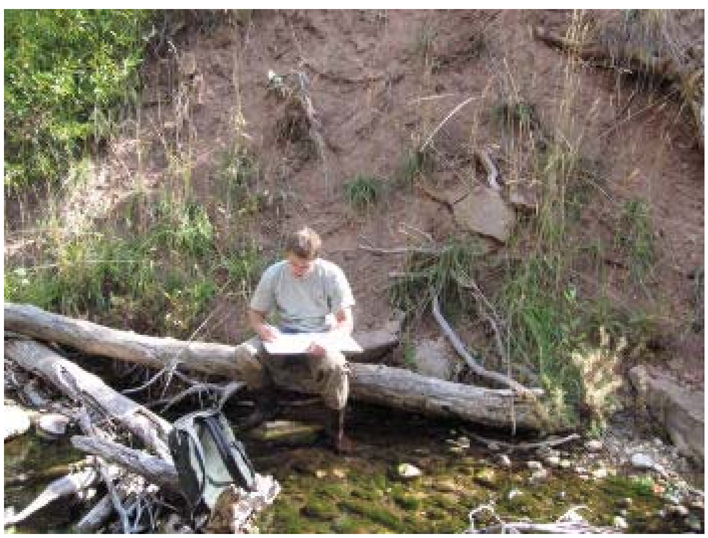
APPENDIX G—EHI/SFI

This appendix contains the protocol for the Ecosystem Health Index (EHI) and Stream Function Index (SFI). Additionally, this appendix includes contains a descriptions of the targets for the EHI and SFI.

Staff collecting stream data for EHI/SFI



Staff collecting stream data for EHI/SFI

Stream Function Index for Salt Lake County, Utah

Methodology

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Acknowledgements
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INTRODUCTION

The Stream Function Index (SFI) is the monitoring tool for watershed managers to achieve the goals of the Salt Lake Countywide Water Quality Stewardship Plan. It is intended to measure the effectiveness of watershed management and be an indication of the general health of the Jordan River and major streams in Salt Lake County. The Stream Function Index examines selected physical, biological and chemical parameters of the river and stream corridors. The SFI also includes the social aspects of aesthetics and recreation along the stream corridors which is used as an indicator of the degree of success that the watershed is used as an amenity for the county's population.

Streams are the visible evidence of their watershed and are indicators of watershed management issues as well as stream stewardship. A watershed is typically identified by its stream or river. Most often the stream or river corridor is the focus of human use for its water and other resources for business, industry, housing and recreation within the watershed. In Utah's arid landscape, stream and river corridors are important wildlife habitat attracting wildlife for food, water, cover and travel corridors.

SETTING

A variety of stream types and conditions exist in Salt Lake County which makes monitoring stream conditions a challenge. The County is divided east and west by a major river with its tributaries reaching from mountain wilderness to highly urbanized cityscapes or fast growing suburban areas. Streams in the northwest area of the county flow north to Great Salt Lake. (Figure 1.) The river and tributaries all vary in character depending on size, water flows, geology, soils, elevation and landuse.

The SFI protocol is designed to include an evaluation of natural as well as man-made conditions of urbanized watersheds. Most existing stream assessment protocol were originally designed for forest or rangelands. Adding an urban element was a challenge that needed to be met in order to realistically characterize the conditions of both the upper non-urbanized and the lower urbanized stream segments in Salt Lake County. The urbanized sub-watersheds have more impervious surfaces and typically have altered and built upon natural floodplains. In addition, riparian vegetation is removed or extremely altered into domestic landscapes, and stabilization structures hold the bank in place rather than vegetation. Road crossings and buildings often define the limits of lateral stream movement. Sediment and debris are removed to keep channels open for flood conveyance. Stream channel characteristics are shaped by the altered water flows including surface diversions, ground water withdrawal and storm water conveyance. Streams continue to downcut due to many of the factors described above, becoming more entrenched and difficult to stabilize.

Twenty five streams and the Jordan River were evaluated in the SFI (Figure 2.) The streams were divided into segments according their location; being in the mountains or the valley. Tributaries of streams within a sub-watershed were rated individually. The Jordan River was divided into upper, middle and lower segments. Each segment was evaluated and given a score. If the stream had an upper and lower segment, those scores can also be combined into a single score. All streams were rated only for relevant conditions so in cases of intermittant or dewatered streams, fish habitat data was not collected.

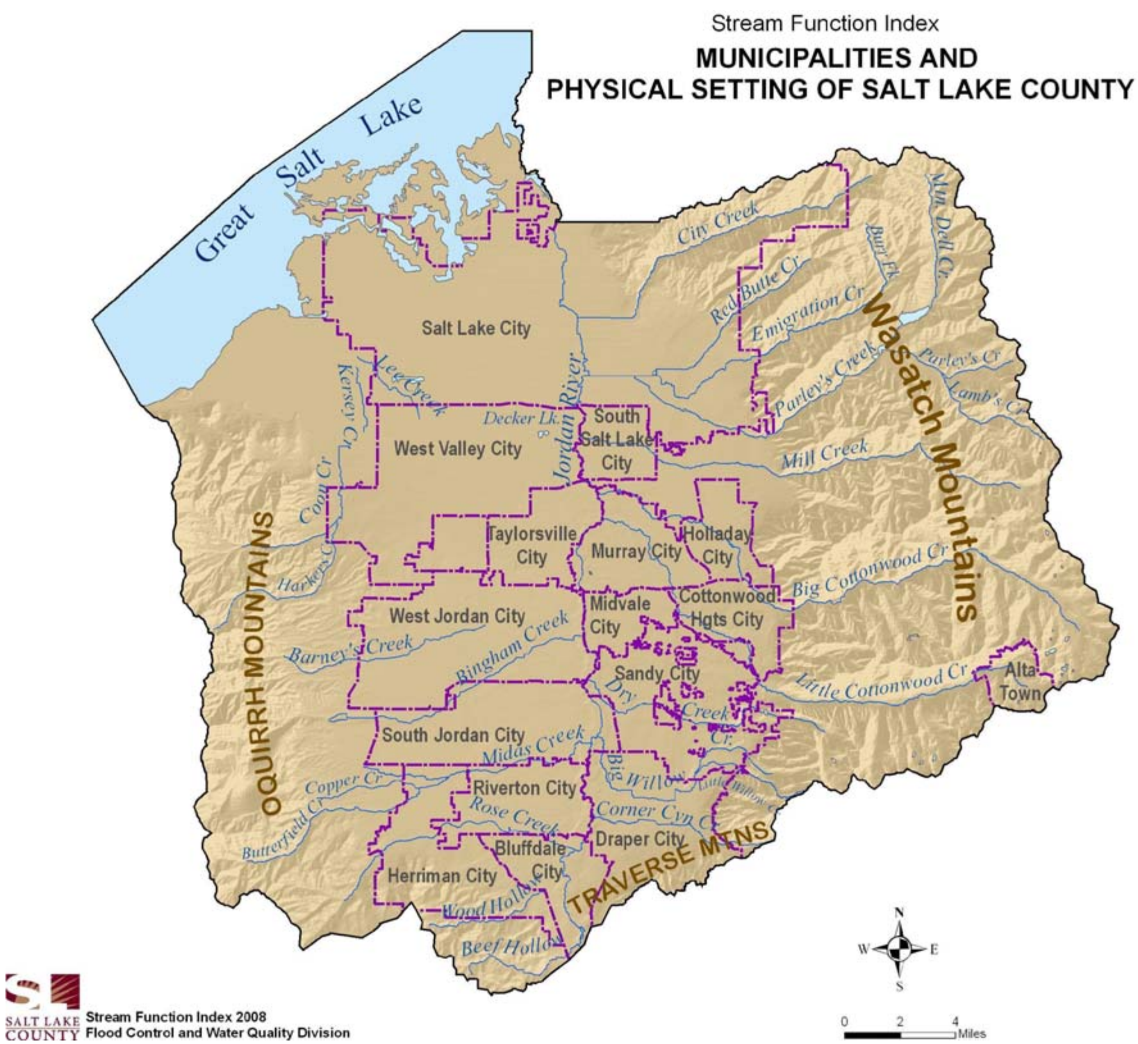

Figure 1. Map showing municipalities and the physical setting of Salt Lake County.

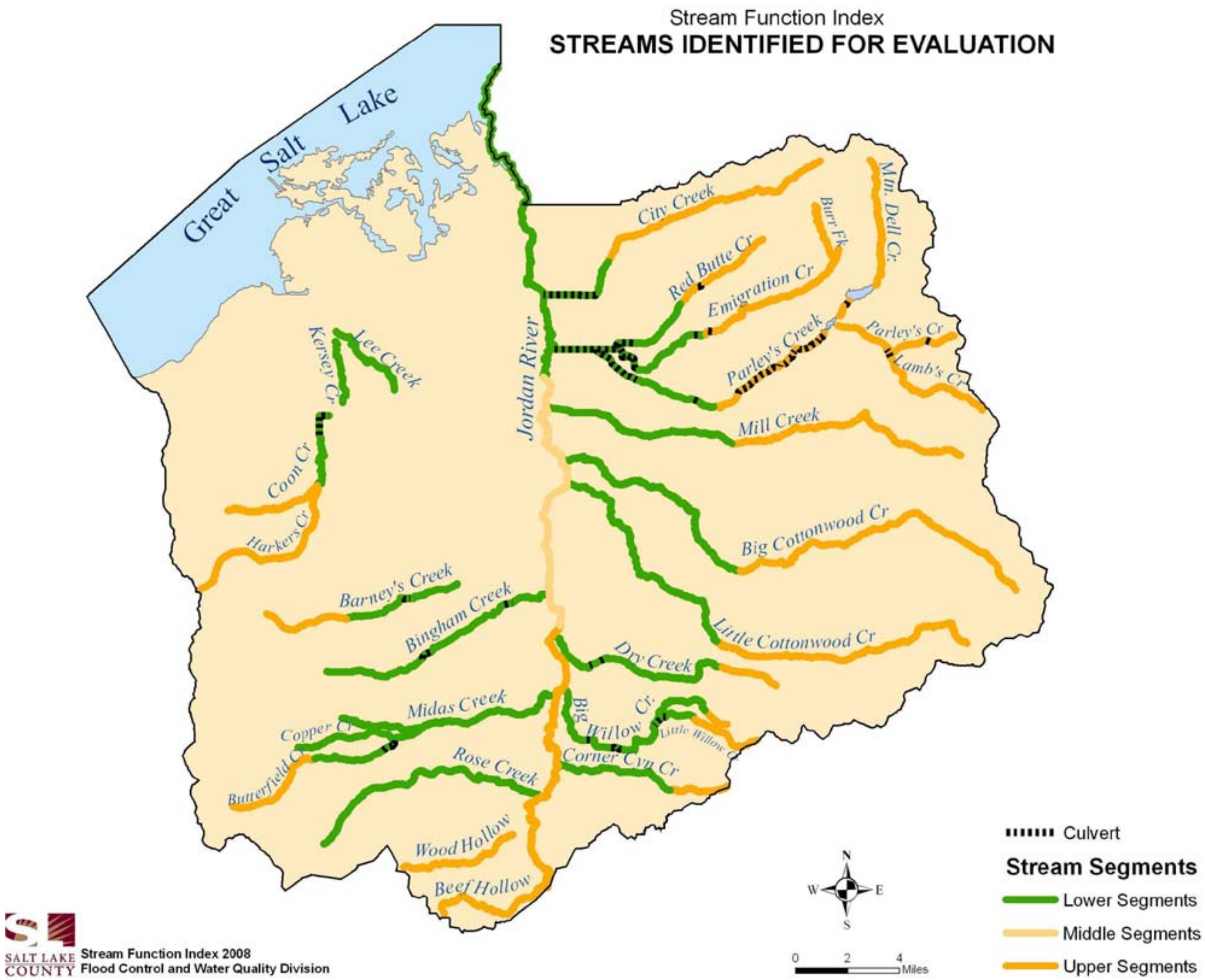

Figure 2. Map showing streams selected for evaluation. Streams were divided into upper and lower segments. The Jordan River was divided into upper, middle and lower segments.

BACKGROUND

The SFI is used to monitor stream functions that defines a healthy watershed as outlined in the Chapter 2 of the WaQSP: Habitat (aquatic and terrestrial), Hydrologic (flood conveyance and stream stability), Water Quality and Social (recreation and aesthetics.) The current Index uses data from existing water quality monitoring and rapid assessments of aquatic and terrestrial habitats, flood conveyance, stream bank stability, recreation and aesthetics. Stream data was collected from 2003 to 2007. The SFI monitoring will continue when the WaQSP is updated ever 6 years.

The SFI is intended to give watershed and stream managers an overview of watershed conditions in order to identify steps to improve or preserve those conditions. As projects are identified, more detailed studies may be required to fully assess the condition of the watershed. All SFI results are intended to be shared in cooperation with the public, cities and agencies. Salt Lake County will also use the index to improve its stewardship of waterways throughout the County.

This document describes the general SFI methodology. Analysis of the data is on-going and results will be published later in the summer of 2008 in a separate report.

METHODOLOGY

The methodology of the SFI includes two phases. One is the data collection, and the other is the method of calculating the scores.

DATA COLLECTION

The data collection effort had to meet the following criteria:

1) To accurately define progress towards goals and objectives of the WaQSP implementation.
2) Provide repeatable quantitative measurements and rapid assessments.
3) Is not time or cost prohibitive.
4) Rapid assessment data can be collected by trained non-professional personnel within one or two field seasons.
5) Able to capitalize upon outside existing data sets.

All of this information is gathered and entered into a geodatabase using ArcGIS. The data is mapped, analyzed and prepared for the next phase. The data is then entered into an Excel spreadsheet that calculates the final score; the scores are then entered into GIS to map. Both the geodatabase and the spreadsheet were developed specifically for the county's unique needs. However, they can be used as a template and adjusted for application to other watersheds. Files of the SFI results will be posted on the Salt Lake County website.

The Stream Function Index is a useful and flexible tool for watershed management. It calculates data results to obtain an overall grade. In addition, data can be backtracked to find metric scores for individual reaches. Reach data can help to prioritize specific areas that need improvement projects or special management needs. The data is also attached to a physical location through GIS that enables a visual display of data through mapping.

The Stream Function Index contains two sets of data: the first is the Ecosystem Health Index (EHI) that summarizes the physical, chemical and biological parameters through Habitat, Hydrology and Water Quality metrics, the second is the Social parameter which includes Aesthetics and Recreation metrics. Together, these create the basis of the Stream Function Index.

One of the key elements to providing a relevant SFI score is the use of targets. Data is evaluated against a target for a particular metric and stream segment. For instance, the valley and mountain segment of Big Cottonwood Creek will have different targets for recreation opportunities, given the different nature of these segments. Targets are used to establish what are reasonably accepted conditions based on stream type, water flows, scientific literature, knowledge of the project area and management objectives. The targets may change over time based on a change in expectations, or from any one of the sources mentioned above. Targets are addressed in detail in Targets for the Stream Function Index (see Appendix XX).

The following summarizes the methodology:

HABITAT

This stream functional group examines ecosystem components that contribute to aquatic and terrestrial habitat values of the stream channel and riparian corridor. Table 1 includes the sub-groups and individual metrics used to calculate the Habitat index score. Two sub-groups contribute to the Habitat Index Score including Stream Channel and Riparian Corridor. Metrics included in the Stream Channel sub-group measure channel features that provide structural habitat for fish and aquatic species. Similarly, metrics in the Riparian Corridor sub-group provide an indication of vegetative features that provide habitat for wildlife, specifically avian species and shade for aquatic species.

Table 1. Sub-groups and individual metrics used to calculate the Habitat index score.

Stream Functional Group	Sub-group	Metric
Habitat Index Score	Stream Channel	Pool/Riffle ratio
		Water depth
		Fish passage
		Habitat structures
		Flow Diversion
	Riparian Corridor	Width
		Community Type

The metrics selected for stream channel habitat look at selected critical parameters for viable fish and wildlife habitat in Salt Lake County streams. The metrics are measured with rapid field assessment techniques in line with the overall purpose, resources and time for this endeavor. More detailed assessments would be required for any project aimed at improving habitat conditions.

Fish habitat data was to be collected from all stream segments in the County that have been identified as having year round flows and reported as having fish present or having potential fish populations. Data was planned to be collected during August through mid-September which is considered to be the most environmentally stressful time of the year for fish and wildlife due to low flows (Binns, 1982.) The low flows also allow the condition of the channel to be more easily measured and assessed. Field data collection was suspended during brief high water resulting from storm events. Low flows are particularly significant in Salt Lake County streams due to water diversions through summer as well as recent drought conditions. The drought in 2007 resulted in water levels staying low through September due to lack of precipitation. Field personnel were able to continue fish habitat assessment longer than a more normal precipitation year.

The criteria for the rapid assessment of the riparian habitat was oriented toward riparian use by avian species including neo-tropical migrants. Within the Great Basin, 82% of the total species of birds are either totally or partially dependent on riparian habitats (Ohmart and Anderson, 1982.) Gardner, et. al. (1999) in their book *A Handbook of Riparian Restoration and Revegetation for the Conservation of Land Birds in Utah with Emphasis on Habitat types in Middle and Lower Elevations* for their purposes used the Arizona Riparian Coalition (Lofgren et al., 1990) definition of riparian. That definition includes not only areas of land directly influenced by permanent water (BLM, 1990) but also habitats associated with floodplains, terraces, and ephemeral and washes.

STREAM CHANNEL

Pool/Riffle Ratio

Description: Natural streams are generally composed of two features, pools and riffles. Pools and riffles generally occur at a spacing of five to seven times the channel width (Leopold, 1994). Several types of pools and riffles occur, depending on stream type and gradient. Although an equal amount of both habitat types is generally considered optimal for a sport fishery, higher gradient streams will generally have lower pool/riffle ratios than low gradient streams. The habitat type of low gradient pools and riffles were selected to be tallied during late summer low flows. High gradient pools and riffles including step pools were not counted. The low gradient pools and riffles are the type of habitat features that are more a feature of the B, C, E, and F stream types than of the A and G stream type (Rosgen, 1996.) They are also the type of habitat where a stream restoration project could successfully be used to enhance fish habitat.

Low gradient riffles are a fast, non-turbulent aquatic habitat type (USFS, 1997.) Water flows swiftly over completely or partially submerged obstructions to produce surface agitation. The gradient is less than 4%, and the substrate is usually gravel, cobble dominated. Pools counted for the pool/riffle ratio are slow water, scoured and dammed habitat types greater than 12" in depth. Dammed pools are formed by downstream damming action. Typically, the deepest area of a dam pool is on the downstream end of the pool. The dam is formed by large woody debris, boulder, artificial structures, beaver, landslide debris or other. Scour pools are formed by scour action when flowing water impinges against and is diverted by a streambank or channel obstruction. Scour pools can be positioned as a result of large woody debris, boulder, artificial structure, bedrock, tributary, meander, culvert, beaver and other. The substrate in pools is primarily silt and sand.

Benefit: A good pool/riffle ratio is important for many fish species. Pools are used by fish during periods of seasonal low flow, as resting points while moving upstream, or as winter habitat. The transition point between pools and riffles is used for spawning purposes by some fish species, due to the moderate-sized substrate in these areas. Riffle areas introduce oxygen into the water, provide habitat for macroinvertebrates, and are primary areas for feeding and travel and some spawning.

Measurement: These features were tallied during late summer 2007 low flow when differences in channel substrate and water depth were easily observed. The number of pools and riffles were be tallied while walking the entire stream length. The pool/riffle ratio was calculated by dividing the total number of pools by the number of riffles for each reach. The number of pools is also used in the Index Score calculation (see below).

Index Score and Target: Two scores were used to obtain an index score: 1) the pool count and 2) the pool/riffle ratio. The following calculation was used. The pool/riffle ratio and the pool total receive equal weighting in the score

$$\frac{\left(\left(\frac{Pool}{Riffle}\right)+\left(\frac{PoolCount}{Target}\right)\right)}{2} = IndexScore$$

The target for the pool/riffle ratio is derived from Rosgen's (1996) recommended pools per mile for lower gradient stream types based on measured bankfull width. The target for high gradient stream types was determined by averaging the counted pools per mile of all the A-type reaches in the Wasatch Mountains that were rated good and excellent for stability.

Table 2. The targets for pool counts based on Rosgen (1996).

Pools per Mile	Stream Type	Rosgen's Description
10	A	Steep, entrenched, cascading, step/pool streams
4	B	Moderate gradient, riffle dominated channel with infrequently spaced pools
5	C	Low gradient, point bar, pool/riffle, alluvial channels
5	D	Typically does not have pool/riffles habitat
5	E	Low gradient, meandering pool/riffle channel
5	F	Low gradient, meandering pool/riffle channel
4	G	Moderate gradient step/pool channel

Water Depth

Description: The water depth at low flow is the critical for fish populations. A species specific minimum depth is required to support movement, access to necessary forage, cover, etc. The minimum depth used is required for adult fish of trout and June sucker in perennial tributaries and another for warm water fishery in the Jordan River.

Benefit: Minimum water depth is needed for travel, water temperature and supports food availability.

Measurement: Water depth was identified during the low flow period from August 1 through mid-September. Because of the drought year, measurements were continued until creeks started to rise from precipitation by the end of September 2007. The representative water depth for the reach was recorded.

Index Score and Target: Water depth was evaluated against a minimum target for each reach based on the requirements of the adult of the species. The score is either 0 or 100.

The Utah Sucker and Mountain Sucker generally require a 12-inch minimum depth to thrive. The Utah DWR has identified Utah Sucker in all Jordan River reaches as well as in the lowest reaches of Mill Creek, Big Cottonwood Creek and Little Cottonwood Creek. In addition, the Mountain Sucker has been identified in the lowest reach of Mill Creek and Big Cottonwood Creek. A minimum of 6" is required for trout species found in the Jordan River tributaries.

Table 3. Minimum water depth for target fish species.

Reach	Description	Species Identified	Target
Mill Creek	Jordan River confluence to Scott Ave.	Utah Sucker Mountain Sucker	12 in.
Big Cottonwood Creek	Jordan River confluence to 6200 S.	Utah Sucker Mountain Sucker	12 in.
Little Cottonwood Creek	Jordan River confluence to 2500 E.	Utah Sucker	12 in.
Jordan River (all)	Jordan River from Great Salt Lake to Utah Co.	Utah Sucker	12 in.
Upper City Creek Mountain Dell Creek Lambs Creek Parleys Creek Emigration Creek Red Butte Creek Mill Creek Big Cottonwood Creek Little Cottonwood Creek Upper Butterfield Creek	Headwaters to Memory Grove Park All All Headwaters to 1200 E. Headwaters to 1100 E. Headwaters to 1050 E. Headwaters to Scott Ave. (or 825 E.) Headwaters to 6200 S. Headwaters to 2500 E. 11000 W. to 7930 W.	Rainbow Trout Brown Trout Bonneville Cutthrout Trout	6 in.

Fish Passage

Description: Restriction of fish passage can be identified in the field by abrupt changes in channel elevation or seasonal changes in flow that entirely dewater the channel. These changes can be produced by man-made features such as culverts and dams, or by natural features such as large headcuts or waterfalls. Restriction of fish passage is defined by some government agencies as any change in elevation ranging from 1 to 3 feet or more and is dependent upon the size of fish species present in a particular stream channel. The minimum distance between restrictions that is considered important by the NRCS is 3 to 5 miles (USDA, 1998). In Salt Lake County, the overall goal is to have the existing non-interrupted stream length fish barrier-free. This assures that the greatest distance available is accessible by the fish and is in line with the recommendations by the NRCS.

Benefit: Unrestricted passage of fish along stream channels allows fish to migrate into areas with suitable habitat for spawning of adult fish and growth of juvenile fish. In addition, fish of any life stage can migrate out of areas with less than desirable habitat. Viability of fish populations is dependent on maintaining reproduction and growth of all life stages. If fish can migrate freely, the potential for locating optimal habitat for spawning and growth of life stages is greater than if fish passage is restricted.

Measurement: Restrictions to fish passage were visually identified during low flow field survey efforts. Both natural and man-made barriers were included to generally characterize the potential fish movement within the stream segment. Each restriction was located on aerial photography (and later mapped on GIS) and tallied as a culvert or other feature. Future investigation of the barriers could include a GPS location and further description.

Barriers other than culverts were tallied if any one of the following criteria were met: 1) drop height of 3 feet or greater, 2) plunge pool depth of 1 foot or less at its deepest point, 3) water depth over barrier 2 inches or less and, 4) a beaver dam greater than 4 feet high that is tightly packed (Duff, personal communication 2007.)

A culvert was tallied as a barrier if any one of the following criteria were met: 1) drop height of 3 feet or greater, 2) plunge pool depth of 1 foot or less at its deepest point, 3) water depth over barrier 2 inches or less, 4) the inside surface was smooth or with very little roughness and, 5) culvert gradient greater than 1 percent (Duff, personal communication 2007.)

Index Score and Target: The index score for fish passage is based upon the distance between channel obstructions that limit free passage of fish and evaluated against a minimum distance between obstructions. A total stream barrier free goal, as stated in the description above, would be difficult to show progress over the years of improvement until the entire stream was totally barrier free. Rather a target of ¼ mile (or 1,320 feet) was assigned to track the incremental improvements to achieve the desired total fish barrier-free streams. If the distance between barriers was equal or greater to ¼ mile, then a score of 100 was given. If the distance was less than the target of ¼ mile, the index score was calculated with the following equation:

$$\left(\frac{BarrierFreeLength}{ReachLength}\right) \Big/ \left(\frac{Target}{100}\right) = IndexScore$$

Habitat Structures

Description: In-stream habitat structures can be the result of human efforts or natural processes. Human designed habitat structures include such features as gabions, vortex weirs, drop structures, or any other stream feature designed to provide protection or shelter to aquatic species by deflecting stream flow energy. Natural habitat structures are defined as large woody debris (LWD) located in the stream channel, including trees, root wads, log jams, etc. A working definition of LWD is wood greater than 3 feet in length and more than 4 inches in diameter (Featherston et. al., 1995). A functional definition of LWD suggests a size that will allow it to remain in place long enough to result in some level of hydrologic modification to the stream channel.

Benefit: Habitat structures can result in multiple benefits. These features provide a location for adult aquatic species to rest and a refuge from predators for juvenile species. In-channel habitat structures can also deflect stream-flow energies and minimize erosion from channel banks and substrate.

Measurement: Habitat structures were visually identified and tallied while walking along the stream channel during late summer low flow. The habitat structures were tallied by type for each reach. The structures that were tallied were required to be associated with the existing water level and available to fish for cover or resting. The following table lists the types of structures and criteria:

Table 4. Types of habitat structures counted.

Type of Fish Habitat Structure	Criteria
Imbedded Log	>4 in. diameter and >3 ft. in length
Log Jam	predominantly large log debris (>12 in. diameter) covering entire stream width, or predominantly smaller log debris (<12 in. diameter) covering entire stream width
Rootwad	>4 feet across
Boulders	>2 feet across
Undercut Bank	6 in. or greater horizontal depth and 3 ft. or longer
Beaver Dam	active
Man-made Fish Habitat Structure	functional, or partial functioning with potential for improvement

Index Score and Target: The index score for habitat structures was determined from the percent of stream miles with sufficient habitat structures to dissipate energy, capture bedload, and aid in floodplain development. The number of habitat structures must be appropriate for stream size and ecological setting. Any stream reaches that have sufficient habitat structures along their entire length were assigned a score of 100.

Habitat structure target is based on expected total pool count (same count used for pool/riffle ratio target) for a given stream type. The pools can be considered similar to the habitat structures listed above that provide cover and resting. The index score was calculated with this equation:

$$\left(\frac{TotalStructures}{\mathrm{Re}\,achLength}\right) \Big/ \left(\frac{T\arg et}{100}\right) = IndexScore$$

Flow Diversion

Description: The presence or absence of water in the stream channel critically influences the quality of habitat in the stream corridor. Low-flow impacts to fish habitat are initially experienced in riffle areas and along stream margins. The hydrologic regime for any stream channel is a function of precipitation levels, contributing watershed area, underlying geology, and human influences such as dams and diversions. Stream channels can exhibit natural seasonal patterns of peak flow and base flow in areas where flow diversions are not present. Stream channels can support healthy aquatic populations if minimum flows are sustained during base flow periods. Minimum flows can be established with computer flow models which assess flow scenarios at critical upstream locations (typically riffles) on a stream. If flow can be sustained at these points, it is assumed that sufficient flow will exist downstream to support fish populations. Flow recommendations can be made to sustain a critical depth, wetted perimeter, and/or flow velocity. If stream flows are significantly reduced by diversions, aquatic populations can be impacted. Such impacts can result in death or emigration to more suitable habitat. If flows are reduced over long periods of time, channel encroachment by riparian species can influence stream channel form and function.

Many valley streams on the east side of the project area are heavily developed for municipal and agricultural use. Streams on the west side of the project area are less developed and characterized by intermittent or seasonal flow patterns. Flow in the Jordan River is regulated by discharge from Utah Lake and water reclamation facilities.

Benefit: Natural hydrologic regimes sustain growth of aquatic and riparian communities. Seasonal runoff provides recharge to riparian corridors and adjacent wetland areas that is slowly released during periods of low flow. Constant flow is critical to maintenance of a self-sustaining fish population.

Measurement: To complete the flow diversion index score, two measurements were used including (1) the percent of stream channel maintaining natural flow and (2) the percent of year that natural flow is maintained. Instream flows are characterized in Chap 4.6 of the WaQSP and used as a basis of existing conditions for the SFI. The instream flows and diversions were mapped to show perennial/intermittant/reduced and interrupted conditions. Where return flows, ground water and springs replenished the flow after an interruption, was counted as perennial reduced. Irrigation diversions occur 5 months out of the year between May 1 and Oct 1. That means 58% of the time the stream is free flowing. In addition, diversions for culinary use typically occur all year. In this case, flows would be considered reduced 100% of the time. The condition of instream flows were calculated for each reach. Field surveys verified data during base flow periods.

Index Score and Target: The flow diversion index score was evaluated from an average of two scores which characterize the length of streams maintaining natural flow and the amount of time stream channel reaches maintain a natural flow regime. Any stream reach which exceeds the target value will be assigned a score of 100. After a score has been assessed for each measurement, the average of the two scores will be used for the flow diversion index score. The target for stream flows is 100% natural flow for perennial and intermittant streams. The index score was calculated with the following equation.

$$\left[\left(\frac{NaturalFlow}{ReachLength}\right)\Big/\left(\frac{Target}{100}\right)\times 100\right]+\left[\left(\frac{TimeOfFlow}{Target}\right)\times 100\right]=IndexScore$$

RIPARIAN CORRIDOR

Corridor Width

Description: The width of riparian corridors determines the amount of habitat available for avian and terrestrial species. Urban development has significantly influenced riparian corridor width along valley streams in the County. The demands of human settlement followed by urbanization required the river and streams to be diverted for essential water source as well as channelizing to control overbank flooding, high ground water and channel meandering, and to accommodate development. The impact on riparian areas from dewatering and channelization greatly reduced even the potential that riparian plants can survive along the County's valley waterways. However, in some areas, urban landscape trees add to the riparian species particularly in older neighborhoods. Although not the typical water-reliant riparian species, they provide the avian habitat structure, typically canopy, along the river and stream corridors. In the canyons, road construction is typically the limiting factor of riparian width.

Benefit: Available avian habitat structure is the purpose of measuring riparian vegetation width. However, the existence of naturally developed riparian corridors wide enough to accommodate floodplains and vegetation that can subsequently provide a positive influence on flow, channel stability, and water quality is an important stewardship goal for the County.

Measurement: Riparian corridor width is the distance contiguous and continuous from bankfull edge to the border of riparian vegetation or a landform feature that supports riparian functions. This rapid assessment relied on aerial photography with field verification to show areas of canopy and middle story. The width was identified from aerial photography up to 100 feet from normal high water and digitized to obtain an acreage for each bank and each reach. The acres were divided by the length of the reach to obtain the average width of riparian for each bank. Canopy and middle story could be discontinuous and still be close enough to provide the benefits of a riparian corridor. However, the fragmented canopy in urban residential and commercial areas were not included since the understory vegetation and human activities do not provide the necessary riparian habitat elements. Other areas that were not included contained only dry hillside grass or were devoid of all vegetation. Grasses were included only if that was all that was present along the intermittant streams such as typically found on the west side of the valley.

Index Score and Target: The index score for riparian corridor width was evaluated against a minimum target width of 100 feet from bankfull width on both sides of perennial streams and Jordan River. Measured widths that exceed the target was assigned a score of 100. If the corridor width is less than 100 feet, the index score will be calculated with the equation below.

$$\left(\frac{AverageWidth}{Target}\right)\times 100 = IndexScore$$

Community Type

Description: Riparian cover density provides a measure of the percent composition of trees, shrubs and forbs and grass species within the riparian corridor.

Benefit: In general, an increase in cover density within all vegetation layers results in an increase of habitat for birds. Surrounded by arid uplands and urban development, riparian areas are an avian magnet, resident and migrants alike. A well developed canopy, middle story and understory provide the greatest diversity of habitat structure. The outer edge of the riparian area provides access to other habitats from the safety of its dense foliage. Disturbances of the vegetation layers occurs over time creating a mosaic of openings that also provide critical edge for bird species.

Measurement: The streams were walked and the density for over-, middle- and understory cover was averaged for the reach and recorded as a range between 0-10%, 10-30%, 30-60% and 60-100% for each bank. The average is calculated based on the middle value of each category, e.g., 5=poor, 20=fair, 45=good and 80=excellent.

Index Score and Target: The final community type index score is based on the average score calculated from over-, middle- and understory. The target for all streams is 80, which is the average of the highest range. Although many streams are naturally intermittent on the west side and south-end of the valley, this metric targets a well developed riparian corridor as being the optimum habitat. The following equation calculates the overall density:

$$\frac{\left[\left(\frac{\%Canopy}{Target}\right)\times 100\right]+\left[\left(\frac{\%Middlestory}{Target}\right)\times 100\right]+\left[\left(\frac{\%Understory}{Target}\right)\times 100\right]}{3} = IndexScore$$

HYDROLOGY

This stream functional group examines hydrologic features that contribute to proper conveyance of flood events through the watershed as well as physical stability of the stream network. Table 2 includes the sub-groups and individual metrics used to calculate the Hydrology index score. Two sub-groups contribute to the Hydrology Index Score: Flood Conveyance and Stream Stability. Metrics included in the Flood Conveyance sub-group measure the ability of the stream channel network to transport design storm events through the watershed. Metrics in the Stream Stability sub-group assess bank stability and amount of stream bank stabilization structures.

Table 5. Sub-groups and individual metrics used to calculate the Hydrology index score.

Stream Functional Group	Sub-group	Metric
Hydrology	Flood Conveyance	Floodplain Development
		Floodplain Connectivity
	Stream Stability	Pfankuch Bank Stability
		Hydraulic Alteration

The metrics selected for hydrology looked at selected critical parameters for flood conveyance and stream stability in Salt Lake County streams. The metrics were measured with rapid field assessment techniques in line with the overall purpose, resources and time for this endeavor. More detailed assessments would be required for any project aimed at improving stream conditions.

Data was collected by walking the streams from March through November, 2007. Data collection was suspended during high runoff flows and during high flows from storm events. Stream stability data collected between 2003-2006 were used for some of the East-side valley streams and Emigration Canyon. Streams that were evaluated in August and September for fish habitat were evaluated for stream stability and floodplain connectivity at the same time. Low flows and clear water allow the condition of the channel to be more easily measured and assessed.

FLOOD CONVEYANCE

Floodplain Development

Description: Protection from development within the floodplain area of stream corridors is typically achieved through regulations enforced by local, state, and federal agencies. Development within the floodplain may result in negative impacts on riparian vegetation, soils, channel banks, and flow. This metric is designed to monitor the amount of impervious surface associated with development within the 100-year floodplain adjacent to streams in the project area.

Benefit: Floodplains that have not been developed are more likely to be capable of accommodating flows from storm events. Undeveloped floodplains slow velocities, allow groundwater recharge and maintain riparian vegetation. Development outside of the 100-year floodplain will not be subject to flood events.

Measurement: Development within the 100-year floodplain was measured through the use of GIS, aerial photography and FEMA mapping. The permeable surfaces for each stream segment were digitized from aerial photography (Sept., 2006). The percent of permeable surface within the 100-year floodplain of each reach was calculated.

Index Score and Target: The index score for Floodplain Development indicates the percent of the 100-year floodplain that is not developed with impervious surfaces. Stream corridors with no development within the 100-year floodplain receive a score of 100. If FEMA has not identified a 100-year floodplain, a No Data (ND) was assigned. The target is 100% of the FEMA 100-year floodplain to be permeable. The following equation calculates the index score for floodplain development.

$$\left[\left(\frac{PermeableArea}{TotalFloodplainArea}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

Floodplain connectivity

Description: This metric is designed to assess the level of connectivity between stream channels and their adjacent floodplains. A quantitative measure of floodplain connectivity can be achieved through measuring channel entrenchment which is defined as the vertical containment of a river and the degree to which it is incised into the surrounding valley floor. Entrenchment ratios provide a consistent means of comparing streams and identifying trends. The entrenchment ratio is the width of the flood-prone area divided by the width of the channel at bankfull stage. The flood-prone area generally includes the active floodplain and low terrace landforms adjacent to the channel. Each stream type has is given an entrenchment ratio criteria. Generally, a ratio of 1 indicates an entrenched stream, while ratios greater than 2.2 streams are connected to well developed floodplains.

Benefit: River channels that are connected to adjacent floodplains have a means by which stream energy can be dissipated during peak flow events. As a result, these stream channels are less likely to become entrenched and remain primarily stable, even during extreme flood events.

Measurement: The entrenchment ratio was measured at representative locations within each stream reach. Flood-prone area width was measured at an elevation corresponding to twice the maximum depth of the bankfull channel as indicated by the stage at bankfull discharge.

Index Score and Target: The measurement of floodplain connectivity was evaluated against a target entrenchment ratio for each stream type. Any stream reach with an entrenchment ratio that fell within the target ration was assigned a score of 100. Any stream reach with an entrenchment ratio that fell above or below this value was assigned a score of 0.

Targets for floodplain connectivity are the criteria for each stream type according to Rosgen, (1996.)

Table 6. Rosgen stream type and entrenchment ratios.

Rosgen Stream Type	Entrenchment Ratio
A	1.0 to 1.4
B	1.4 to 2.2
C	>2.2
D	>2.2
E	>2.2
F	1.0 to 1.4
G	1.0 to 1.4

The following equation calculates the index score for floodplain connectivity.

$$\left[\left(\frac{LengthOf\ ReachMeetingStreamTypeTarget}{ReachLength}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

<u>STREAM STABILITY</u>

Pfankuch Bank Stability

<u>Description:</u> An assessment of channel bank stability provides an indication of existing hydrologic concerns. Stream channels with unstable banks can quickly degrade into conditions that require a significant commitment of time and money to repair. Unstable banks cause excessive sediment deposition or excessive erosion causing the channel bed to rise or stream banks to fail. The Pfankuch method of assessing bank stability accounts for stability in the upper and lower banks as well as the channel bottom. Scores are associated with categories in each bank and channel zone and can be adjusted for geomorphic stream type. This adjustment accounts for levels of bank erosion that occur naturally in many stream types and does not indicate bank instability problems. Good stability ratings per Pfankuch for moderate gradient streams are 40–60 and 60–90 for lower gradient streams.

<u>Benefit</u>: Stream channels with stable banks have a positive influence on aquatic species, water quality, aesthetics, and establishment of riparian vegetation. Stream channels that maintain stable banks are capable of efficiently transporting a wide range of flows and sediment loads. Downstream impacts are also minimized for stream reaches that maintain stable banks.

<u>Measurement:</u> Pfankuch bank stability was measured at a representative location on each stream reach, assessing both left and right banks. Note that one mile of stream channel equals two miles of channel banks. A total of 18 categories were evaluated and scored.

Index Score and Target: The Pfankuch bank stability score was calculated as the percentage of stream banks associated with good bank stability. Stream reaches with all stream banks in excellent and good condition was assigned a score of 100. The target is excellent and good, ratings which receive a score of 100. All other ratings receive a 0. The following equation calculates the index score for bank stability:

$$\left[\left(\frac{MeetsGoodOrExcellentRating}{\mathrm{Re}\,achLength}\right)\Big/\left(\frac{T\arg et}{100}\right)\right]\times 100 = IndexScore$$

Hydraulic Alteration

Description: Hydraulic alteration consists of human-made structures with the purpose to stabilize or prevent bank erosion. Bank stabilization structures may or may not be engineered, with different degrees of success and can be made of many types of materials including concrete, gabions, rock, concrete riprap, log debris and fencing. In urban and rural areas, streams face changes in stream flows, gradient changes, restrictive floodplain and other bank disturbances, often becoming unstable until an equilibrium is established again. Land use along these streams usually restricts options that allow a stream to equalize on its own. Stabilization structures are used to remedy the eroding banks, reducing sediment loads, improving water quality and protect property.

Benefit: Where appropriate, a more natural stabilization method with vegetation as a component not only provides erosion control, improves water quality and protects property, but improves riparian and fish habitat and the aesthetics of the stream corridor. A more natural stabilization design is very site specific and may be more challenging than structures alone. However, designing a combination of structure with vegetation is a more comprehensive approach to stream stewardship.

Measurement: Observers noted stream stabilization structures while walking each stream. At the end of the reach, a range was checked for the percent of stream without stabilization structures present: <5%, 5-25%, 25-50%, 50-75% and 75 to 100%. Stabilized areas that appeared natural with vegetation were not included as altered. In addition, in a GIS exercise, instream culverts and water features were attached where possible to the reach length immediately below. If that was not possible, the culvert or water feature were attached to the reach length immediately above.

Index Score and Target: The index score for hydraulic alteration was based on the percent of stream channel miles without hydraulic alteration. Stream reaches without hydraulic alteration were assigned a score of 100. The target for hydraulic alteration is 87%, the midpoint of the highest category. The following equation calculates the index score for hydraulic alteration:

$$\left[\left(\frac{LengthNotAltered}{\mathrm{Re}\,achLength}\right)\Big/\left(\frac{T\arg et}{100}\right)\right]\times 100 = IndexScore$$

WATER QUALITY

This functional group provides a means to assess water chemistry and the processes that influence water chemistry in the project area. Table 3 includes the sub-groups and individual metrics used to calculate the water quality index score. The Utah 303(d) list of impaired waters is used to characterize water quality from a regulatory perspective. The composition of macroinvertebrate communities reflect different species tolerance of species to pollution or changes in water quality and thus can be used as a surrogate measure of water chemistry. Monitoring of water quality through direct measurements can indicate changes in upstream areas that contribute flow to receiving water bodies.

Table 7. Sub-groups and individual metrics used to calculate the Water Quality index.

Stream Functional Group	Sub-group	Metric
Water Quality	Regulatory	303(d) list
	Aquatic	Macroinvertebrate Indices
	Monitoring	Total Phosphorus
		Temperature
		Total Dissolved Solids
		Dissolved Oxygen
		E. coli

Due to time, personnel and budget constraints, macroinvertabrate data and water quality data was not collected by Salt Lake County for this initial EHI. However, future on-going macroinvertebrate indices monitoring program and water quality monitoring program by Salt Lake County is desired to obtain a more comprehensive picture of water quality conditions in all major streams and the Jordan River. EPA's STORET data was utilized for this study (see Monitoring section).

Consistent sampling is needed to identify trends and seasonal variations. The monitoring programs would identify locations and sampling schedule that would include all county sub-watersheds. Rapid assessment techniques can be used for all metrics except phosphorous, which would require lab analysis.

REGULATORY

303(d) List

Description: The 303(d) list maintained by the Utah Division of Water Quality (Utah DWQ) contains all impaired water bodies in the state, including any that might be located in the project area. Impaired water bodies are waters of the state that do not meet applicable water quality standards, based on designated beneficial uses. Once impairment has been determined, the state must identify contributing sources of point and non-point pollution and allocate responsibility for controlling the pollution in a manner that will allow standards to be met. This process is called a Total Maximum Daily Load (TMDL) analysis and plan.

Benefit: Identification of water quality impairment through the 303(d) list provides a means of identifying and managing pollutant sources. Proactive measures toward maintaining or improving water quality conditions on a continual basis will keep water bodies from appearing on this impaired list.

Measurement: The 2006 Utah DWQ 303(d) list was used to identify streams in the project area that are water quality impaired. As required by the Clean Water Act, the 303(d) list is updated every 2 years. The list can identify only a portion of a stream as impaired and provides the linear distance of impaired water bodies in miles.

Index Score and Target: The water quality index score was calculated by determining the percent of stream miles that are not included on the most recent 303(d) list. Any stream reaches that are not included on the most recent 303(d) list was assigned a score of 100. The following equation calculates the index score for listing as impaired.

$$\left[\left(\frac{LengthNotMeetingS\tan dard}{\mathrm{Re}\,achLength}\right)\bigg/\left(\frac{T\arg et}{100}\right)\right]\times 100 = IndexScore$$

AQUATIC

Macroinvertebrate Indices

Description: The macroinvertebrate index score is used to identify the composition of benthic aquatic insects with respect to their sensitivity to pollution. If macroinvertebrate communities consist of pollutant tolerant species such as worms, leeches, or snails, water quality is likely to be poor. If macroinvertebrate communities are comprised of species that are not tolerant of pollution, such as stoneflies, mayflies, or caddisflies, water quality is likely to be in good or excellent condition. Macroinvertebrates are good indicators of localized conditions, can integrate the effects of short-term environmental conditions, and are easily identified with a minimum of training.

The Utah DWQ is currently developing a macroinvertebrate database for the entire state. This information will eventually be used to associate numeric criteria with beneficial use categories in a manner similar to water quality criteria. Macroinvertebrate criteria will be based on a ratio of observed numbers and composition (O), divided by the expected number and composition (E) of macroinvertebrates associated with a given beneficial use class. This measure is defined as the O/E ratio.

Benefit: Macroinvertebrates represent an important link in the aquatic food chain. These life forms consume organic material in the stream and represent an important source of energy for many fish species. A diverse and abundant macroinvertebrate community will help insure the long-term viability of fish species.

Measurement: Although macroinvertebrate data was not collected for the EHI this time, when data is collected, macroinvertebrates will be sampled using Rapid Bioassessment Protocols that are recommended by the EPA. These sampling methods are both efficient and accurate. Resource constraints may limit the number of sample sites to less than the number of stream reaches. If this occurs, composite samples will be used or sample sites will be assumed to represent upstream conditions for more than one stream reach.

Index Score and Target: The index score will be evaluated using the O/E ratio utilized by the Utah DWQ. O/E ratios will then be multiplied by 100 to produce an index score for a stream reach. If the observed number and composition of macroinvertebrates equal the expected levels (O/E = 1), a score of 100 will be assigned to the stream reach.

MONITORING

Description: The intent of water quality monitoring is to identify water quality concerns and to preserve and maintain the quality of water resources in the project area. With the exception of some canals, all water bodies in the project area have been assigned a beneficial use class, including domestic use prior to treatment, secondary recreation, cold and warm water fish species, water fowl, and irrigation use.

Water quality monitoring under this protocol includes five parameters that represent a combination of field and laboratory measurements. They are identified here as a group and will not be addressed individually. Total phosphorus, temperature, total dissolved solids (TDS), dissolved oxygen (DO), and coliforms are all associated with numeric criteria that are enforced by the Utah DWQ. Many water bodies currently exhibit levels of water quality that exceed state criteria, particularly in upper headwater portions of the project area.

Benefit: Water quality chemistry directly influences aquatic and human health. Good water quality is a valuable resource to all life forms in the project area.

Measurement: The monitoring data for this first EHI score originates from data available from EPA's STORET. This nationwide database includes water quality data on selected streams in Salt Lake County on a five-year rotation. The data is representative of sub-watershed conditions rather than by reach.

Index Score and Target: The monitoring score will be determined as the percent of samples that meet state criteria. Stream segments where all samples meet numeric criteria will be assigned a score of 100. It is noted that high concentrations of some water quality constituents will periodically occur in healthy stream systems during extreme storm events or the spring runoff period. Data collected as part of the monitoring effort will be screened to remove outliers associated with these events. The following equation calculates the index score for meeting DWQ's water quality criteria:

$$\left[\left(\frac{SampleThatMeetsCriteria}{TotalSamples}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

SOCIAL

The Social stream functional group is designed to reflect social aspects of a watershed that are important to residents of the project area. This index will account for the need that exists for interaction between social and ecological components of the watershed. Social aspects can be combined with ecological metrics to determine the influence these aspects might have on watershed health. This relationship is numerically defined with the Stream Function Index or SFI. A total of ten metrics have been defined which identify aesthetics and recreational amenities that are socially significant. Table 4 includes the sub-groups and individual metrics used to calculate the social index score. All metrics associated with the social index score will be measured within a 100-foot corridor extending outward from each stream bank.

Table 8. Sub-groups and individual metrics used to calculate the Social index score.

Stream Functional Group	Sub-group	Metric
Social	Aesthetics	Management
		Visual Aesthetics
	Recreational Amenities (Nodes)	Location
		Accessibility (ADA Standard)
		Restrooms
		Resource Compatibility
	Recreational Amenities (Trails)	Trail Corridor
		Connectivity
		Resource Compatibility

The metric definition, data collection and scoring for the Social index score were developed specifically for Salt Lake County. Rapid assessments of node and trail conditions were developed so they could easily be completed in a single site visit. The rapid assessment for meeting ADA Standard requirements was developed with the help of Salt Lake County's ADA Specialist.

Although a methodology was created for Visual Aesthetics, time constraints prevented an assessment in 2007.

AESTHETICS

Management

Description: This metric identifies the amount of land within the stream corridor that is managed as protected, open space. This metric is based on the assumption that lands in the stream corridor assigned to this status will be subject to management goals and objectives designed to restrict development and maintain natural conditions. As a result, these areas will generally have a greater potential for achieving proper ecological function than lands where development could occur.

Benefit: Lands designated as protected open space have the potential to support vegetation that is conducive to healthy riparian corridors and provide space for floodplains as well as providing social values.

Measurement: This metric was measured with the use of a GIS and land ownership information obtained from federal, state, and local agencies. The countywide parks and recreation GIS layer and the Salt Lake County parcel layer were used to identify the protected open space parcels. Included in the parcels were parks, golf courses, open land recreation areas and mitigation areas. Acres of managed open space were digitized within a 100-foot corridor along both banks from the bankfull normal high water line. Each reach was scored as a percent of the corridor that is managed as open space. The score is obtained for the upper and lower stream segments rather than by reach.

Index Score and Target: The management score was based on the percent of land in the stream corridor under federal, state, or local management as open space. If all land in the stream corridor is managed as open space, a score of 100 will be assigned.

The target for the managed open space was determined by the existing general land use and expected future land use along the stream corridors. The target for the east and west side mountains is 100%, the target for the valley streams is 25% and the target for the Jordan River is 100%. The following equation calculates the index score for managed open space within the stream corridor.

$$\left[\left(\frac{ManagedAcres}{TotalAcres}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

Visual Aesthetics

Description: A definition of visually pleasing land areas is difficult to determine due to varied perspectives held by stakeholders and agencies. An effort has been made here to create a limited number of general categories that balance development and maintenance of stream corridors.

Benefit: Stream corridors that are visually pleasing maintain a higher value to society and are more likely to be used in a way that benefits many aspects of watershed health and function.

Measurement: When this metric is used, stream reaches will be scored according to five categories shown in Table 5. Note the definition of maintenance provided in the table caption.

Table 9. Scores associated with the visual aesthetics index. Maintenance is defined as the absence of trash, yard debris, grass clippings, car bodies or homeless camps located on the stream bank or within the stream corridor.	
Score	**Description**
1	Stream channel located within culvert.
2	Stream channel banks covered with concrete or rip/rap material that is not maintained.
3	Stream channel banks consist of natural material (soil, vegetation, etc.) that is not maintained.
4	Stream channel banks are covered with concrete or rip/rap material that is maintained.
5	Stream channel banks consist of natural material (soil, vegetation, etc.) that is maintained.

Index Score and Target: The visual aesthetics index score will be based on a target value that indicates the desired level of visually pleasing stream corridors. If the measured score is greater than the target, a score of 100 will be assigned. Equation 1 will be used to calculate the visual aesthetics index score if the measured score is less than the target.

RECREATIONAL AMENITIES (NODES)

Location

Description: This metric is designed to assess the number of recreational locations (nodes) located in the stream corridor. Nodes are defined here as trailheads, picnic areas, campgrounds, parks, interpretive sites, and any other non-linear feature that can be considered as a recreational amenity. These facilities provide a means for interaction between society and the stream corridor. Goals and objectives of master plans used by agencies often include development of these types of facilities and account for recreational demand.

Benefit: Stakeholders value recreational opportunities in the project area. A sufficient number of well designed and well maintained nodes will provide such opportunities and minimize damage to stream corridors created by dispersed use.

Measurement: The number of nodes within the stream corridor was calculated using a GIS and information obtained from federal, state and local agencies. The Countywide Parks and Recreation GIS layer was used to identify the recreation nodes. The score was obtained for the upper and lower stream segments rather than by reach.

Index Score and Target: The location score was evaluated against a target for number of nodes per stream mile. If the number of recreational nodes in the stream corridor met or exceeded the target, a value of 100 was assigned to the stream reach.

The target for the number of recreational nodes along a stream segment is a minimum of one node per mile. This target was based on a general distance between neighborhoods that may be served by the recreational nodes as well as the dispersal of recreationists in the mountain segments. The following equation calculates the location index score if the measured score is less than the target:

$$\left[\left(\frac{\#ofNodes}{Segment}\right)\Big/\left(\frac{T\arg et}{Segment}\right)\right]\times 100 = IndexScore$$

Accessibility (ADA Standard)

Description: This metric is designed to assess the number of appropriate recreational nodes within the stream corridor that are accessible and usable to individuals with disabilities. The Americans with Disabilities Act of 1990 (ADA) require facilities and programs be equally accessible and usable by people with disabilities. The approved ADA Standard by the Justice Department addresses buildings only. Several Guidelines exist which are proposed standards that have not been approved and may not be enforced. However, Guidelines are used in anticipation of their approval as Standards. Recreation has been addressed in a 2007 Guideline document and is currently under review. "Universal Access to Outdoor Recreation" (PLAE, Inc., 1993) and "Designing Sidewalks and Trails for Access" (Kirschbaum, 1999) has been used in the interim to guide accessibility design for the outdoors. In the Forest Service document, the Recreation Opportunity Spectrum guides the appropriate expectations of facilities for accessibility. Categories include an urban/rural level with expectations of paved parking lots, flush toilets and sidewalks which applies to all Salt Lake Valley recreation nodes and the ski areas. The category "roaded natural" applies to nodes along streams in Salt Lake County's mountain region.

Benefit: Nodes meeting ADA Standards for accessibility and usability serve a greater cross-section of the public along stream corridors.

Measurement: The accessibility level of recreational nodes was determined through information obtained through field surveys. Each node identified partially or fully within 100 feet of the bankfull line of a stream was visited and evaluated. The entire node was evaluated even though it may have extended beyond the 100 feet. Each activity center within the node was evaluated. An activity center may be a picnic pavilion, sports field, trailhead or parking lot. Each activity center was first evaluated for appropriateness of accessible standards; all restroom facilities and paved parking lots were appropriate. Activity centers that may not be appropriate were pocket parks that use street parking and do not have a restroom; or primitive area trailheads that may have a gravel parking lot and do not have a restroom. Those were given a score of 100% by default. The score was obtained for the upper and lower stream segments rather than by reach.

Index Score and Target: The accessibility score was evaluated against a target that reflects the percent of appropriate recreational nodes with handicap accessibility. If all appropriate recreational nodes in the stream corridor met the target, a value of 100 was assigned. The target for meeting ADA Standard is 100% of appropriate recreational nodes. The following equation calculates the index score for meeting ADA Standards:

$$\left[\left(\frac{\#ActivityCentersMeetsADAS\tan ards}{TotalActivityCenters}\right)\Big/\left(\frac{T\arg et}{100}\right)\right]\times 100 = IndexScore$$

Restrooms

Description: This metric is designed to assess the number of restrooms that are present at each appropriate recreational node in the stream corridor. It is noted that presence of restroom facilities may not be desired for all recreational nodes in the stream corridor.

Benefit: Restroom facilities associated with recreational nodes that are properly designed and maintained reduce coliform loading to streams.

Measurement: Appropriate locations for restroom facilities were obtained from planning information provided by federal, state, and local agencies. The actual number of restroom facilities in the stream corridor was obtained from these agencies and through field surveys.

Index Score and Target: The restroom score was based on the percent of appropriate recreational nodes that have restroom facilities. If all appropriate recreational nodes in a stream corridor have restroom facilities, a value of 100 was assigned. The target for all restrooms was 100%. The following equation calculates the index score for meeting ADA Standards:

$$\left[\left(\frac{\#\,of\,\mathrm{Re}\,stroomsInAppropriateNodes}{TotalAppropriateNodes}\right)\Big/\left(\frac{T\,\mathrm{arg}\,et}{100}\right)\right]\times 100 = IndexScore$$

Resource Compatibility (Nodes)

Description: This metric is designed to indicate if recreational nodes are resulting in damage to the immediate vicinity, as evidenced by litter, tree damage, graffiti, human waste, etc. A separate assessment was completed for each node.

Benefit: Nodes are more frequently used by the public if they are clean and in good repair. In addition, with more visitors, fewer acts of vandalism may occur at these sites resulting in cost savings to management agencies.

Measurement: Field surveys were conducted at each recreational node located in the stream corridor. The percent of the node that is in good condition (absence of litter, tree damage, graffiti, human waste, etc.) was recorded.

Index Score and Target: The resource compatibility index score was calculated from the percent of the recreational nodes that were in good condition. If all of the node were in good condition, a value of 100 was assigned. The target for all sites was 100%. The following equation calculates the index score for resource compatibility:

$$\left[\left(\frac{\#\,ofNodesInGoodOrExcellent}{TotalNodes}\right)\Big/\left(\frac{T\,\mathrm{arg}\,et}{100}\right)\right]\times 100 = IndexScore$$

RECREATIONAL AMENITIES (TRAILS)

Trail Corridor

Description: Trails in the stream corridor provide an important amenity to stakeholders as a naturally attractive travel way.

Benefit: Travel along the corridor provides a connection to the stream and the sights and sounds of a nature experience sometimes within a heavily urbanized area.

Measurement: Trails located in the stream corridor were determined through the use of GIS and trail network information obtained from federal, state, and local agencies.

Index Score and Target: The trail corridor score was based on the percent of trail miles located in the stream corridor. If the trail corridor is continuous through the entire length of the stream segment, a score of 100 will be assigned. The target for the trails within stream corridors is 25% for the Wasatch Mountains and the east side valley, 50% for the west side valley and 100% for the Oquirrh Mountains and the Jordan River. The following equation calculates the index score for trails within the stream corridors:

$$\left[\left(\frac{MilesOfTrails\Pr esent}{TotalMilesInSegment}\right) \Big/ \left(\frac{T\arg et}{100}\right)\right] \times 100 = IndexScore$$

Connectivity

Description: Trails provide an important amenity to stakeholders. Trails can be used to access the river corridor as well as to travel throughout the watershed without encountering motor vehicle transportation routes. A common objective in master planning documents is a trail network that allows recreational users to access numerous points throughout a watershed by a trail network. This metric evaluates the degree to which trails in the river corridor are connected to a network.

Benefit: Connected trails provide a higher level of function to recreational users and potentially a greater level of support by stakeholders.

Measurement: Connectivity of trails located in the stream corridor was determined through the use of a GIS and trail network information obtained from federal, state, and local agencies. Trails and trailheads located in the stream corridor were identified as either being connected to a network or isolated from the network, i.e., trail dead-ends so the traveler must return the way they came. Each length of trail associated with a node in the stream corridor or an isolated trail not associated with a node were identified as either connected to a network or not connected. The results were then totaled and used to calculate the percent of trails that connected to a network.

Index Score and Target: The connectivity score was based on the percent of trails located in the stream corridor connected to a network. If all trails in the stream corridor are connected to a network, a score of 100 will be assigned. The target for trail connectivity is 85% of all trails or trailheads within 100 feet of the stream bankfull width are connected to other trails (excluding roadways.) Fifteen percent of all trails are expected to be local trails. The following equation calculates the index score for trails connected to others for extended travel opportunities:

$$\left[\left(\frac{\#ofTrailsConnected}{Total\#ofTrails}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

Resource Compatibility (Trails)

Description: Similar to the resource compatibility index measured for nodes, this metric evaluates the condition of the trails themselves as well as the area immediately adjacent to the trails. A separate assessment is completed for each aspect as they appear in the trail corridor.

Benefit: Trails and the areas surrounding trails will be used more often if they are well maintained. Trails that are used as per their design reduce the amount of user-created trails and subsequent damage to off-trail areas. Trails located in the stream corridor that are properly maintained have a much lower potential to contribute runoff and sedimentation to streams.

Measurement: Field surveys were conducted for each trail located in the stream corridor. The percent of the trail and the area immediately adjacent to the trail in good condition (absence of litter, human waste, trail erosion, user created trails, etc.) was recorded.

Index Score and Target: The resource compatibility index score were calculated from the percent of trails that are in good condition. If all trails and the areas surrounding trails are in good condition, a value of 100 will be assigned. The target for trail compatibility is 100%. The following equation calculates the index score for trail compatibility:

$$\left[\left(\frac{\#ofTrailsInGoodOrExcellent}{TotalTrails}\right)\Big/\left(\frac{Target}{100}\right)\right]\times 100 = IndexScore$$

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PROPOSED TARGETS FOR THE STREAM FUNCTION INDEX – SALT LAKE COUNTY WATER QUALITY STEWARDSHIP PLAN

INTRODUCTION

The Stream Function Index (SFI) was originally developed as the Watershed Function Index (WFI) and later renamed to reflect a focus on the stream corridor (Cirrus 2006). Development of the SFI was been guided by input from Salt Lake County and local stakeholders. Indices in the SFI characterize stream functions that reflect local concerns and management goals established for stream and riparian corridors in Salt Lake County.

The SFI is composed of functional groups, sub-groups, and individual metrics. The organization of these groups is shown in Figure 1. Generally speaking, functional groups reflect components that are most important to Salt Lake County and stakeholders, and can generally be associated with biological, physical, chemical, or social aspects of the project area. Sub-groups include metrics that address the health of habitat, hydrology, and water quality as it occurs in stream and riparian corridors. Individual metrics provide objective measures for these variables.

The purpose of this technical report is to recommend targets that can be used to evaluate individual metrics associated with SFI functional groups that represent stream ecological functions, including habitat, hydrology, and water quality (the Ecosystem Health Index or EHI portion of the SFI). No recommendations are provided in this report for metrics included in the social functional group, as the County will establish these. Targets will allow the County to measure progress in improving watershed management and identifying opportunities for restoration and remediation. Target values provided in this report are meant for use in interpreting individual metric scores and do not define an overall SFI score that the County wants to ultimately reach.

Estimates of target values were previously submitted to the County to provide an initial starting point for developing SFI scores (Table 7, Cirrus 2006). The targets presented in this report rely upon scientific literature that defines each metric in a natural ecological setting. This method is similar to the approach used by other agencies where existing conditions are assessed against a potential reference state. Although targets are not meant to represent the "pristine" state of a particular metric, they do indicate a condition and level of function that will support healthy ecological processes that occur in stream corridors.

Metric	Metric Weighting Factors	Sub-Group	SubGroup Weighting Factors	Functional Group	Functional Group Weighting Factors	Ecological Health Index	EHI/SFI Weighting Factors	Stream Function Index
Pool/Riffle Ratio		Stream Channel		Habitat		EHI		SFI
Minimum Depth								
Fish Passage								
Habitat Structures								
Flow Diversion								
Width		Riparian Corridor						
Community Type								
Floodplain Development		Flood Conveyance		Hydrology				
Floodplain Connectivity								
Pfankuch Bank Stability		Stream Stability						
Hydraulic Alteration								
303(d) List		Regulatory		Water Quality				
Macroinvertebrate		Aquatic						
Total P		Monitoring						
Temperature								
Total Dissolved Solids								
Dissolved Oxygen								
E. coli								
Management		Aesthetics		Social				
Visual Aesthetics								
Location		Amenities (Nodes)						
Accessibility (ADA Standard)								
Restrooms								
Resource Compatibility (Nodes)								
Connectivity		Amenities (Trails)						
Resource Compatibility (Trails)								

Figure 1. Organization of metrics, sub-groups, and functional groups that contribute to the Ecosystem Health Index (EHI) and the Stream Function Index (SFI).

Several targets are based upon the natural stream classification system proposed by Rosgen (1996). This method is widely used throughout the United States and accepted by federal and state agencies as a means of classifying stream channels. More specifically, this method provides a quantitative assessment of the difference between existing conditions and an accepted range of morphological values for stream types. Survey measurements collected from tributary streams in Salt Lake County identified a range of Rosgen stream types, some of which were in transitional stages and naturally moving towards a more stable condition. Targets associated with stream types in transitional stages represent the more stable condition and not the existing condition. Discussion of Rosgen stream types throughout this report assumes that the reader has a basic knowledge and understanding of this methodology and the geomorphic processes important to stream classification.

A summary of the recommended targets for each metric is provided in Table 1. Where applicable, targets are specified by physiographic region including mountain streams, valley streams, and the Jordan River. Note that some metrics shown in Table 1 are not applicable to intermittent streams. The remainder of this report includes a brief discussion of each ecological metric, followed by the rationale used to select the recommended target value.

Table 1. Recommended Stream Function Index (SFI) targets for mountain streams, valley streams, and the Jordan River in Salt Lake County. Targets for SFI metrics shown in bold text are not applicable to intermittent streams.

SFI Sub-Group	SFI Metric	Mountain Streams	Valley Streams	Jordan River
Stream Channel	**Pool/Riffle Ratio**	Pool/Riffle ratio of 1. The appropriate number of pools per stream length is based on Rosgen stream type.		
	Minimum Depth	6 – 9 inches.	6 – 12 inches.	Lower Jordan: 12-20 inches. Upper Jordan: 9-12 inches.
	Fish Passage	• Unobstructed passage in all streams. • 3-5 miles (USDA 1998). • 0.25 miles.		
	Habitat Structures	Specific to Rosgen stream type.		
	Flow Diversion	100 percent of all streams supporting natural flow regimes throughout year.		
Riparian Corridor	Width	• 120-360 feet. • 200 feet.	• 120-360 feet. • 200 feet.	• 480-720 feet. • 300 feet.
	Community Type	All stream banks with 60 percent or more cover for over, middle, and understory vegetation.		
Flood Conveyance	Flood Protection	No development in 100 percent of the area contained in the 100 year floodplain as defined by FEMA.		
	Floodplain Connectivity	Specific to Rosgen stream type.		

Table 1. Recommended Stream Function Index (SFI) targets for mountain streams, valley streams, and the Jordan River in Salt Lake County. Targets for SFI metrics shown in bold text are not applicable to intermittent streams.

SFI Sub-Group	SFI Metric	Mountain Streams	Valley Streams	Jordan River
Stream Stability	Pfankuch Bank Stability	100 percent of all channel banks in good or excellent condition.		
	Hydraulic Alteration	100 percent of all stream channels without hydraulic alteration.		
Regulatory	303(d) list	100 percent of all streams not included on 303(d) list.		
Aquatic	Macroinvertebrate	Ratio of Observed (O) to Expected (E) taxa greater than 0.74 or 0.54 (per sample size) based on Utah DWQ O/E model (DWQ 2008).		
Monitoring	Total P	100 percent of all water quality samples collected from designated monitoring sites in compliance with DWQ numeric criteria and pollution indicator levels.		
	Temperature			
	Total Dissolved Solids			
	Dissolved Oxygen			
	Coliform			

HABITAT

This watershed functional group examines ecosystem components that contribute to aquatic and terrestrial habitat values of the stream channel and riparian corridor. Two sub-groups contribute to the Habitat Index Score including Stream Channel and Riparian Corridor. Metrics included in the Stream Channel sub-group measure channel features that provide habitat for the aquatic food chain. Similarly, metrics in the Riparian Corridor sub-group provide an indication of vegetative features that provide habitat for wildlife and shade for aquatic species.

STREAM CHANNEL

Pool/Riffle Ratio

This metric indicates the observed ratio of pools to riffles in a stream channel. Pools and riffles are important stream features that provide habitat for aquatic species including fish and supporting components of their food chain. Targets for this metric are meant to be applied only to perennial streams due to the absence of fish in intermittent streams. For most Utah sport fishery aquatic species, a 1:1 ratio is considered optimal (Hickman and Raleigh 1982). In a natural setting, higher gradient streams will generally have lower pool/riffle ratios than lower gradient streams.

The target for this metric should account for two measures of pools and riffles including a target ratio as well as the appropriate number of each feature for a given length of stream channel. Both of these features should rely on the Rosgen stream classification method (Rosgen 1996). Table 2 indicates the pool-to-pool spacing for Rosgen stream types identified in Salt Lake County. The numbers shown in Table 2 are presented in units of bankfull width. The bankfull width for mountain, valley, and Jordan River reaches should be based on measurements collected from reference stream reaches for the appropriate Rosgen stream type. This value can then be translated into a linear distance that represents a pool spacing target or an equivalent number of pools per length of stream channel for each Rosgen stream type. Measurements of pool numbers collected during stream surveys can then be evaluated against the target. Stream channel surveys should also identify the number of riffles and determine the pool/riffle ratio in each reach. This ratio should be evaluated against a target of 1:1.

Survey information collected by Salt Lake County indicates that Rosgen type A and type B (to a lesser extent) stream reaches were typically identified in mountain areas of the County while Rosgen type C stream reaches were found in valley areas including tributaries and the Jordan River. As mentioned previously, targets for stream types considered to be in transitional stages represent a naturally stable condition that should be reached by existing channel conditions as a reach moves through a range of geomorphic processes that promote stability. Rosgen stream types G, F, and D are considered to be in transitional stages that will naturally develop into other, more stable geomorphic forms. In general, Rosgen type G would evolve to a type B or type C stream (depending on size and location in the watershed), Rosgen type F would evolve to a type E stream, and Rosgen type D would evolve to a type C stream. The targets shown in Table 2 reflect this methodology.

The Jordan River is considered to have been a C4/C5 stream type historically, and is now thought to resemble a combination of C4, C5, B4c, and F5 stream types between Turner Dam and 2100 S (Jensen and Fillmore 1997). Targets for the Jordan River are based on a C4/C5 stream type.

Minimum Depth

This metric represents the minimum depth of flow required to support viable populations of fish species that inhabit mountain and valley tributary streams as well as the Jordan River. Targets for this metric are meant to be applied only to perennial streams due to the absence of fish in intermittent streams. Minimum flow depths for the different life stages of each aquatic species were obtained from published literature and are shown in Table 3. The full list of references used to identify minimum flow depths for each species is presented at the end of this report.

In general, aquatic species identified in mountain tributaries primarily consist of cold water species. Valley tributaries support a mixture of warm and cold water species, with more warm water species occurring near the confluence with the Jordan River. Aquatic species in the Jordan River are also a mixture of warm and cold water species with cold water species occurring primarily upstream of the confluence with Little Cottonwood Creek.

Table 2. Pool spacing for Rosgen (1996) stream types. Pool/riffle targets can be determined based on a 1:1 ratio of pools to riffles.

<table>
<tr><th colspan="3">Rosgen Type</th><th colspan="2">A</th><th colspan="2">B</th><th>C</th><th>D</th><th>E</th><th>F</th><th colspan="2">G</th></tr>
<tr><td rowspan="6">Dominant Bed Material</td><td>Bedrock</td><td>1</td><td colspan="2">Pool spacing is highly irregular and controlled by bedrock and large, wood organic debris.</td><td colspan="2">Extensive rapids with infrequent scour holes (pools). Pool spacing is irregular and infrequent due to the presence of bedrock.</td><td rowspan="2">Spacing of pools is related to the nature and resistance of bedrock and boulders. Backwater pools are often created by irregular spacing of large, woody, organic debris.</td><td rowspan="2">NA</td><td rowspan="2">NA</td><td rowspan="6">F type channels are working towards reestablishment of floodplains within an eroding channel that is increasing in width.</td><td colspan="2">The G1 channel has randomly spaced steps and plunge pools.</td></tr>
<tr><td>Boulders</td><td>2</td><td colspan="2">Steep gradients produce channels that exhibit step/pool bed features.</td><td colspan="2">Series of rapids with irregularly spaced pools.</td><td colspan="2" rowspan="3">The G2, G3, and G4 stream types have a characteristic step/pool morphology. Pools in G4 streams are often filling with bedload, as the potential for sediment storage is high.</td></tr>
<tr><td>Cobble</td><td>3</td><td colspan="2" rowspan="2">The A3 and A4 channel bed features occur as a step/pool, cascading channel which often stores large amounts of sediment in the pools associated with debris dams.</td><td colspan="2" rowspan="4">Channel morphology continues to be characterized by a series of rapids with irregularly spaced pools. However, spacing of pools is less dominated by channel substrate in comparison to bedrock and boulder channels. Pool spacing adjusts inversely to stream gradient.</td><td rowspan="4">Morphology is slightly entrenched, meandering, riffle/pool channel with well-developed floodplain.</td><td rowspan="4">Bed morphology is characterized by a closely spaced series of rapids (riffles) and scour pools formed by convergence/divergence processes that are very unstable. The riffle/pool sequence in D type streams is similar to C type streams.</td><td rowspan="4">E type channels develop inside of F type channels as they are recovering to a more stable condition. Bed morphology of E type channels includes a consistent series of riffle/pool reaches and the highest number of pools/length for alluvial type channels.</td></tr>
<tr><td>Gravel</td><td>4</td></tr>
<tr><td>Sand</td><td>5</td><td colspan="2" rowspan="2">The A5 and A6 stream types are normally associated with a step/pool profile.</td><td colspan="2" rowspan="2">The bed features of G5 and G6 channel types are generally considered to exhibit unstable, degrading step/pool morphology.</td></tr>
<tr><td>Silt/Clay</td><td>6</td></tr>
<tr><td colspan="3">Stream gradient</td><td>> 0.10</td><td>0.10 - 0.04</td><td>0.04 - 0.02</td><td>< 0.02</td><td>< 0.02</td><td>< 0.04</td><td>< 0.02</td><td>< 0.02</td><td>0.04 - 0.02</td><td>< 0.02</td></tr>
<tr><td colspan="3">Target Pool spacing (bankfull widths)</td><td>1.5 - 2.0</td><td>3.5 - 4.0</td><td>4</td><td>4 - 6</td><td>5 - 7</td><td>5 - 7</td><td>5 - 7</td><td>5 - 7</td><td>4 - 6</td><td>5 - 7</td></tr>
</table>

As indicated by Table 3, minimum flow depths are generally greater for warm water species and for spawning life stages of both warm and cold water species. A conservative method for defining targets for minimum flow depth would select the highest value from the lower end of the flow range deemed suitable for aquatic species that inhabit stream reaches. This method would insure that all species would be protected during periods of low flow. A less conservative method would select the minimum value from the range of flow depths for the aquatic species that inhabit a particular stream reach. While this value would not be in the desired range for some species and therefore not support viable populations over the long term, it would likely not be lethal and still permit migration to areas of deeper water. Based on these two methods, the recommended target ranges for Minimum Depth are as follows:

- Mountain streams = 6–9 inches.
- Valley streams = 6–12 inches.
- Jordan River from Burton Dam-LCC confluence = 12–20 inches.
- Jordan River from LCC confluence-Narrows Dam = 9–12 inches.

Fish Passage

This metric identifies the Minimum Stream Length (MSL) needed by aquatic species to support a viable population. Most fish species migrate between feeding and spawning areas and make other seasonal movements in order to access important habitats or avoid stream reaches where impaired habitat exists. Barriers to fish passage prevent migratory patterns and may result in loss of access to critical habitat for some life stages, reductions in genetic diversity, or increased risk of extinction.

From a management perspective, natural obstructions can provide a way of separating native and introduced species. Natural obstructions should remain where they currently exist. Human created obstructions to fish passage can be introduced by (1) culverts that create high water velocities or maintain elevation drops at the downstream end, (2) dams or other manmade structures that present a change in elevation that exceeds the jump height of fish, and (3) reaches that are entirely dewatered by diversions. It is possible for fish to move over and through some obstructions if sufficient water is present. The following list provides general characteristics that would support fish migration across obstructions (Meehan 1991):

- A resting-jumping pool must be present immediately below the obstacle. This allows the fish to conserve energy and build up swimming speed to overcome the obstacle.

- Individual jumps must not be too high. For adult trout, a single vertical jump should be no higher than 12 inches, and individual jumps in series should be 6 inches or less.

- Water depth through the culvert must be adequate for swimming. A minimum water depth of 6 inches is recommended for trout.

- The water velocity in the culvert must not exceed the maximum sustained swimming ability of the migrating species for which the passage is designed.

- Resting areas must be provided en route wherever the swimming distance through a difficult obstacle exceeds approximately 50-100 feet.

Table 3. Habitat suitability for aquatic species in Salt Lake County streams, including minimum water depth.

Fish Species	General Habitat Type	Water Velocity	Water Depth (range)	Mountain Stream Species	Valley Stream Species	Jordan River Species
Black Bullhead *Ameirus melas*	50-80% total stream area with low velocity pools/backwaters and riffle/run areas.	S: Slow. G:Weak or absent; ≤4cm/sec.	S: 50-150 cm. G: Pools.		X	X
Brook Trout *Salvelinus fontinalis*	Clear, cold water with riffle/run habitat, areas with slow, deep water and a 1:1 pool/riffle ratio.	S: 1-92 cm/sec. G: ≤15 cm/sec.	G: >15 cm.	X		
Brown Trout *Salmo trutta*	Clear, cool /cold water with 50-70% pools and 30-50% riffle/run habitat and areas with slow deep water.	S: 40-70 cm/sec. G: ≤15 cm/sec.	S: 24-46 cm. G: ≥15 cm.	X	X	X
Channel Catfish *Ictalurus punctatus*	Warm waters of deep pools and backwaters of rivers and lakes.	S: Weak or absent. G: <15 cm/sec.	S,G: Deep pools and littoral areas <5m.		X	X
Cutthroat Trout *Oncorhynchys clarki*	Clear, cold headwater streams and lakes with 1:1 pool-to-riffle ratio and areas of low velocity flow for feeding.	S: 30-60 cm/sec. G: Mix of riffle, run, and pool habitats with slow, deep areas.	S: 18-61 cm. G: 15-75 cm.	X	X	X
Longnose Dace *Rhinichthys cataractae*	Swift flowing, steep gradient, headwater streams with a mix of riffles and calm shallow areas.	S: Swift; 45-60 cm/sec. G: Swift; >45 cm/sec.	S: Shallow areas. G: <30 cm and rarely >1.0 m.		X	X
Mountain Sucker *Catastomus platyrhynchus*	Cold, clear riffles of streams and rivers.	G: Calm to swift.	G: Shallow areas; 0.3-0.9 m.		X	X
Rainbow Trout *Oncorhynchus mykiss*	Clear, cold lakes and streams with 1:1 pool-to-riffle ratio.	S: 30-70 cm/sec. G: ≤15 cm/sec.	S: Shallow riffle areas. G: Deeper; ≥15cm.	X	X	X
Utah Chub *Gila atraria*	Diverse habitats including irrigation ditches, reservoirs, ponds, sloughs, creeks, large rivers, and large lakes.	G: Calm or swift.	S: <61 cm. G: 50-120 cm.		X	X
Utah Sucker *Catostomus ardens*	Warm to cold waters of lakes, rivers, and creeks.	G: Absent or swift.	No published information available. Assumed to be similar to other sucker species; > 30 cm.		X	X
Walleye *Sander vitreus*	Cool waters of rivers and lakes.	S: Sufficient for oxygen circulation. G: Slow.	S: 60-120 cm. G: Shallow-moderate.			X
White Bass *Morone chrysops*	Warm waters of larger rivers, lakes, and reservoirs.	G: Slow.	S: 50-600 cm. G: 50-300 cm; dependent upon prey abundance.			X

S: Spawning Grounds G: General Habitat Note: Shaded rows indicate warm water species.

- A resting pool at the upstream end of a difficult obstacle is necessary so that exhausted fish are not swept downstream.

The MSL for a given stream reach should account for the desired target population size (no. of fish/length of stream channel) for a given fish species and could simply define the minimum space requirements for survival or account for other factors needed to support a self-sustaining, healthy population. An effective population size of 500 is generally considered sufficient to maintain genetic diversity and reduce demographic and stochastic extinction risks. However, the effective population size may be only a fraction of the actual population size needed for long-term persistence of isolated populations.

Historically speaking, trout species have been considered sedentary based on the results of numerous studies that measured seasonal movement patterns of less than 200 feet. (Gerking 1959, Shetter 1968, Heggenes 1988, Fleener 1951, Miller 1957 as reported by Hildebrand and Kershner 2000a). Due to improvements in fish tracking technology, recent studies have shown that trout populations are comprised of sedentary and mobile individuals (Heggenes et al. 1991, Gowan and Fausch 1996 as cited in Hildebrand and Kershner 2000a, Colyer et al. 2005). In addition, individual trout can exhibit both sedentary and mobile behaviors within and between seasons (Harcup et al. 1984, Brown and Mackay 1995 as cited in Hildebrand and Kershner 2000a). The degree of movement observed from individual fish is generally believed to be a response to habitat preference or avoidance of unfavorable conditions such as dewatering, ice formation, or predation.

Young (1995) noted studies that tracked seasonal movements of adult brown trout in excess of 18 miles and annual migration up to 56 miles. Colyer et al (2005) determined the seasonal extent and travel of Bonneville cutthroat trout (BCT) in the Thomas Fork and mainstem Bear River. This study found median travel distances of 7,300 feet and maximum travel distances of 53 miles away from the original study site during the spring season. Hildebrand and Kershner (2000b) estimated MSL for cutthroat trout populations with different levels of abundance and population loss. The MSL for a target population of 2,500 individuals (equivalent to an effective target population of 500), was estimated to be 5.8 miles for a high fish abundance (0.09 fish/feet) and 15.5 miles for a low fish abundance (0.03 fish/feet).

At present, the Utah Division of Wildlife Resources (UDWR) does not establish target populations for Utah waters (Slater 2008). However, streams in Salt Lake County are managed by UDWR according to three use classifications including Basic Yield (BY), Wild Fish (WF), or Special Fish Species (SFS) waters (Thompson 2003). Waters in the BY classification are stocked by UDWR while those in the WF or SFS classification are not stocked by UDWR or any other agency. UDWR stocks BY waters at levels considered to yield a fish harvest of 0.5 fish/hr to anglers (Slater 2008). It is anticipated that UDWR is aware of minimum space requirements necessary to support this rate of harvest and that stocked fish levels are managed appropriately in all BY waters. The fate and future of existing fish populations in WF water bodies is dictated solely by the ability of fish to survive and reproduce naturally in the stream without human intervention. Waters in the SFS classification are used to protect native populations of Bonneville cutthroat trout (BCT). This species is considered the only native trout in the Jordan River drainage (Thompson 2003). The SFS status of these waters is being used to secure BCT populations from hybridization with rainbow trout. Additional work is being completed to further identify the genetic purity of this species in the Jordan River drainage.

The most conservative fish passage target would be 100 percent of all perennial stream miles maintaining unobstructed passage for fish. A target of this level would guarantee that fish could move out of segments with poor habitat. However, this target would not protect BCT populations in east canyon streams from the threat of hybridization. Scientific literature provides estimates of MSL for cutthroat trout species in the range of approximately 6–16 miles depending on abundance levels. These distances are close to, or in excess of, many tributary reaches found in Salt Lake County. An intermediate target could be based on the 3–5–mile distance considered important by the NRCS for fish passage (USDA 1998).

A second intermediate target could utilize information included in the WaQSP report (Chapter 3 Table 3.10.1) which indicates the miles of stream for each tributary and the Jordan River with interrupted flow (reaches that are completely dewatered during any portion of the year). The total miles of interrupted flow for each stream could be used as stream specific targets that would ensure fish could move out of or across dewatered segments. These values range from about 0.5–7.5 miles. However, there are several perennial tributaries, as well as the Jordan River, that have no interrupted reaches.

At a minimum, fish passage targets should represent channel lengths that prevent fish from being stranded in any segment maintaining lethal conditions. A GIS review of the locations of fish passage obstructions on perennial tributaries and local knowledge of fish populations indicates that a distance of 0.25 mile would meet the minimum requirements for avoiding lethal conditions. With respect to the Jordan River, it is recommended minimum fish passage targets be set to the distances between existing diversions on the river including Turner Dam, Joint Diversion, North Jordan Canal, Brighton Dam, Surplus Canal, and Burnham Dam.

Habitat Structures

This metric measures the number and type of habitat structures needed to support fish species. Habitat structures benefit different life stages of aquatic species, some of which include spawning, juvenile protection from predators, and places of rest for adult species. These structures can be organic (logs, stumps, etc.) or inorganic (boulders) and occur naturally or through manmade construction of gabions, check dams, random boulder placement, vortex weirs, etc.

Much discussion has taken place with regard to the number and type of in-stream organic habitat structures which can be described as pieces of Large Woody Debris (LWD). The functions of LWD include providing critical habitat as well as geomorphic processes such as creation and maintenance of pools or trapping and sorting of sediment. A working definition of LWD is wood greater than 3 feet in length and more than 4 inches in diameter (Featherston et. al. 1995). However, in order for LWD to create habitat and interact with channel morphology, the pieces must be large enough to influence flow over multiple seasons as well as remain immobile and intact. These requirements eliminate smaller wood pieces that will accumulate along with other material (i.e. trash) that is typically considered a nuisance. The recommended minimum diameters for LWD are (ODF 1995):

Bankfull Width (feet)	Minimum diameter (inches)
0–10	10
10–20	16
20–30	18
>30	22

The amount of LWD considered to be supportive of a healthy stream ecosystem should account for stream slope and stream size, both of which influence the relationship between geomorphic processes and LWD (ODF 1995). Strictly viewed from a habitat perspective, there is no difference between organic and inorganic structures. Therefore, while an ecologically healthy number of habitat structures is considered to be dependent on site-specific conditions, an appropriate target value can be inferred from pool spacing. In general, the occurrence of pools can be associated with the upstream presence of organic (LWD) or inorganic structures (boulders) of sufficient size to alter flow paths, create channel scour, and ultimately develop pools. Therefore, the recommended target for Habitat Structures is considered equal to the pool spacing shown in Table 2 above for each Rosgen stream type.

Flow Diversion

This metric assesses both the percent of stream channel length that maintains natural flow as well as the percent of each year that channels maintain a natural flow regime. Flow diversions from many streams in Salt Lake County have removed the natural hydrologic patterns in both time and space. Stream channels can support healthy aquatic populations if minimum flows are sustained during baseflow periods. If stream flows are significantly reduced by diversions, aquatic populations can be impacted. Such impacts can result in death or emigration to more suitable habitat.

The recommended target for Flow Diversion is 100 percent of stream lengths supporting a natural flow regime throughout each year. This target is to be applied to all mountain and valley portions of tributary streams as well as the length of the Jordan River in Salt Lake County. Recognizing that the Jordan River is highly managed for purposes of seasonal flood control and irrigation, it should be noted that achieving the target does not require that diversions and releases cease entirely. Water diverted from tributaries can be replaced in equal amounts over time and space through exchange agreements. Although management of Utah Lake is based on flood control strategies and water rights law, progress toward the target recommended for the Jordan River could still be made through timed releases that more closely mimic the natural flow regime during the spring season and other times of the year.

RIPARIAN CORRIDOR

Width

This metric defines the minimum width needed to maintain connectivity of avian habitat and allow travel/migration along riparian corridors. When considering corridor width, factors such as ecological processes and size of the river system are typically considered. However, migration of bird species have been selected by Salt Lake County as the ecological process by which riparian corridor width will be evaluated. Much of the migration that occurs in riparian corridors takes place along the upland edge or the channel edge and not through the vegetation itself. Therefore, narrow corridor widths may support avian movement but, it should be noted, provide less support of desired improvements in water quality such as filtering surface runoff and lowering water temperatures.

Riparian areas can be considered as a naturally occurring transitional zone (or ecotone) between aquatic and terrestrial ecosystems with a varying width. An estimate of the natural width of riparian areas can be obtained from a measurement of belt width or the perpendicular distance between the outside of successive meander bends. Belt width is assumed to represent a maximum width traversed by stream channels and loosely captures the width of natural riparian areas. A maximum width of natural riparian areas could be estimated as twice the belt width or the full belt width on either side of the channel bank. Belt width (B) can be estimated by the equation $B = 3.7\ W^{1.12}$ or approximately equal to six bankfull channel widths (W). Bankfull widths are typically on the order of 10–30 feet for tributaries and 40–60 feet for the Jordan River. Based on this methodology, an estimate of natural riparian areas could be 120–360 feet for tributaries and 480–720 feet for the Jordan River.

An alternative strategy for managing riparian resources can rely on riparian "corridors" as opposed to natural riparian "areas". A riparian corridor can be defined with a fixed width that may or may not include the riparian area. While riparian corridors may not include the full benefit of natural riparian areas, they can still provide valuable contributions to water quality as well as support to avian migration and habitat for all life stages.

Scientific literature indicates that width of riparian corridors can significantly influence the number and type of avian species that inhabit these areas. Cronquist and Brooks (1993) studied bird species richness and abundance and noted these parameters decreased rapidly with distance from stream channels in disturbed (developed) watersheds in comparison to non-disturbed watersheds. In addition, they noted that riparian corridors as narrow as 7 feet seemed to be important in maintaining portions of bird communities. Fischer (2000) provided a summary of recent scientific studies that examined minimum corridor widths necessary to sustain bird populations. A summary of these findings is provided in Table 4 below. Several of these studies indicated that neotropical migrants would not inhabit corridors narrower than 150 feet and a minimum of 300 feet was necessary in order to sustain functional assemblages of the most common neotropical breeding species (Tassone 1981, Hodges and Krementz 1996 as cited in Fischer 2000). Riparian buffers on headwater streams were noted to provide the most benefit to forest bird species if they were greater than 120 feet (Hagar 1999 as cited in Fischer 2000). Triquet et al (1990 as cited in Fischer 2000) found that riparian corridors less than 300 feet were primarily inhabited by resident or short-distance migrants.

The recommended target for Width of riparian corridors is 200 feet for tributaries and 300 feet for the Jordan River. These corridor widths represent the total distance extending outwards from each channel bank, i.e. 100 feet each side of tributaries and 150 feet each side of the Jordan River. This distance should be considered a minimum width that will support migration of neotropical species. As indicated by the literature, greater widths may be necessary if sustainable populations of some species are desired.

<u>Community Type</u>

This metric identifies structural habitat needs of avian species with respect to percent surface cover of riparian vegetation (i.e. canopy, mid-story, and forb/grass). The target is based on avian species included on the sensitive species list for Salt Lake County. This list is established by the Utah Division of Wildlife Resources for each county in Utah. Habitat needs for avian species that utilize riparian corridors in Salt Lake County are shown in Table 5.

The total amount of cover provided by each structural component for the particular species of concern is not specified in scientific literature. Furthermore, it is likely that an optimal amount for one species is different from that of other species of concern. In general, higher levels of structural complexity in the riparian corridor result in greater habitat opportunities for individual species and a greater probability that needs of all species will be met.

Table 4. Recommended Minimum Widths of Riparian Buffer Strips and Corridors for Birds (Fischer 2000).

Authors	Location	Minimum Width	Benefit
Darveau et al. 1995	Canada	>60 m	There was evidence that 50-m-wide forested buffer strips were required for forest-dwelling birds. Bird populations may decline in strips before regeneration of adjacent clearcuts provide suitable habitat for forest birds.
Hodges and Krementz 1996	Georgia	>100 m	Riparian strips >100 m were sufficient to maintain functional assemblages of the six most common species of breeding neotropical migratory birds.
Mitchell 1996	New Hampshire	>100 m	Need >100-m-wide buffers to provide sufficient breeding habitat for area-sensitive forest birds and nesting sites for red-shouldered hawks.
Tassone 1981	Virginia	>50 m	Many neotropical migrants will not inhabit strips narrower than 50 m.
Triquet, McPeek, and McComb 1990	Kentucky	>100 m	Neotropical migrants were more abundant in riparian corridors wider than 100 m; riparian areas <100 m wide were inhabited mainly by resident or short-distance migrants.
Spackman and Hughes 1995	Vermont	>150 m	Riparian buffer widths of at least 150 m were necessary to include 90 percent of bird species along mid-order streams.
Kilgo et al 1998	South Carolina	>500 m	Although narrow bottomland hardwood strips can support an abundant and diverse avifauna, buffer zones at least 500 m wide are necessary to maintain the complete avian community.
Keller, Robbins, and Hatfield 1993	Maryland; Delaware	>100 m	Riparian forests should be at least 100 m wide to provide some nesting habitat for area-sensitive species.
Gaines 1974	California	>100 m	Provide riparian breeding habitat for California yellow-billed cuckoo populations.
Vander Haegen and DeGraaf 1996	Maine	>150 m	Managers should leave wide (>150 m) buffer strips along riparian zones to reduce edge-related nest predation, especially in landscapes where buffer strips are important components of the existing mature forest.
Whitaker and Montevecchi 1999	Canada	>50 m	50-m-wide riparian buffers only supported densities <50 percent of those observed in interior forest habitats.
Hagar 1999	Oregon	>40 m	Although riparian buffers along headwater streams are not expected to support all bird species found in unlogged riparian areas, they are likely to provide the most benefit for forest-associated bird species if they are >40 m wide.

Table 5. Physical habitat components for Salt Lake County species of concern (UCDC 2008).					
Common Name	**Scientific Name**	**State Status**	**Primary Breeding Habitat**	**Secondary Breeding Habitat**	**Habitat description**
American White Pelican	*Pelecanus erythrorhynchos*	SPC	Water	Wetland	Great Salt Lake foraging environments reflect many of the qualitative values identified for American pelicans. Because of the low gradient bottom of the Great Salt Lake and its associated wetlands, pelicans have thousands of hectares of fisheries that are 0.5-2 m deep. These fisheries are high in nutrients, warm quickly, and provide excellent breeding, nursery, and foraging habitats for "rough" fish. Subsequently, these habitats allow for a broad range of American white pelican foraging strategies.
Bald Eagle	*Haliaeetus leucocephalus*	S-ESA	NA	NA	Throughout the breeding range of this species, nests are almost always in tall trees and commonly near bodies of water where fish and waterfowl prey are available. During non-breeding periods, especially during winter, bald eagles are relatively social and roost communally in sheltered stands of trees. Wintering areas are commonly associated with open water, though other habitats may be used if food resources, such as rabbit or deer carrion, are readily available.
Black Swift	*Cypseloides niger*	SPC	Lowland Riparian	Cliff	Nesting habitat is classified as mountain riparian; however, waterfalls are the key characteristic of nesting sites. Black swifts require waterfalls for nesting. Typically the falls are permanent but may be intermittent if they flow throughout the breeding season (June to early September). Nesting sites are typically surrounded by coniferous forests, but this varies depending on elevation and aspect, and nest sites may include mountain shrub, aspen, or even alpine components.
Bobolink	*Dolichonyx oryzivorus*	SPC	Wet Meadow	Agriculture	Bobolinks in the West nest and forage in wet meadow (grasses and sedges), wet grassland, and irrigated agricultural (primarily pasture and hay fields) areas. These habitats, particularly wet meadows, tend to be associated with riparian or wetland areas. Nest sites tend to be in wet habitats but also occur in transitional areas between wet and dry areas. Nests are almost always built on the ground and are often located at the base of large forbs. Although grass usually makes up a large portion of the general nesting area, nests are rarely located in grass but are instead located in forbs and sedges.

Table 5. Physical habitat components for Salt Lake County species of concern (UCDC 2008).					
Common Name	**Scientific Name**	**State Status**	**Primary Breeding Habitat**	**Secondary Breeding Habitat**	**Habitat description**
Grasshopper Sparrow	*Ammodramus savannarum*	SPC	Grassland	Grassland	In April of each year, nests of grass are built on the ground at the bases of grass clumps. This sparrow feeds largely on insects. Although grasshoppers may compose a significant portion of the diet, the source of the common name is the bird's characteristically insect-like song.
Lewis's Woodpecker	*Melanepres lewis*	SPC	Ponderosa Pine	Lowland Riparian	The major breeding habitat consists of open park-like ponderosa pine forests. The Lewis's woodpecker is attracted to burned-over Douglas-fir, mixed conifer, pinyon-juniper, riparian, and oak woodlands, but is also found in the fringes of pine and juniper stands and deciduous forests, especially riparian cottonwoods. Areas with a good understory of grasses and shrubs to support insect prey populations are preferred. Dead trees and stumps are required for nesting. Wintering grounds are over a wide range of habitats, but oak woodlands are preferred.
Long-billed Curlew	*Numenius americanus*	SPC	Grassland	Agriculture	Long-billed curlews have four essential nesting habitat requirements in the northwestern United States: (1) short grass (less than 30 cm tall), (2) bare ground components, (3) shade, and (4) abundant vertebrate prey. They seem to be most successful nesting in mixed fields with adequate, but not tall, grass cover and fields with elevated points. Uncultivated rangelands and pastures support most of the continental long-billed curlew breeding population.
Yellow-billed Cuckoo	*Coccyzus americanus*	S-ESA	Lowland Riparian	Agriculture	Nesting habitat is classified as dense lowland riparian characterized by a dense sub-canopy or shrub layer (regenerating canopy trees, willows, or other riparian shrubs) within 300 feet of water. Over story in these habitats may be either large, gallery-forming trees (30–90 feet) or developing trees (10–30 feet), usually cottonwoods. Yellow-billed cuckoos are considered a riparian obligate and are usually found in large tracts of cottonwood/willow habitats with dense sub-canopies (below 30 feet).

Previous riparian surveys conducted by the County measured density of overstory, middle, and understory vegetation cover into four categories including 0–10 percent (poor), 10–30 percent (fair), 30–60 percent (good) and 60–100 percent (excellent) for each stream bank. The recommended target for Community Type is all stream banks with 60 percent or greater cover for each structural component.

HYDROLOGY

This functional group involves hydrologic features that contribute to proper conveyance of flood events through the watershed as well as physical stability of the stream network. Two sub-groups contribute to the Hydrology Index Score including Flood Conveyance and Stream Stability. Metrics included in the Flood Conveyance sub-group measure the potential of the stream channel network to transport flood events through the watershed. Metrics in the Stream Stability sub-group assess bank stability and the level of hydraulic alteration associated with stream channels.

FLOODPLAIN DEVELOPMENT

This metric assesses the level of development within the 100-year floodplain adjacent to all tributary streams and the Jordan River. Development in the floodplain can result in negative impacts on riparian vegetation, soils, channel banks, and the stream flow regime during periods of high runoff or baseflow. Floodplains that have not been developed are more capable of accommodating peak flows through the buffering effects of well established riparian vegetation and diversion of flow volumes into shallow areas outside of the established stream channel. Efforts to minimize or eliminate development in the 100-year floodplain will likewise decrease the risk of flooding and resultant financial impacts on Salt Lake County and adjacent municipalities.

The 100–year floodplain has been defined by the Federal Emergency Management Agency (FEMA) for many of the streams and Jordan River in Salt Lake County. Floodplains are defined from the surface elevation of the 100–year flood event projected to the adjacent stream corridor. The geographic area within the floodplain is defined by FEMA according to specific levels of risk including low, moderate and high risk of flooding.

The target for Flood Protection is no development in 100 percent of the area contained in the 100–year floodplain as defined by FEMA. This target applies to floodplains of mountain and valley tributaries as well as the Jordan River. If FEMA has not defined a floodplain, it is recommended that no score be calculated for that particular stream.

Floodplain Connectivity

This metric is designed to assess the level of connectivity between stream channels and their adjacent floodplains. A quantitative measure of floodplain connectivity can be achieved through measuring channel entrenchment, which is defined as the vertical containment of a river and the degree to which it is incised into the surrounding valley floor. Characteristics of channel entrenchment are provided in Table 6 and indicate that flows in slightly entrenched stream channels frequently access floodplains while deeply entrenched channels access floodplains during extreme events only. This contrast is due to changes in elevation difference between bankfull stage and top of bank stage.

Table 6. Definitions and characteristics of stream channel entrenchment (as cited in Rosgen 1996).	
Kellerhalls et al. 1972	**Qualitative definition:** Vertical containment of a river and the degree to which it is incised in the valley floor.
Rosgen 1994	**Quantitative definition:** Ratio of width of the flood-prone area to surface width of the bankfull channel. The flood-prone area generally includes the active floodplain and the low terrace. The flood prone area width is measured at the elevation that corresponds to twice the maximum depth of the bankfull channel as taken from the established bankfull stage. A ratio of 1–1.4 represents an entrenched stream while ratios greater than 2.2 represent streams that are connected to well developed floodplains.
Rosgen 1996	**General characteristics:** Field observations indicate that for most stream types, the elevation corresponding to the flood-prone area width is associated with a < 50 year return period flood rather than an extreme event. For stream types that are only slightly entrenched (e.g., stream types C, D, DA, and E) flows greater than the bankfull stage overtop their streammbanks and extend onto their floodplain. This natural phenomenon does not hold true for deeply entrenched channels (e.g., stream types A, F, and G) where the actual top of bank elevations are much higher than the bankfull stage. For entrenched channels, streamflows greater than bankfull increase in depth much faster than in width, as discharge increases. In entrenched channels, the flood-prone area increases only marginally in width with an increasing flow stage above bankfull elevations.

Stream channels become entrenched in response to relatively short-term events such as headcuts and channel scour. Events such as these can remove large amounts of material and lower the channel elevation to a level that isolates riparian vegetation from water. Entrenchment can also occur from longer term processes that create an imbalance in the stream channel by minimizing deposition of sediment and beload in a reach while allowing existing material to be removed. This condition typically occurs following construction of reservoirs or large diversions that radically alter natural flow patterns downstream of their location.

The targets for Floodplain Connectivity are based on stable Rosgen stream types and are shown in Table 7. As mentioned previously Rosgen stream types G, F, and D are considered to be in transitional stages that will naturally develop into other, more stable geomorphic forms. In general, Rosgen type G would evolve to a type B or type C stream (depending on size and location in the watershed), Rosgen type F would evolve to a type E stream, and Rosgen type D would evolve to a type C stream. Targets are applicable to Rosgen stream types identified in field surveys of mountain and valley tributaries as well as the Jordan River.

Table 7. Stream channel entrenchment targets by Rosgen stream type.	
Rosgen Type	**Entrenchment Ratio**
A	1.0 - 1.4
B	1.41 - 2.2
C	>= 2.2
D	>=2.2
E	>=2.2
F	>=2.2
G	1.41 - 2.2

STREAM STABILITY

Pfankuch Bank Stability

Measurements of channel bank stability provide an indication of existing hydrologic concerns. Stream channels with unstable banks can quickly degrade into conditions that require a significant commitment of time and money to repair. The Pfankuch method of assessing bank stability accounts for stability in the upper and lower banks as well as the channel bottom (Pfankuch 1975). To address urban stream conditions, the Pfankuch method was modified to include evaluation of stream bank structures (see Hydraulic Alteration below). Scores are associated with categories for each zone (including upper and lower banks and channel bottom) and can be adjusted for geomorphic stream type. This adjustment accounts for levels of bank erosion that occur naturally in many stream types and subsequently do not indicate bank instability problems. Good stability ratings per Pfankuch for moderate gradient streams are 40–60 and 60–90 for lower gradient streams. Table 8 summarizes the bank features and associated rating criteria used in the Pfankuch methodology.

The target for Pfankuch Bank Stability is 100 percent of stream banks rated as good or better. This target applies to mountain and valley tributaries as well as the Jordan River. GIS information has been compiled that displays all surveyed measurements of bank stability collected from Salt Lake County streams. This information provides a higher resolution of bank stability beyond the pass/fail methodology used to evaluate targets and will help to determine where improvement efforts should be made.

Hydraulic Alteration

Urbanization of stream corridors in Salt Lake County have resulted in significant changes to physical characteristics and processes that tend to naturally promote stability in stream channels. In the absence of these processes, stream channel banks have been hydraulically altered in Salt Lake County with the intent to stabilize channel banks and minimize or eliminate bank erosion. Structures used typically involve placement of organic or inorganic materials that harden channel banks and deflect flow velocities. Use of these structures can occur through a “hard” engineering approach that relies upon concrete structures or riprap material. While effective in terms of maintaining bank stability and reducing bank erosion, these structures provide little support to development of floodplains or riparian vegetation. In addition, the aesthetic perception of these structures is low.

Table 8. Measurements of bank and channel features used per Pfankuch (1975) methodology modified per Salt Lake County 2007 to assess bank stability.

Bank Feature	Excellent	Good	Fair	Poor
Mass Wasting or Failure	No evidence of past or potential for future mass wasting.	Infrequent and/or very small Low future potential.	Moderate frequency and size with some raw spots.	Frequent or large, causing sediment nearly yearlong.
Debris Jam Potential	Essentially absent from immediate channel area.	Present but mostly small limbs and twigs.	Present, volume and size are both increasing.	Moderate to heavy amounts, predominantly larger sizes.
Vegetative Bank Protection	90% plant density.	70-90% plant density.	50-70% plant density.	< 50% plant density.
Upper Bank Stabilization Structures	Structures are in good condition and functioning properly. Or, no structures	Structures have minor damage or is in an inappropriate application with some potential for mass wasting.	Structures are moderately damaged with some raw spots eroded during high flow.	Structures have failed causing sediment nearly year long or imminent danger of same.
Channel Capacity	Ample for present flows, Peak flows contained. W:D ratio < 7.	Adequate. Overbank flows rare. W:D ratio 8-15.	Occasional overbank flows. W:D ratio 15-25.	Inadequate. Overbank flows common. W:D ratio > 25.
Bank rock content	65% with large, angular boulders 30cm numerous.	40-65%, mostly small boulders to cobbles 15-30 cm.	20-40%, with most in the 7.5-15 cm diameter class.	<20% rock fragments of gravel sizes, 2.5-7.5 cm or less.
Obstructions (flow deflectors Sediment traps)	Rocks and old logs firmly embedded. Flow pattern without cutting or deposition. Pools and riffles stable.	Some present, causing erosive cross currents and minor pool filling. Obstructions/deflectors less firm.	Moderately frequent, unstable obstructions and deflectors move with high water, bank cutting and deposition.	Frequent obstructions and deflectors cause bank erosion. Sediment traps' full channel migration occurring.
Undercutting	Little or none evident. Infrequent raw banks <150 cm high.	Some, intermittently at outcurves and constrictions. Raw banks <30 cm.	Significant. Cuts 15-30 cm high. Root mat overhangs and sloughing evident.	Almost continuous cuts, some >30 cm high. Failure of overhangs frequent.
Deposition	Little or no enlargement of channel or point bars.	Some new increase in bar formation, mostly from course gravels.	Moderate deposition of new gravel and course sand on old and some new bars.	Extensive deposits of predominantly fine particles. Accelerate bar development.
Lower Bank Stabilization Structures	Structures are in good condition and functioning properly. Or, no structures.	Structures have minor damage or is in an inappropriate application with some potential for cutting.	Structures are moderately damaged with some bank cutting.	Structures have failed causing cutting nearly year long or imminent danger of same.
Rock Angularity	Sharp edges and corners, plane surface roughened.	Rounded corners and edges, surfaces smooth and flat.	Corners, edges well rounded in two dimensions.	Well rounded in all dimensions, surfaces smooth.
Brightness	Surfaces dull, darkened, or stained. Generally not "bright."	Mostly dull, but may have up to 35% bright surfaces.	Mixture, 50/50% dull and bright, +/- 15%.	Predominately bright, 65%, exposed or scoured surfaces.
Consolidation or Particle Packing	Assorted sizes tightly packed and/or overlapping.	Moderately packed with some overlapping.	Mostly a loose assortment with no apparent overlap.	No packing evident. Loose assortment, easily moved.
Bottom Size Distribution and % Stable Materials	No change in sizes evident. Stable materials 80-100%.	Distribution shift slight. Stable materials 50-80%.	Moderate change in sizes. Stable materials 20-50%.	Marked distribution change. Stable materials 0-20%.
Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition.	5-30% affected. Scour at constrictions and gradient changes. Some deposition in pools.	30-50% affected. Deposits & scour at obstructions, constrictions, and bend. Some filling of pools.	More than 50% of the bottom in a state of flux or change nearly yearlong.
Clinging Aquatic Vegetation	Abundant. Growth largely moss-like, dark green, perennial.	Common. Algal forms in low velocity and pool areas.	Present but spotty, mostly in back water areas.	Perennial types scarce or absent. Yellow-green, short term blooms present.
Structures	Structures are in good condition and functioning properly. Or, no structures.	Structures have minor damage or potential for scouring.	Structures are moderately damaged with some scouring.	Structures have failed causing cutting nearly year long or danger of same.

Alternatively, use of organic materials and designs that replicate physical proportions of natural channel features can produce acceptable levels of bank stability and erosion control. Use of this design type can not only promote short term stability (root wads, and log cribs that deflect flow away from banks) but also incorporate natural geomorphic processes that further stabilization such as growth of riparian vegetation, establishment of floodplains, balanced sediment transport, etc.

The majority of stream and river channels in the valley areas of Salt Lake County have been influenced by development. In some situations, restoration of channel dimension, pattern, and profile to predevelopment conditions may not be possible. However, channel designs that mimic natural features can provide levels of channel stability that are similar to a hard engineering approach, as well as providing support to riparian vegetation and floodplain development.

The recommended target for Hydraulic Alteration is 100 percent of channel banks without hydraulic alteration. Channel reaches with hydraulic alteration that mimic natural stream channel features will be considered in support of this target and equivalent to reaches that have not experienced hydraulic alteration.

WATER QUALITY

This functional group provides a means to assess water quality conditions in the project area. Three sub-groups are used including Regulatory, Aquatic, and Monitoring. Each subgroup addresses water quality from a slightly different perspective. The Utah 303(d) list of impaired waters is used to characterize water quality from a regulatory perspective. The composition of macroinvertebrate communities reflect different species tolerance of species to pollution or changes in water quality and thus can be used as a surrogate measure of water chemistry. Monitoring of water quality through direct measurements can indicate changes in upstream areas that contribute flow to receiving water bodies.

REGULATORY

303(d) List

Section 303(d) of the Clean Water Act requires States to identify water bodies that do not meet water quality standards that are designed to protect the beneficial use for the water body. Measurements of water quality are evaluated against numeric standards and pollution indicator levels. In general, if more than 10 percent of measurements collected during an intensive monitoring period violate criterion, the AU is considered non supportive of beneficial use and a candidate for the 303(d) list. E. coli is assessed with two criteria. If one or both criteria for E. coli are not met, the AU is considered non supportive of the assigned beneficial use.

The initial assessment of water quality monitoring is compiled into a report (more commonly called the 303(d) list), that is updated every 2 years and submitted to the Environmental Protection Agency (EPA) for review and approval. Once a water body is included on the 303(d) list, action must be taken to identify pollutant sources that contribute to water quality impairment. Load recommendations are then made for each source that will result in achievement of water quality standards. This process results in a Total Maximum Daily Load (TMDL) for a water body. When a TMDL has been approved by the EPA, the water body is recommended for delisting and removal from the 303(d) list.

Waters of Utah are organized by the Utah Division of Water Quality (DWQ). Streams and rivers are typically divided into individual Assessment Units (AU) that may have different beneficial uses and water quality standards. Individual AUs for a stream can be included on the 303(d) list. The target for the 303(d) List is 100 percent of all AUs, including those found on mountain and valley tributaries as well as the Jordan River, not included on the Utah 303(d) list.

AQUATIC

Macroinvertebrate

The standard method to assess support and protection of beneficial uses in Utah has relied only upon water quality samples and standards that are designed to protect aquatic life forms. DWQ has recently incorporated a biological component to their evaluation of beneficial use (DWQ 2008). The biological approach relies on Observed (O) measurements of benthic macroinvertebrate taxa as well as Expected (E) taxa numbers predicted by an empirical model developed for Utah. The ratio of O/E is then compared to a recommended threshold that defines support or non-support of the assigned beneficial use.

The empirical model developed by DWQ provides an estimate of the number of macroinvertebrate taxa expected at a site that is absent of human impacts. Model predictions of E are based on measurements collected from reference sites located in relatively undisturbed sites throughout Utah. Selection of reference sites was initially completed by DWQ personnel and later screened by scientists familiar with local conditions. Associations were then developed between measurements of benthic macroinvertebrates collected from each reference site and a group of 15 GIS-based descriptors. As a result, the model is capable of predicting E under reference type conditions for any location in Utah. The accuracy of the model was tested by looking at the distribution of O/E scores for reference sites. This assessment found that O/E scores were not biased by stream size, elevation, or ecoregion. A complete discussion of model development and the results of O/E ratios for monitoring sites can be found in the 2008 305(b) report (DWQ 2008).

Beginning in 2008, Utah DWQ will utilize macroinvertebrate survey data to assess support or non-support of beneficial use assigned to waters of the state. Thresholds used to evaluate beneficial use are dependent upon sample size. If more than 3 samples have been collected from a particular site, an O/E ratio of 0.74 or greater indicates full support of beneficial use. This threshold represents departure from a ratio of 1.0 (observed taxa = expected taxa) of 2 standard deviations from reference O/E scores. If fewer than 3 samples have been collected, a second threshold value of 0.54 or greater is used to determine full support.

The recommended target for Macroinvertebrate is equivalent to 0.74 or 0.54 (depending on sample size) as calculated by the O/E model developed by DWQ (DWQ 2008). Individual E values must be determined for each aquatic monitoring location used to evaluate the watersheds and subwatersheds in Salt Lake County. In order to provide some spatial distribution of O/E scores, it is recommended that Salt Lake County select two macroinvertebrate monitoring locations for the mountain and valley portion of each perennial tributary and eight monitoring locations for the Jordan River, including one site for each Jordan River AU. These locations should be the same locations used for evaluation of water quality monitoring discussed below. If possible, sites should be selected that are currently used by DWQ and have an existing water quality monitoring record. DWQ can provide the corresponding E values to Salt Lake County once the geographic coordinates of each site are known. Values for E have already been completed by DWQ for selected sites in the Jordan River basin. These values are provided below in Table 9.

Table 9. Expected number of taxa for all stream monitoring locations in Salt Lake County (Ostermiller 2008).		
STORET ID	**Site Name**	**Expected Number of Taxa**
4993780	Little Cottonwood Creek above confluence with Red Pine Creek.	12.72
5918860	Little Cottonwood Creek below Columbus Rexall Mine discharge - 0.1 mile above Alta bridge.	12.04
5918880	Little Cottonwood Creek above Columbus Rexall Mine Outfall.	12.04
4993592	Little Cottonwood Creek at Murray Park.	7.39
5918860	Little Cottonwood Creek downstream from mine.	12.04
4993660	Little Cottonwood River at USFS boundary.	10.80
4993203	Big Cottonwood Creek.	11.50
4992290	Jordan River at 1700 South.	6.86
4994100	Jordan River at 6800 South.	6.85
4994600	Jordan River at Bluffdale Road crossing.	7.38
4990880	Jordan River at State Canal Road crossing.	6.84
4994500	Jordan River at 123000 South.	6.88
4994170	Jordan River at 7800 South.	6.85
4994600	Jordan River at Bluffdale Road crossing.	7.38
4990880	Jordan River at Newstate Canal Road crossing.	6.84
4992640	Mill Creek at USFS boundary.	11.76
4956435	Mill Creek upstream from Loop Road.	12.67
4992783	Mill Creek within Salt Lake City.	12.05

MONITORING

A total of five parameters are associated with this subgroup including Total Phosphorus (Total P), Water Temperature (Temperature), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and Coliform (E. coli). Four of these parameters are associated with numeric criteria and one parameter (Total P) is considered a pollution indicator value (Table 10). Numeric criteria are established at levels designed to protect beneficial uses associated with a particular water body. Pollution indicator levels are used to indicate potential water quality problems. If sample measurements exceed indicator levels, other processes may be present that lead to water quality impairment, such as eutrophication or low DO concentrations.

DWQ monitors water quality at sites located in or immediately downstream of stream AUs to determine the level of support to beneficial uses. Monitoring may take place on a frequent basis during intensive monitoring cycles that occur once every 5 years. During these periods, samples are collected every 2–4 weeks. Outside of intensive monitoring periods, sites are visited infrequently or not at all unless a site has been selected for long-term monitoring site. A total of 51 sites have been selected state-wide for long term monitoring with the intent to identify water quality trends. These sites are visited every 6–8 weeks or roughly eight times per year. Six long term sites maintained by DWQ are located in Salt Lake County including three on the Jordan River, and three others on lower Little Cottonwood Creek, Lee Creek, and the Surplus Canal. One additional long term site is located on the Jordan River just upstream of Salt Lake County at the Utah Lake outlet. The United States Geological Survey (USGS) and Jordan Valley Water Conservancy District (JVWCD) also operate long term sites on the Jordan River at 1700 South and the Narrows, respectively. A list of currently active water quality monitoring sites located in the Jordan River basin, is shown in Table 10 below.

Table 10. Active water quality sampling stations located in the Jordan River Basin.

Water Body	Station ID	Location	Agency	Type
Big Cottonwood Creek	4992970	Jordan River	DWQ	Intensive
Big Cottonwood Creek	4993100	USFS Boundary	Salt Lake City	Cooperative
Big Cottonwood Creek	4993230	Mill D	Salt Lake City	Cooperative
Bingham Creek	4994180	Jordan River	DWQ	Intensive
Butterfield Creek	4994440	Canyon	DWQ	Intensive
Central Valley WRF Discharge	4992500	Outfall	DWQ	Compliance
City Creek	4991950	Above Treatment Plant	Salt Lake City	Cooperative
Emigration Creek	4992160	Switchback	Salt Lake City	Cooperative
Jordan River	4990880	New State Road	DWQ	Intensive
Jordan River	4990890	Above Bumham Dam	DWQ	TMDL
Jordan River	4991820	Cudahy Lane	DWQ	Long Term
Jordan River	4991860	Redwood Road	DWQ	TMDL
Jordan River	4991910	North Temple	DWQ	Intensive
Jordan River	4991940	400 South	DWQ	Intensive
Jordan River	4992030	700 South	DWQ	Intensive
Jordan River	4992270	1300 South	DWQ	Intensive
Jordan River	4992320	2100 South	DWQ	Intensive
Jordan River	4992880	3300 South	DWQ	Long Term
Jordan River	4994090	5400 South	DWQ	Intensive
Jordan River	4994170	7800 South	DWQ	Intensive
Jordan River	4994370	10600 South	DWQ	TMDL
Jordan River	4994500	12300 South	DWQ	TMDL
Jordan River	4994600	Bluffdale Road	DWQ	Long Term
Jordan River	4994720	Narrows	DWQ	Intensive
Jordan River	4994790	Utah Lake Outlet	DWQ	Long Term
Jordan River	10171000	1700 South	USGS	Long Term
Jordan River		Narrows	JVWCD	Long Term
Lambs Creek	4992210	Canyon	Salt Lake City	Cooperative
Lee Creek	4991430	I-80	DWQ	Long Term
Kersey Creek	4994650	Above Magna WWTP	DWQ	Waste Load Allocation
Little Cottonwood Creek	4993580	Jordan River	DWQ	Intensive
Little Cottonwood Creek	4993660	Above Power Plant	DWQ	Long Term
Little Cottonwood Creek	4993780	Red Pine	Salt Lake City	Cooperative
Little Cottonwood Creek	10168000	Jordan River	USGS	Regular
Little Dell Creek	4992190	Utah 65	Salt Lake City	Cooperative
Mill Creek	4992540	Jordan River	DWQ	Intensive
Mill Creek	4992640	USFS Boundary	Salt Lake City	Cooperative
Mill Creek	4992780	Elbow Fork	Salt Lake City	Cooperative
Mt. Dell Creek	4992170	Utah 65	Salt Lake City	Cooperative

Table 10. Active water quality sampling stations located in the Jordan River Basin.				
Water Body	**Station ID**	**Location**	**Agency**	**Type**
Parley's Creek	4992200	Utah 65	Salt Lake City	Cooperative
Red Butte Creek	4992100	Above Reservoir	Salt Lake City	Cooperative
South Davis South WRF Discharge	4991810	Outfall	DWQ	Compliance
South Valley WRF Discharge	4994160	Outfall	DWQ	Compliance
Surplus Canal	4991310	I-80	DWQ	Long Term

With regard to Temperature and DO, most grab samples are collected during hours that do not represent the worst-case scenario for DO concentrations. Therefore, measurements of DO are compared to the 30-day average criterion as shown in Table 11. E. coli samples are collected during the summer recreation season, typically June through September, and assessed with instantaneous maximum and geometric mean criteria. Total P is a pollution indicator and is not required to be assessed with regulatory thresholds similar to numeric criteria. The concentration associated with this criterion represents a threshold that is known to limit algal production and eutrophication.

The Monitoring target is 100 percent of all samples in compliance with DWQ numeric criteria and pollution indicator levels. It is recognized that high concentrations of some water quality constituents will periodically occur in healthy stream systems during extreme storm events or the spring runoff period. Data collected as part of the monitoring effort will be screened to remove outliers associated with these events. Numerous monitoring locations have previously been established by DWQ on perennial tributaries as well as the Jordan River. Where possible, Salt Lake County should utilize these locations as well as data collected by DWQ and other agencies and municipalities.

Table 11. Numeric criteria and pollution indicator levels associated with metrics included in the Monitoring sub group.

Parameter	Class 2A – Primary Contact Recreation	Class 2B – Secondary Contact Recreation	Class 3A – Cold Water Fishery	Class 3B – Warm Water Fishery	Class 4 - Agriculture
Total Phosphorus[1]	na	na	0.05 mg/l	0.05 mg/l	na
Water Temperature	na	na	20 °C	27 °C	na
Total Dissolved Solids	na	na	na	na	1,200 mg/l
Dissolved Oxygen[2]	na	na	6.5 mg/l	5.5 mg/l	na
Coliform[3]	Max: 576 col/100 ml Mean: 126 col/100 ml	Max: 940 col/100 ml Mean: 206 col/100 ml	na	na	na

[1] Pollution Indicator
[2] The 30 day average criterion is used to assess instantaneous readings of DO.
[3] Max indicates one time maximum, Mean indicates 30-day Geometric mean calculated from a minimum of 5 samples.

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