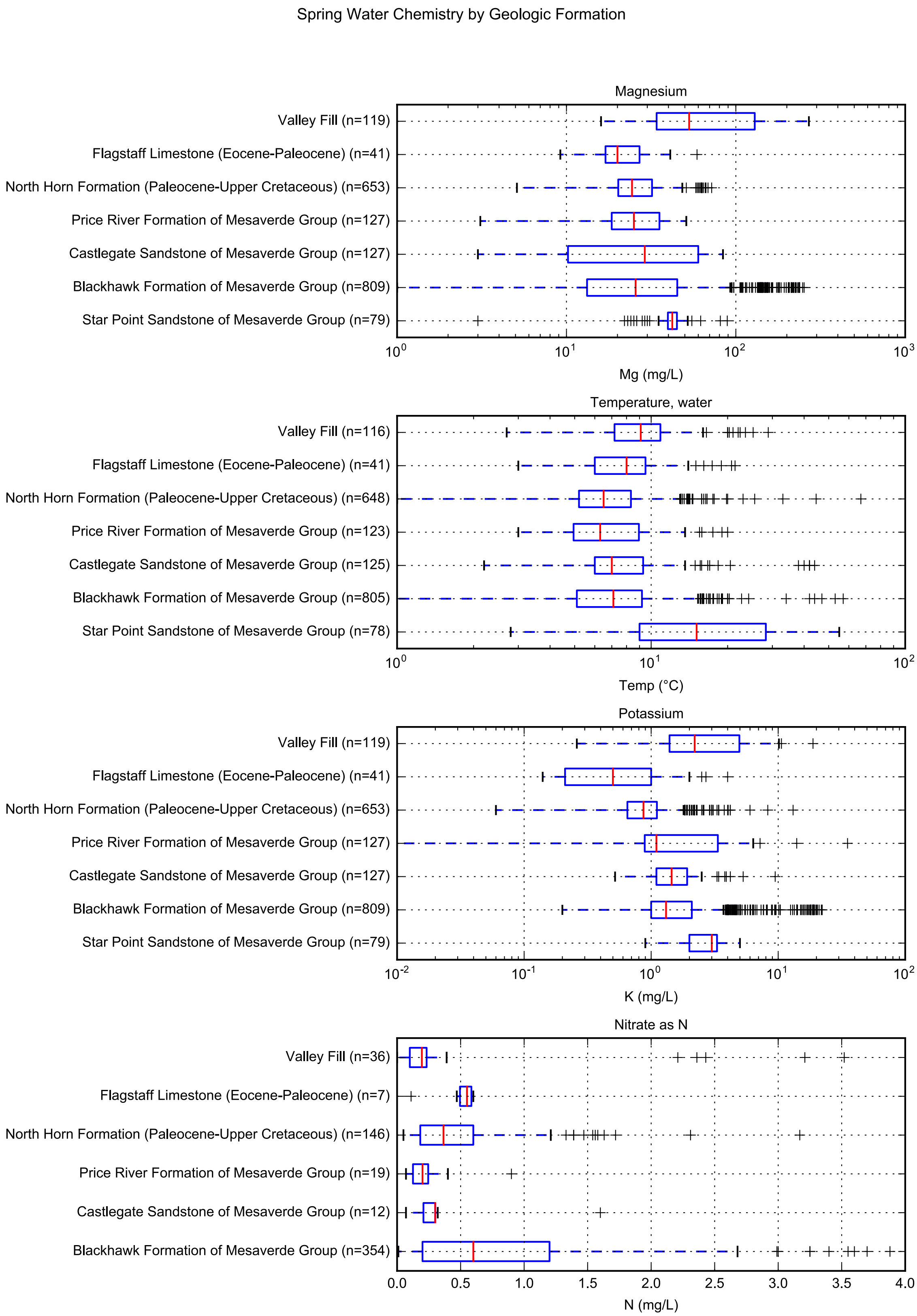

Surface Water Chemistry by HUC8
Flow rate, instantaneous
San Pitch 16030004 (n=3)
Kanab 15010003 (n=154)
Muddy 14070002 (n=992)
San Rafael 14060009 (n=1381)
Price 14060007 (n=1861)
Q (gpm)
Silica
San Pitch 16030004 (n=33)
Spanish Fork 16020202 (n=22)
Muddy 14070002 (n=264)
San Rafael 14060009 (n=435)
Price 14060007 (n=191)
Si (mg/L)
Sulfate
San Pitch 16030004 (n=478)
Middle Sevier 16030003 (n=32)
Spanish Fork 16020202 (n=413)
Kanab 15010003 (n=158)
Muddy 14070002 (n=1599)
San Rafael 14060009 (n=2241)
Price 14060007 (n=2440)
SO4 (mg/L)

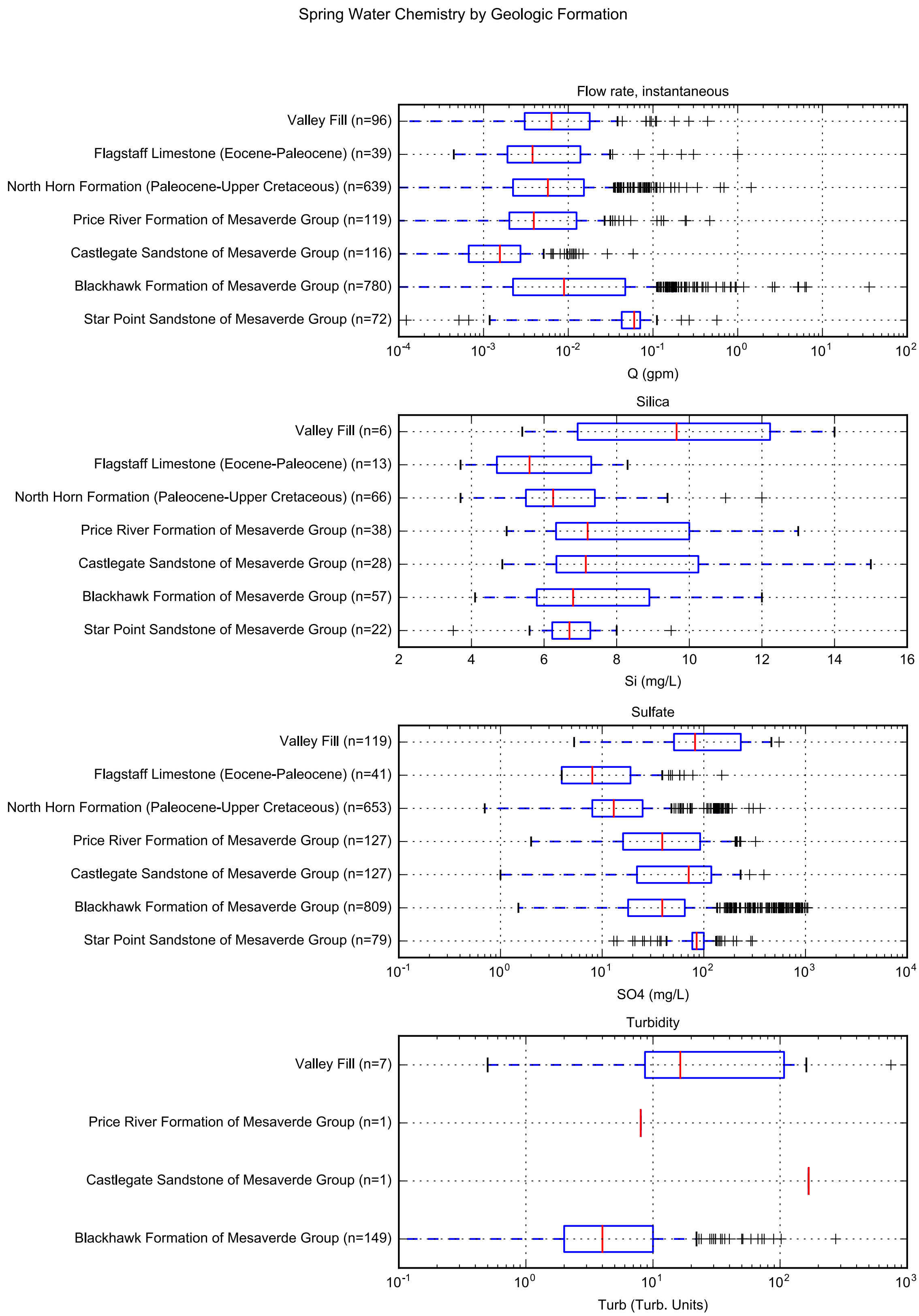
Surface Water Chemistry by HUC8

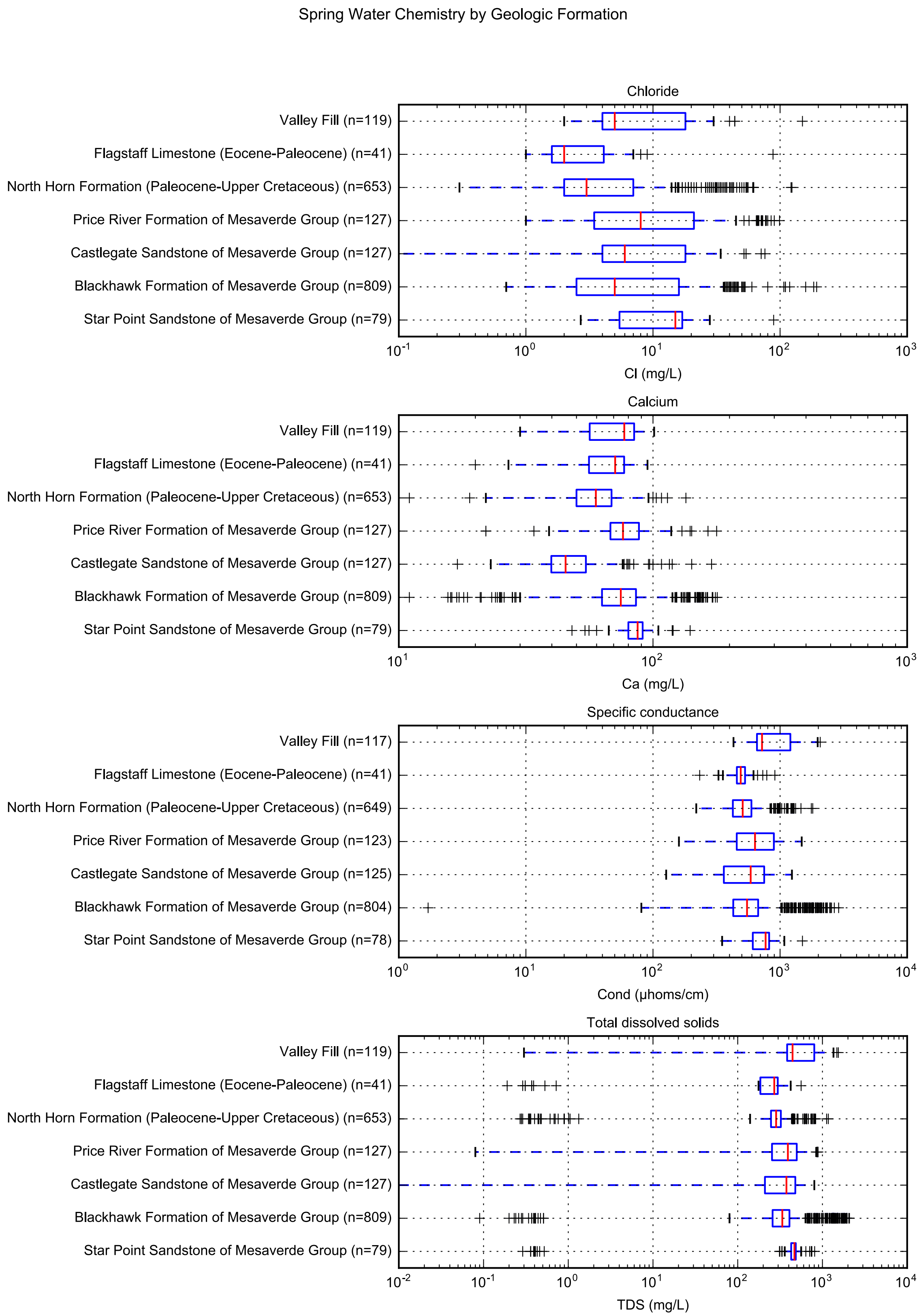


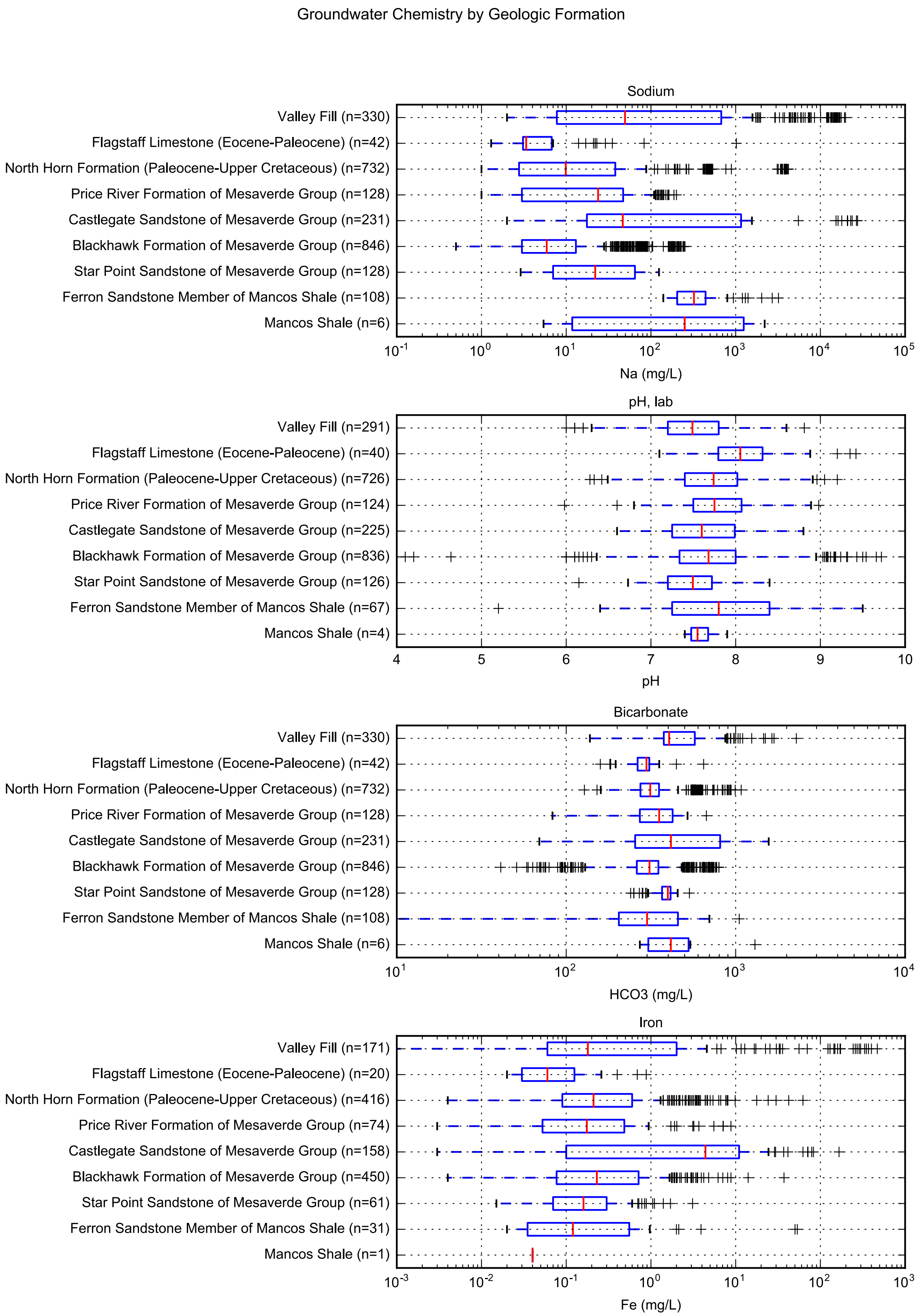

Surface Water Chemistry by HUC8
Specific conductance
San Pitch 16030004 (n=474)
Middle Sevier 16030003 (n=32)
Spanish Fork 16020202 (n=413)
Kanab 15010003 (n=157)
Muddy 14070002 (n=1484)
San Rafael 14060009 (n=2236)
Price 14060007 (n=2424)
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5}
Cond (μhoms/cm)
Total dissolved solids
San Pitch 16030004 (n=478)
Middle Sevier 16030003 (n=32)
Spanish Fork 16020202 (n=413)
Kanab 15010003 (n=158)
Muddy 14070002 (n=1599)
San Rafael 14060009 (n=2241)
Price 14060007 (n=2440)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5}
TDS (mg/L)

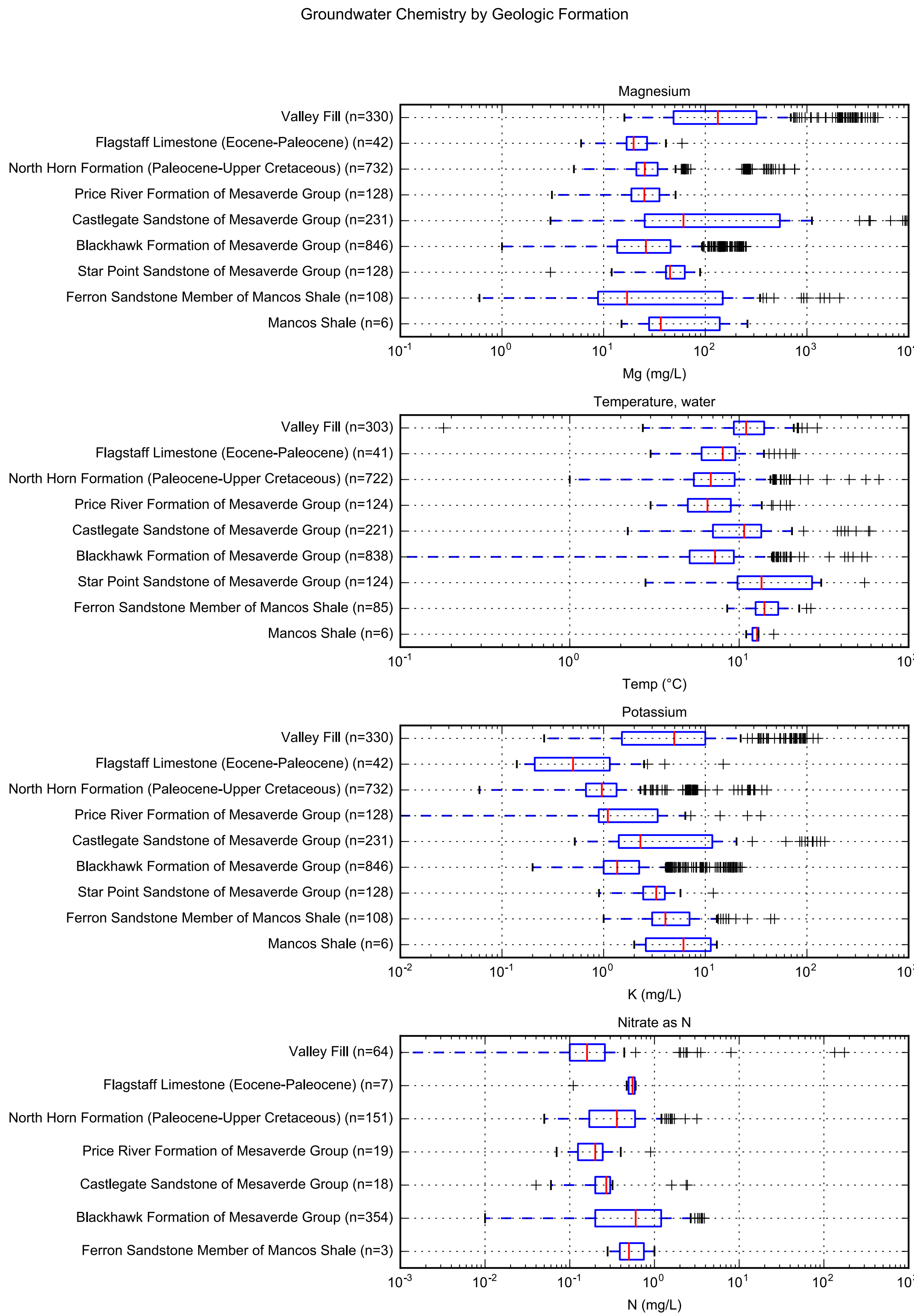

Spring Water Chemistry by Geologic Formation
Sodium
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
Na (mg/L)
pH, lab
Valley Fill (n=115)
Flagstaff Limestone (Eocene-Paleocene) (n=39)
North Horn Formation (Paleocene-Upper Cretaceous) (n=648)
Price River Formation of Mesaverde Group (n=123)
Castlegate Sandstone of Mesaverde Group (n=122)
Blackhawk Formation of Mesaverde Group (n=801)
Star Point Sandstone of Mesaverde Group (n=78)
4 5 6 7 8 9 10
pH
Bicarbonate
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
10^{1} 10^{2} 10^{3}
HCO3 (mg/L)
Iron
Valley Fill (n=76)
Flagstaff Limestone (Eocene-Paleocene) (n=20)
North Horn Formation (Paleocene-Upper Cretaceous) (n=357)
Price River Formation of Mesaverde Group (n=73)
Castlegate Sandstone of Mesaverde Group (n=58)
Blackhawk Formation of Mesaverde Group (n=424)
Star Point Sandstone of Mesaverde Group (n=28)
10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
Fe (mg/L)

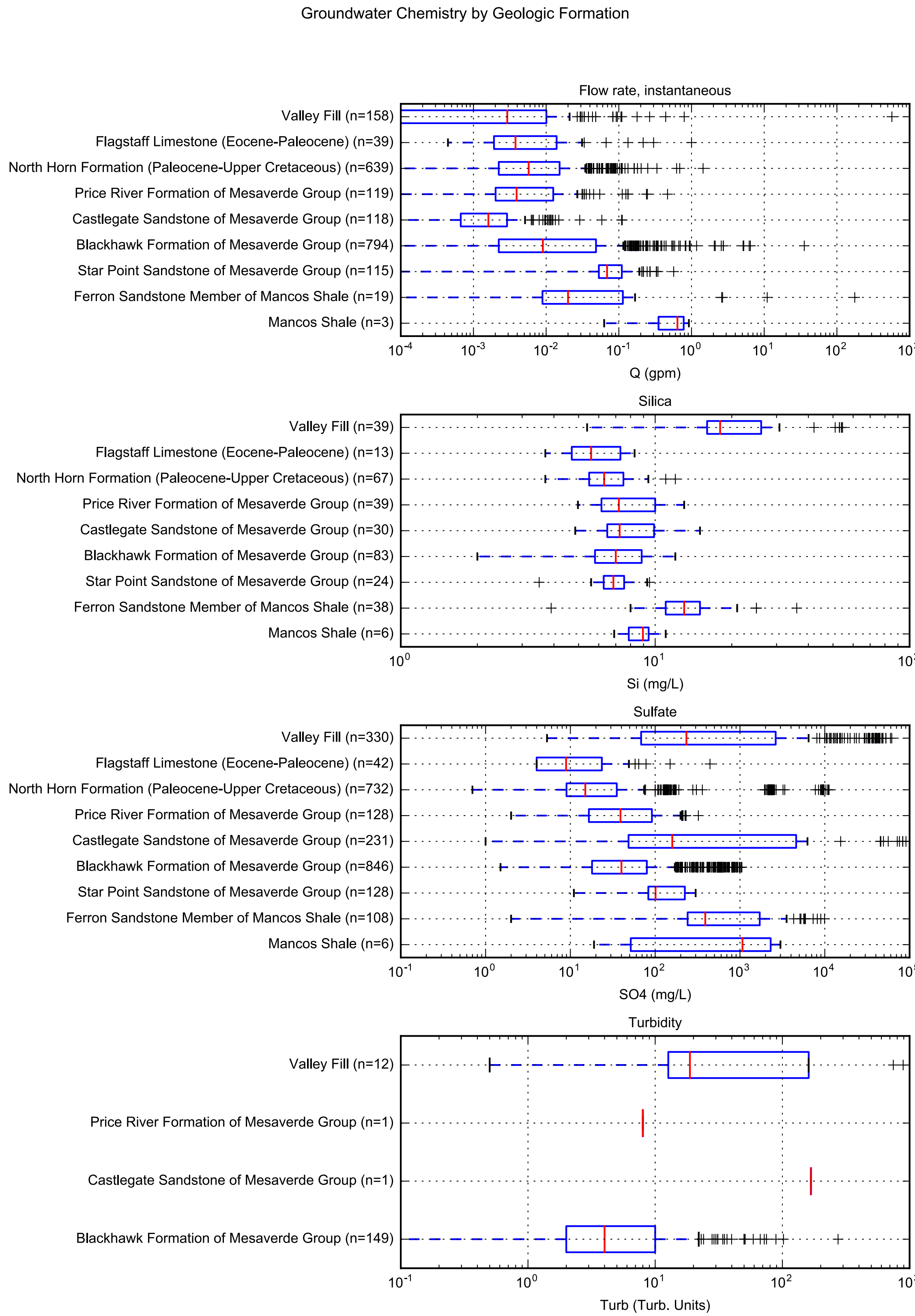

Spring Water Chemistry by Geologic Formation
Magnesium
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
Mg (mg/L)
Temperature, water
Valley Fill (n=116)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=648)
Price River Formation of Mesaverde Group (n=123)
Castlegate Sandstone of Mesaverde Group (n=125)
Blackhawk Formation of Mesaverde Group (n=805)
Star Point Sandstone of Mesaverde Group (n=78)
Temp (°C)
Potassium
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
K (mg/L)
Nitrate as N
Valley Fill (n=36)
Flagstaff Limestone (Eocene-Paleocene) (n=7)
North Horn Formation (Paleocene-Upper Cretaceous) (n=146)
Price River Formation of Mesaverde Group (n=19)
Castlegate Sandstone of Mesaverde Group (n=12)
Blackhawk Formation of Mesaverde Group (n=354)
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0
N (mg/L)


Spring Water Chemistry by Geologic Formation
Flow rate, instantaneous
Valley Fill (n=96)
Flagstaff Limestone (Eocene-Paleocene) (n=39)
North Horn Formation (Paleocene-Upper Cretaceous) (n=639)
Price River Formation of Mesaverde Group (n=119)
Castlegate Sandstone of Mesaverde Group (n=116)
Blackhawk Formation of Mesaverde Group (n=780)
Star Point Sandstone of Mesaverde Group (n=72)
Q (gpm)
Silica
Valley Fill (n=6)
Flagstaff Limestone (Eocene-Paleocene) (n=13)
North Horn Formation (Paleocene-Upper Cretaceous) (n=66)
Price River Formation of Mesaverde Group (n=38)
Castlegate Sandstone of Mesaverde Group (n=28)
Blackhawk Formation of Mesaverde Group (n=57)
Star Point Sandstone of Mesaverde Group (n=22)
Si (mg/L)
Sulfate
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
SO4 (mg/L)
Turbidity
Valley Fill (n=7)
Price River Formation of Mesaverde Group (n=1)
Castlegate Sandstone of Mesaverde Group (n=1)
Blackhawk Formation of Mesaverde Group (n=149)
Turb (Turb. Units)

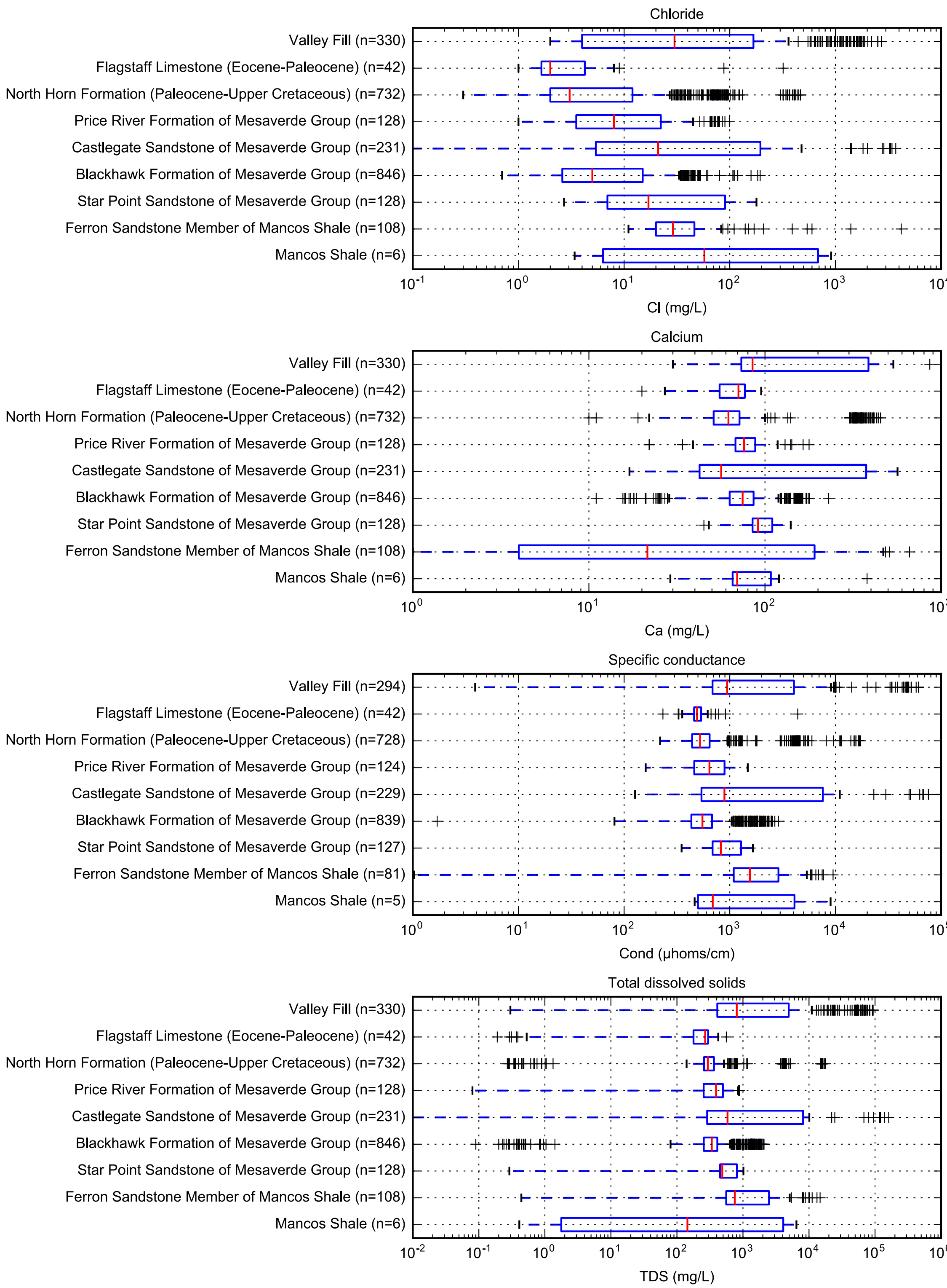

Spring Water Chemistry by Geologic Formation
Chloride
Valley Fill (n=119)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=653)
Price River Formation of Mesaverde Group (n=127)
Castlegate Sandstone of Mesaverde Group (n=127)
Blackhawk Formation of Mesaverde Group (n=809)
Star Point Sandstone of Mesaverde Group (n=79)
Cl (mg/L)
Calcium
Ca (mg/L)
Specific conductance
Valley Fill (n=117)
North Horn Formation (Paleocene-Upper Cretaceous) (n=649)
Price River Formation of Mesaverde Group (n=123)
Castlegate Sandstone of Mesaverde Group (n=125)
Blackhawk Formation of Mesaverde Group (n=804)
Star Point Sandstone of Mesaverde Group (n=78)
Cond (µhoms/cm)
Total dissolved solids
TDS (mg/L)


Groundwater Chemistry by Geologic Formation
Sodium
Valley Fill (n=330)
Flagstaff Limestone (Eocene-Paleocene) (n=42)
North Horn Formation (Paleocene-Upper Cretaceous) (n=732)
Price River Formation of Mesaverde Group (n=128)
Castlegate Sandstone of Mesaverde Group (n=231)
Blackhawk Formation of Mesaverde Group (n=846)
Star Point Sandstone of Mesaverde Group (n=128)
Ferron Sandstone Member of Mancos Shale (n=108)
Mancos Shale (n=6)
Na (mg/L)
pH, lab
Valley Fill (n=291)
Flagstaff Limestone (Eocene-Paleocene) (n=40)
North Horn Formation (Paleocene-Upper Cretaceous) (n=726)
Price River Formation of Mesaverde Group (n=124)
Castlegate Sandstone of Mesaverde Group (n=225)
Blackhawk Formation of Mesaverde Group (n=836)
Star Point Sandstone of Mesaverde Group (n=126)
Ferron Sandstone Member of Mancos Shale (n=67)
Mancos Shale (n=4)
pH
Bicarbonate
Valley Fill (n=330)
Flagstaff Limestone (Eocene-Paleocene) (n=42)
North Horn Formation (Paleocene-Upper Cretaceous) (n=732)
Price River Formation of Mesaverde Group (n=128)
Castlegate Sandstone of Mesaverde Group (n=231)
Blackhawk Formation of Mesaverde Group (n=846)
Star Point Sandstone of Mesaverde Group (n=128)
Ferron Sandstone Member of Mancos Shale (n=108)
Mancos Shale (n=6)
HCO3 (mg/L)
Iron
Valley Fill (n=171)
Flagstaff Limestone (Eocene-Paleocene) (n=20)
North Horn Formation (Paleocene-Upper Cretaceous) (n=416)
Price River Formation of Mesaverde Group (n=74)
Castlegate Sandstone of Mesaverde Group (n=158)
Blackhawk Formation of Mesaverde Group (n=450)
Star Point Sandstone of Mesaverde Group (n=61)
Ferron Sandstone Member of Mancos Shale (n=31)
Mancos Shale (n=1)
Fe (mg/L)


Groundwater Chemistry by Geologic Formation
Magnesium
Valley Fill (n=330)
Flagstaff Limestone (Eocene-Paleocene) (n=42)
North Horn Formation (Paleocene-Upper Cretaceous) (n=732)
Price River Formation of Mesaverde Group (n=128)
Castlegate Sandstone of Mesaverde Group (n=231)
Blackhawk Formation of Mesaverde Group (n=846)
Star Point Sandstone of Mesaverde Group (n=128)
Ferron Sandstone Member of Mancos Shale (n=108)
Mancos Shale (n=6)
Mg (mg/L)
Temperature, water
Valley Fill (n=303)
Flagstaff Limestone (Eocene-Paleocene) (n=41)
North Horn Formation (Paleocene-Upper Cretaceous) (n=722)
Price River Formation of Mesaverde Group (n=124)
Castlegate Sandstone of Mesaverde Group (n=221)
Blackhawk Formation of Mesaverde Group (n=838)
Star Point Sandstone of Mesaverde Group (n=124)
Ferron Sandstone Member of Mancos Shale (n=85)
Mancos Shale (n=6)
Temp (°C)
Potassium
Valley Fill (n=330)
Flagstaff Limestone (Eocene-Paleocene) (n=42)
North Horn Formation (Paleocene-Upper Cretaceous) (n=732)
Price River Formation of Mesaverde Group (n=128)
Castlegate Sandstone of Mesaverde Group (n=231)
Blackhawk Formation of Mesaverde Group (n=846)
Star Point Sandstone of Mesaverde Group (n=128)
Ferron Sandstone Member of Mancos Shale (n=108)
Mancos Shale (n=6)
K (mg/L)
Nitrate as N
Valley Fill (n=64)
Flagstaff Limestone (Eocene-Paleocene) (n=7)
North Horn Formation (Paleocene-Upper Cretaceous) (n=151)
Price River Formation of Mesaverde Group (n=19)
Castlegate Sandstone of Mesaverde Group (n=18)
Blackhawk Formation of Mesaverde Group (n=354)
Ferron Sandstone Member of Mancos Shale (n=3)
N (mg/L)


Groundwater Chemistry by Geologic Formation
Flow rate, instantaneous
Valley Fill (n=158)
Flagstaff Limestone (Eocene-Paleocene) (n=39)
North Horn Formation (Paleocene-Upper Cretaceous) (n=639)
Price River Formation of Mesaverde Group (n=119)
Castlegate Sandstone of Mesaverde Group (n=118)
Blackhawk Formation of Mesaverde Group (n=794)
Star Point Sandstone of Mesaverde Group (n=115)
Ferron Sandstone Member of Mancos Shale (n=19)
Mancos Shale (n=3)
Q (gpm)
Silica
Valley Fill (n=39)
Flagstaff Limestone (Eocene-Paleocene) (n=13)
North Horn Formation (Paleocene-Upper Cretaceous) (n=67)
Price River Formation of Mesaverde Group (n=39)
Castlegate Sandstone of Mesaverde Group (n=30)
Blackhawk Formation of Mesaverde Group (n=83)
Star Point Sandstone of Mesaverde Group (n=24)
Ferron Sandstone Member of Mancos Shale (n=38)
Mancos Shale (n=6)
Si (mg/L)
Sulfate
Valley Fill (n=330)
Flagstaff Limestone (Eocene-Paleocene) (n=42)
North Horn Formation (Paleocene-Upper Cretaceous) (n=732)
Price River Formation of Mesaverde Group (n=128)
Castlegate Sandstone of Mesaverde Group (n=231)
Blackhawk Formation of Mesaverde Group (n=846)
Star Point Sandstone of Mesaverde Group (n=128)
Ferron Sandstone Member of Mancos Shale (n=108)
Mancos Shale (n=6)
SO4 (mg/L)
Turbidity
Valley Fill (n=12)
Price River Formation of Mesaverde Group (n=1)
Castlegate Sandstone of Mesaverde Group (n=1)
Blackhawk Formation of Mesaverde Group (n=149)
Turb (Turb. Units)

Groundwater Chemistry by Geologic Formation



APPENDIX C

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

WETLANDS AND DEEPWATER HABITATS CLASSIFICATION

System: L - Lacustrine

Subsystem: 1 - Limnetic

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular

Subsystem: 2 - Littoral

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent

System: P - Palustrine

Class	RB – Rock Bottom	UB – Unconsolidated Bottom	AB – Aquatic Bed	US – Unconsolidated Shore	ML – Moss-Lichen	EM – Emergent	SS – Scrub-Shrub	FO – Forested
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	1 Moss 2 Lichen	1 Persistent 2 Nonpersistent 5 *Phragmites australis*	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen	1 Broad-Leaved Deciduous 2 Needle-Leaved Deciduous 3 Broad-Leaved Evergreen 4 Needle-Leaved Evergreen 5 Dead 6 Deciduous 7 Evergreen

System: R - Riverine

Subsystem: 1 - Tidal; 2 – Lower Perennial; 3 – Upper Perennial; 4* - Intermittent; 5** – Unknown Perennial

Class	RB*** – Rock Bottom	UB – Unconsolidated Bottom	SB****– Streambed	AB – Aquatic Bed	RS – Rocky Shore	US – Unconsolidated Shore	EM – Emergent
Subclass	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic	1 Bedrock 2 Rubble 3 Cobble-Gravel 4 Sand 5 Mud 6 Organic 7 Vegetated	1 Algal 2 Aquatic Moss 3 Rooted Vascular 4 Floating Vascular	1 Bedrock 2 Rubble	1 Cobble-Gravel 2 Sand 3 Mud 4 Organic 5 Vegetated	2 Nonpersistent

* **Intermittent** is limited to the **Streambed** Class;
** **Unknown Perennial** is limited to **Unconsolidated Bottom** Class code **R5UB** only
** **Rock Bottom** is not permitted for the **Lower Perennial** Subsystem;
**** **Streambed** is limited to **Tidal** and **Intermittent** Subsystems

MODIFIERS

In order to more adequately describe the wetland and deepwater habitats, one or more of the water regime, water chemistry, soil, or special modifiers may be applied at the class or lower level in the hierarchy. The farmed modifier may also be applied to the ecological system.

Water Regime	Special Modifiers	Water Chemistry		Soil
Nontidal		**Halinity/Salinity**	**pH Modifiers for all Fresh Water**	
A Temporarily Flooded	b Beaver	1 Hyperhaline / Hypersaline	a Acid	g Organic
B Seasonally Saturated	d Partly Drained/Ditched	2 Euhaline / Eusaline	t Circumneutral	n Mineral
C Seasonally Flooded	f Farmed	3 Mixohaline / Mixosaline (Brackish)	i Alkaline	
D Continuously Saturated	m Managed	4 Polyhaline		
E Seasonally Flooded/Saturated	h Diked/Impounded	5 Mesohaline		
F Semipermanently Flooded	r Artificial Substrate	6 Oligohaline		
G Intermittently Exposed	s Spoil	0 Fresh		
H Permanently Flooded	x Excavated			
J Intermittently Flooded				
K Artificially Flooded				

Modified from: Classification of Wetlands and Deepwater Habitats of the United States, Cowardin and others, 1979 (modified to exclude tidal wetland systems and water regimes)

NWI Water Regime Restriction Table

Class/Subclass	Code	Riverine			Lacustrine				Palustrine	
		Lower Perennial R2	Upper Perennial R3	Intermittent R4	Limnetic L1		Littoral L2		P	
ROCK BOTTOM	RB		F G H		V	G H K	T V	F G H K		F G H K
Bedrock	RB1		F G H		V	G H K	T V	F G H K		F G H K
Rubble	RB2		F G H		V	G H K	T V	F G H K		F G H K
UNCONSOLIDATED BOTTOM	UB	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Cobble-Gravel	UB1	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Sand	UB2	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Mud	UB3	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Organic	UB4	F G H			V	G H K	T V	F G H K	T V	F G H K
AQUATIC BED	AB	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
Algal	AB1	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Aquatic Moss	AB2	F G H	F G H		V	G H K	T V	F G H K	T V	F G H K
Rooted Vascular	AB3	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
Floating Vascular	AB4	C F G H	C F G H		V	G H K	Q R T V	C F G H K	R T V	C F G H K
STREAMBED	SB			A C J						
Bedrock	SB1			A C J						
Rubble	SB2			A C J						
Cobble-Gravel	SB3			A C J						
Sand	SB4			A C J						
Mud	SB5			A C J						
Organic	SB6			C						
Vegetated	SB7			A C J						
ROCKY SHORE	RS	A C	A C				Q	A C J K		
Bedrock	RS1	A C	A C				Q	A C J K		
Rubble	RS2	A C	A C				Q	A C J K		
UNCONSOLIDATED SHORE	US	A C E J	A C E J				Q	A C E J K	R S	A C E J K
Cobble-Gravel	US1	A C J	A C J				Q	A C J K	R S	A C J K
Sand	US2	A C J	A C J				Q	A C J K	R S	A C J K
Mud	US3	A C J	A C J				Q	A C J K	R S	A C J K
Organic	US4	E	E				Q	E		E
Vegetated	US5	A C J	A C J				Q	A C J K		A C J K
MOSS-LICHEN	ML									B C D E
Moss	ML1									B C D E
Lichen	ML2									B C D E

Saltwater Tidal = **BROWN** Water Regimes; Freshwater Tidal = **BLUE** Water Regimes; Nontidal = **RED** Water Regimes.

		Riverine			Lacustrine		Palustrine
		Lower Perennial	Upper Perennial	Intermittent	Limnetic	Littoral	
Class/Subclass	**Code**	R2	R3	R4	L1	L2	P
EMERGENT							
Persistent	EM1						R S T A B C D E F J K
Non persistent	EM2	F G H				Q T V F G H K	T V F G H K
Phragmites australis	EM5						R S T A B C D E F K
SCRUB-SHRUB							
Broad-Leaved Deciduous	SS1						R S T A B C D E F J K
Needle-Leaved Deciduous	SS2						R S T A B C D E F J K
Broad-Leaved Evergreen	SS3						R S A B C D E K
Needle-Leaved Evergreen	SS4						R S A B C D E K
Dead	SS5						T V F G H K
Deciduous	SS6						R S T A B C D E F J K
Evergreen	SS7						R S A B C D E K
FORESTED							
Broad-Leaved Deciduous	FO1						R S T A B C D E F K
Needle-Leaved Deciduous	FO2						R S T A B C D E F K
Broad-Leaved Evergreen	FO3						R S A B C D E K
Needle-Leaved Evergreen	FO4						R S A B C D E K
Dead	FO5						T V F G H K
Deciduous	FO6						R S T A B C D E F K
Evergreen	FO7						R S A B C D E K

Saltwater Tidal = **BROWN** Water Regimes; Freshwater Tidal = **BLUE** Water Regimes; Nontidal = **RED** Water Regimes.

Modified from: Data Collection Requirements and Procedures for Mapping Wetland, Deepwater, and Related Habitats of the United States (version 2) Table Revised August 31, 2015 (modified to exclude tidal wetland systems and water regimes)

APPENDIX D

WETLAND SUMMARY TABLES BY HUC 10 AND HUC 12

Total acres of wetlands mapped by National Wetland Inventory summarized by HUC 10

HUC 10 Name	Emergent Wet Meadow	Emergent Marsh	Lacustrine (Reservoir)	Lacustrine Shore	Palustrine (Pond)	Stock pond or Small Reservoir	Scrub-Shrub	Forested	HUC 10 Total Wetland by Type
Cottonwood Creek	807.9	7.7	1027.6	140.8	40.7	34.8	110.1	3	2172.7
Ferron Creek	237.2	11.2	159.5		59.1	8.1	41.6		516.6
Gordon Creek		0.3				0.1	0	11.4	11.9
Headwaters Muddy Creek	169.6	8.6	45.4	35.7	43.8	17.8	33.6	1.6	356.2
Huntington Creek	889.5	9.2	885.3	34.8	28.1	5.8	132.3	8.6	1993.5
Ivie Creek	4.7	0.2			0.4	0.4	0		5.7
Lower San Pitch River	113.1	4.1	6		41	11	18.6	1.1	194.8
Middle San Pitch River	20.9	2.7			17	3.4	28.3		72.3
Miller Creek	0.8					0.4	0		1.1
Salina Creek	6.2	0.3	6	5.2	3.8	13.4	0		35
Scofield Reservoir	653.7	6	123	29.9	10	7.2	362.3		1192.2
Soldier Creek	8.8	0.6	21.5		0.6	0.3	24.6		56.3
Thistle Creek							7.1		7.1
Twelvemile Creek	116.1	8.7	31.9		72.6	30.7	20.3		280.3
Upper San Pitch River	7.3				0.1		0		7.4
Total Wetland Type	3035.7	59.6	2306.2	246.4	317.1	133.5	778.8	25.7	6903

Total acres of wetlands mapped by National Wetland Inventory summarized by HUC 12

HUC 12 Name	Emergent Wet Meadow	Emergent Marsh	Lacustrine (Reservoir)	Lacustrine Shore	Palustrine (Pond)	Stock pond or Small Reservoir	Scrub-Shrub	Forested	HUC 12 Total Wetland by Type
Beaver Creek	99.8	5.8	45.4	35.7	33.4	13.9	23.4	1.6	258.9
Big Bear Creek	70.3	2.7	37.4		13.7	3.4	6.7		134.3
Birch Creek-San Pitch River	1.4						0		1.4
Box Canyon-Muddy Creek	12.8	0.6				3.9	0		17.3
Canal Creek	2.2	0.2			1.5		0		3.8
Cedar Creek	5.6	0			0.2	0.1	0		5.9
Clawson Spring-Miller Creek	0.8					0.4	0		1.1
Clear Creek-Twelvemile Creek	35.4	0.2			17.9	16.1	1.5		71.1
Cottonwood Canyon-San Pitch River	0.6						0		0.6
Dry Canyon-San Pitch River	5.4				9.4	0.9	22.4		38.1
Dry Creek-San Pitch River	2						0		2
Ephraim Creek	12.7	2.5			6.1	2.4	5.9		29.7
Ferron Reservoir-Ferron Creek	125.3	5.2	111.6		35	4.1	31.1		312.4
Fish Creek	54.2				5.8		73		133
Gooseberry Creek	587.5	6	123	29.9	3.2	6.2	195.8		951.4
Grimes Wash	3.7	0.5				1.5	0		5.7
Headwaters Twelvemile Creek	47.2	7.4			23.2	2.9	17.7		98.4
Horse Creek	57	2.3			10.5		10.2		80
Huntington Lake-Huntington Creek	14.7				0.9	0.1	0	6	21.7
Indian Creek	454.6				0.2	0.2	44.7		499.8
Lake Fork	2.5	0.6	21.5		0.4		0		25
Left Fork Huntington Creek	549	7.2	453.7	34.8	25.7	1.8	96.7	2.6	1171.5
Lower Soldier Creek	4.3						0		4.3
Lowry Water	168.9	4.1	406.6	65.8	18.4	21.2	26.1	0.7	711.7
Manti Canyon	22.6	0.8	6		9.3	9.7	3.1	1.1	52.6
Mill Fork						0	0		0
Miller Fork Canyon-Huntington Creek	7.3				0.5	0.4	0		8.2
Millsite Reservoir-Ferron Creek	41.6	3.2	10.5		10.3	0.5	3.8		69.9
Mud Creek	1				0.3	1	0		2.2
Mud Water Canyon		0.3				0.1	0	11.4	11.9
North Fork Quitchupah Creek	4.7	0.2			0.4	0.4	0		5.7
North Hollow-Twelvemile Creek	4.2					0.2	1.1		5.5
Oak Creek-San Pitch River	0.1						0		0.1
Pigeon Creek	0.3						0		0.3
Pontown Creek-Fish Creek	11				0.8	0.1	93.6		105.5
Right Fork Huntington Creek	316.1	1.9	431.6		0.8	3.5	35.5		789.5
Seely Creek	91.1		249.7	32	7.4	9.2	35.8		425.2
Sixmile Creek	90.5	3.3			31.7	1.3	15.5		142.2
Skumpah Creek-Salina Creek	6.2	0.3	6	5.2	3.8	13.4	0		35
South Fork	29.4	1.2	31.9		31.5	11.5	0		105.4
Starvation Creek	2				0.2	0.3	24.6		27
Straight Canyon	77.2	1.6	371.2	43	12.8	1.3	3.5	2.4	513.1
Upper Cottonwood Creek	11.5	0.4			0.2	0.5	0		12.6
Upper Oak Creek	0.2					0.1	0		0.3
Upper Rock Canyon Creek	0.9	1.1			1.6	0.9	0		4.5
Upper Thistle Creek							7.1		7.1
Total Wetland Type	3035.7	59.6	2306.2	246.4	317.1	133.5	778.8	25.7	6903

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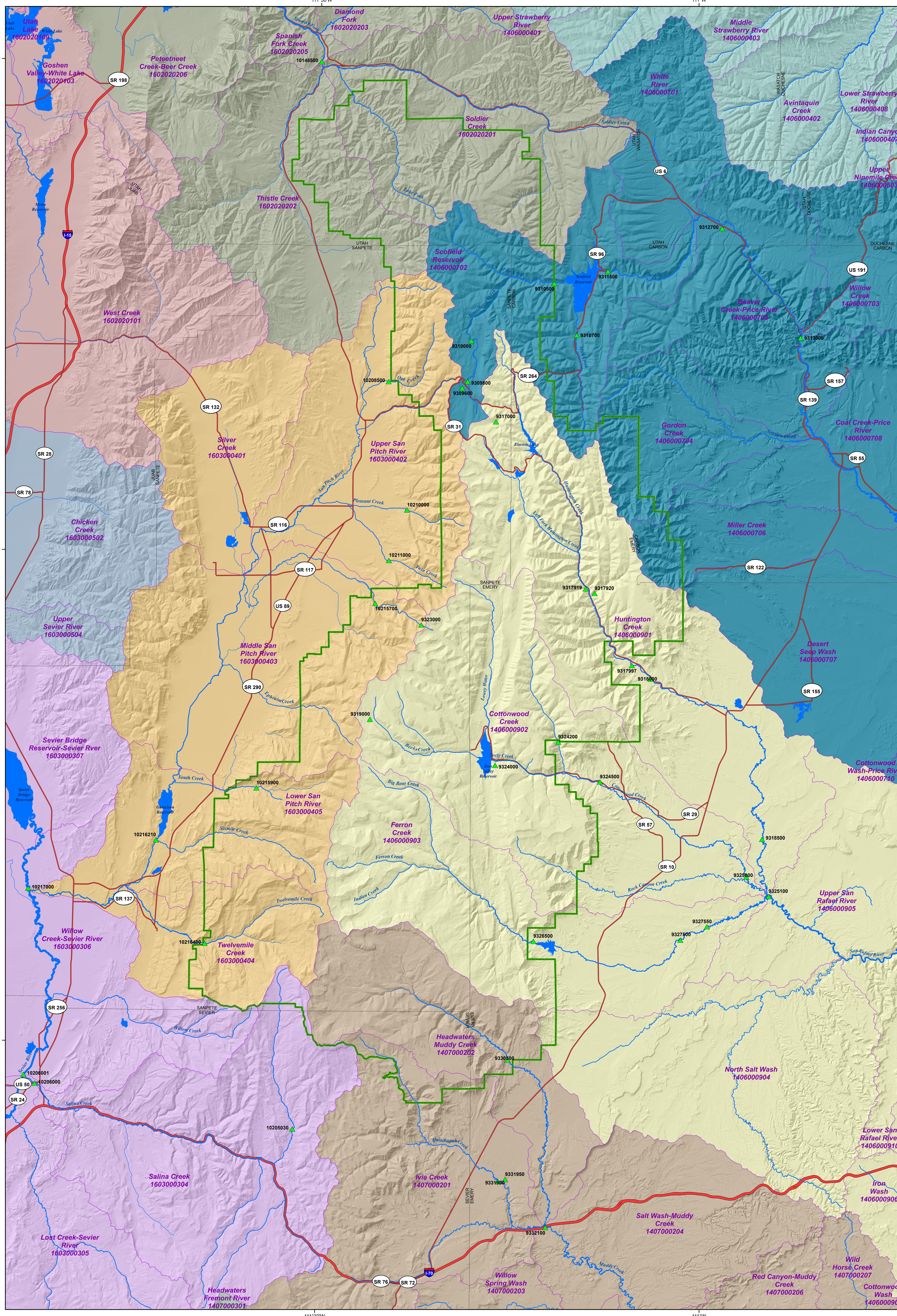


Hillshade from Utah Automated Geographic Reference Center (Based on USGS NED)
Projection: Universal Transverse Mercator, 1983 North American Datum
Cartography by Paul Inkenbrandt

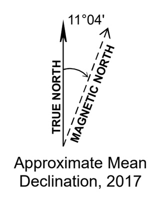
Hydrologic Unit Boundaries of the Wasatch Plateau

by
Paul Inkenbrandt

1:200,000

10 5 0 10 Miles

10 5 0 10 Kilometers



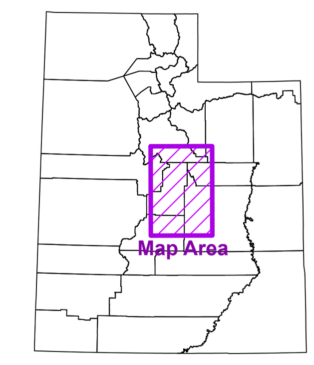
Approximate Mean Declination, 2017

Explanation

Stream mean annual flow (cfs)
- 0 - 40
- 41 - 166
- 167 - 374
- 375 - 652
- 653 - 939

- USGS surface gage (station id)
- Lake
- Manti LaSal National Forest boundary for the Wasatch Plateau
- Interstate
- State Highway
- Counties
- HUC 10 boundary

Watershed (HUC 8)
- 14060004
- 14060005
- 14060007
- 14060009
- 14070002
- 14070003
- 16020201
- 16020202
- 16030003
- 16030004
- 16030005



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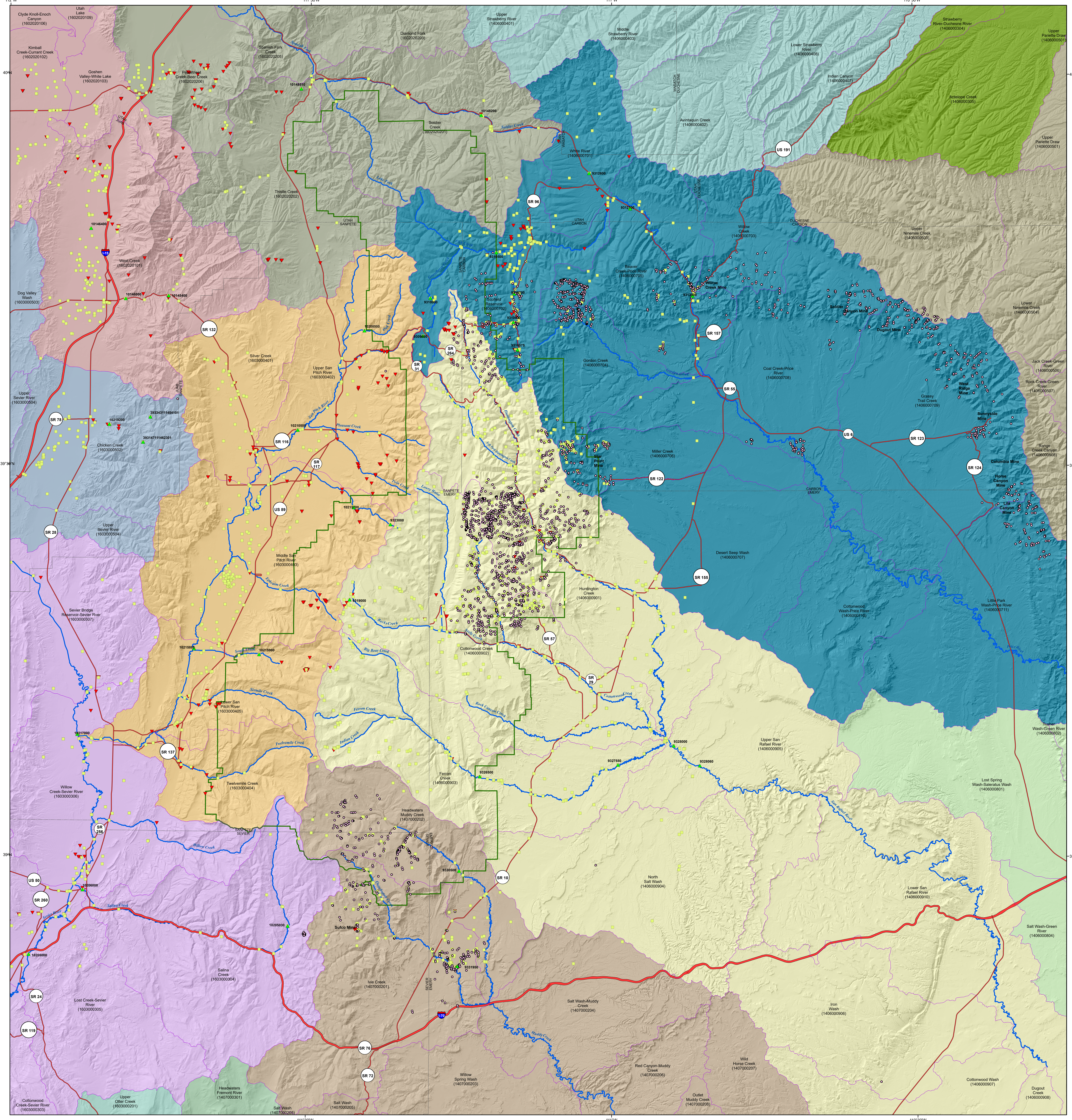
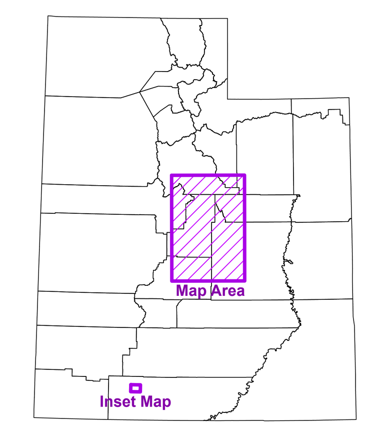
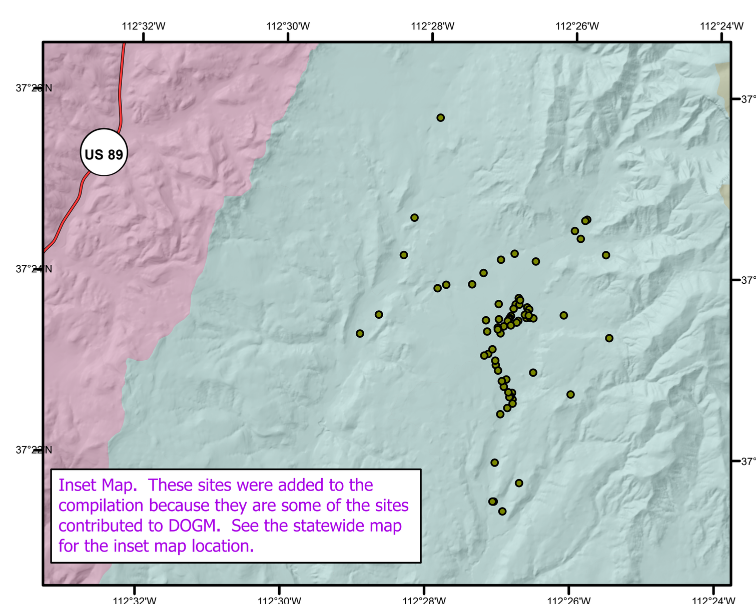
Locations of Utah Division of Oil, Gas and Mining Monitoring Points

Cartography and compilation by Paul Inkenbrandt







Explanation

- U.S. Geological Survey (USGS) stream gage (station id)
- Utah Division of Oil, Gas and Mining (UDOGM) station
- Water Quality Portal (WQP) station
- Utah Division of Drinking Water (SDWIS) station
- HUC10 Boundary
- Manti LaSal National Forest boundary for the Wasatch Plateau
- Interstate
- State Highway
- Major Stream
- Counties

Watershed (HUC 8)

14060003
14060004
14060005
14060007
14060008
14060009
14070002
14070003
16020201
16020202
16030002
16030003
16030004
16030005

Inset Map Watershed (HUC8)

15010003
15010008
16030002

Hillshade from Utah Automated Geographic Reference Center (Based on USGS NED)
Projection: Universal Transverse Mercator, 1983 North American Datum
Cartography by Paul Inkenbrandt

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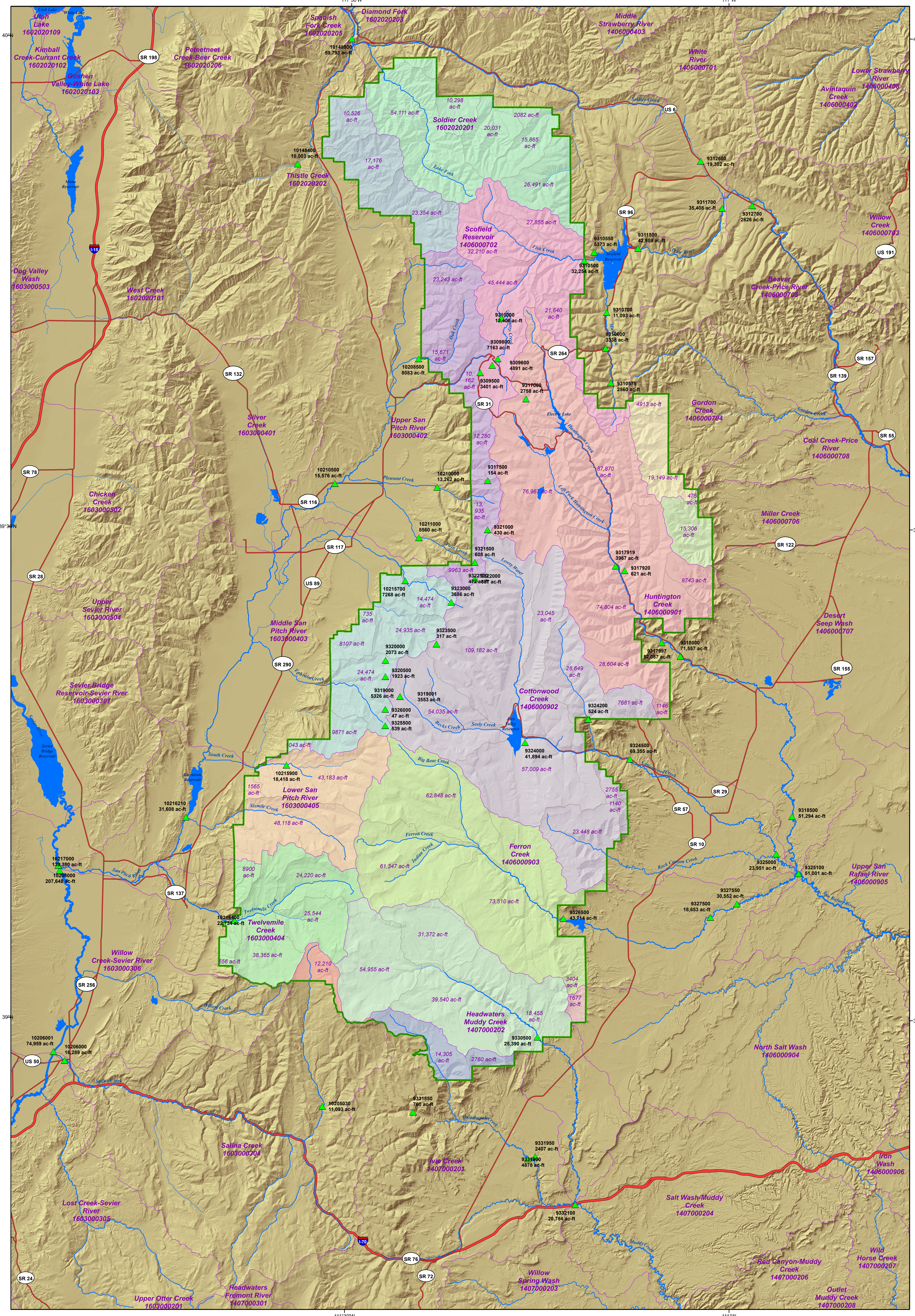

Hillshade from Utah Automated Geographic Reference Center (Based on USGS NED)
Projection: Universal Transverse Mercator, 1983 North American Datum
Cartography by Paul Inkenbrandt

Precipitation and Flow Volumes of the Wasatch Plateau

Cartography and compilation by Paul Inkenbrandt

1:200,000

10 5 0 10 Miles

10 5 0 10 Kilometers

Approximate Mean Declination, 2017

Explanation

Stream mean annual flow (cfs)
- 0 - 40
- 41 - 166
- 167 - 374
- 375 - 652

- USGS surface gage (station id)
- Lake
- Manti LaSal National Forest boundary for the Wasatch Plateau
- Interstate
- State Highway
- HUC 10 Boundary

HUC 10

1406000702	1406000903	1603000304
1406000704	1406000904	1603000402
1406000706	1407000201	1603000403
1406000901	1407000202	1603000404
1406000902	1602020201	1603000405
	1602020202