Section 319 Nonpoint Source Pollution Control Program
Watershed Project Final Report

Jordan River Murray Taylorsville
Improvement Project

FY2018

By

Salt Lake County
Watershed Planning and Restoration Program

Figure 1: Phase 1 Toe wood structure install on the Jordan River

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Executive Summary

PROJECT TITLE: Jordan River Murray Taylorsville Rehabilitation

GRANT SOURCE: Utah Division of Water Quality, EPA Clean Water Act section 319.

INITIATION DATE: 06/02/2014 EXPIRATION DATE: 03/03/2018

EPA FUNDING: $319,096.00 TOTAL BUDGET: $531,827.00

Total EPA 319:	$319,096.00
Total EPA 319 Expenditures:	$319,096.00
Total Eligible Match Accrued:	$212,731.00

Summary Accomplishments

Ecosystem Restoration began mid-October 2015 and was completed November 2018. More than 3600 lineal feet of Jordan River east and west banks were reconstructed using natural channel designs including toe wood structures. More than 17,000 live willow and dogwood cuttings and container stock shrubs and trees were installed on the Toe-Wood structures. The entire project area has been seeded each spring and fall since the start of the project and was seeded while construction was in process to mix seed with all layers of disturbed earth and when construction was completed on each phase. The toe wood structures have held with no evidence of erosion despite multiple bankfull flow events, cuttings are surviving at approximately 85% survival rate and the seed has taken with remarkable success. To date, all of the riparian plantings have been installed with resounding success. 198 riparian sod mats have been installed in tandem with 5000 bare root stock riparian plantings. Over 17,000 live willow and dogwood cuttings have been installed. Weed mitigation began on the north end of the project summer 2015 and has progressed through the entire project. The continued spraying and mechanical removal of weeds is still occurring. Survival rates have greatly exceeded the anticipated 60%, with more than an 80% survival rate. The STEPL model displays an estimate in reductions of TSS, N and P with the completion of the first phase increasing as each congruent phase was completed, table 1 below shows the estimated Pollutant Load Reductions per year for each phase.

Phase 1, Oct 2015

Jordan River TSS 998-Natural Channel Restoration	*100 tons/yr*	*3 year*	*300 tons*
Jordan River N-998 Natural Channel Restoration	*201.8lbs/yr*	*3 year*	*605.4 lbs*
Jordan River P-998 Natural Channel Restoration	*78.2lbs/yr*	*3 year*	*234.6 lbs*

Phase 2, Oct 2016

Jordan River TSS 998-Natural Channel Restoration	*4.9 tons/yr*	*2 year*	*9.8 tons*
Jordan River N-998 Natural Channel Restoration	*18.6lbs/yr*	*2 year*	*37.2lbs*
Jordan River P-998 Natural Channel Restoration	*6.5lbs/yr*	*2 year*	*13lbs*

Phase 3, Oct 2017

Jordan River TSS 998-Natural Channel Restoration	*6.7 tons/yr*	*1 year*	*6.7 tons*
Jordan River N-998 Natural Channel Restoration	*25.7lbs/yr*	*1 year*	*25.7lbs*
Jordan River P-998 Natural Channel Restoration	*9.0lbs/yr*	*1 year*	*9.0lbs*

Table 1: STEPL Pollutant Load Reductions

Introduction

Project Water Quality Priority

Salt Lake Counties continued beneficial use of aquatic life requires protections of fish and other organisms in and along the Jordan River. Currently the Utah DWQ has identified and listed Segment 5 (Little Cottonwood creek confluence to 7800 South) of the Jordan River as impaired for temperature, total dissolved solids (TDS) and E. coli.

Temperature

The section of the river that the JRMT project took place in has been identified as impaired for the Class 3A beneficial use due to high water temperature. During the 2004 Jordan River Water Quality Total Maximum Daily Load (TMDL) Assessment done by Salt Lake County, it was found that mean temperature in the Jordan River varied between 17.94 °C and 20.34 °C for the ten sample locations utilized in this study. Ambient temperature for Salt Lake City varied between 11 °C and 37 °C during the same time period as the testing (NOAA, website). The data suggests that the River's temperature increases as it progresses downstream. Notably, the highest mean temperature was observed at the Cudahy Lane sample location (20.34 °C) and the lowest mean temperature was observed at the 6400 South sample location (17.94 °C) As with mean summer temperature, 30-day average water temperatures increased as the River progresses downstream. Overall, temperatures were highest in the month of July (varying between 19.57 °C and 21.7C) and lowest in the month of June (varying between 17.31°C and 19.15 °C). August temperatures were slightly lower than July temperatures but remained above the values observed for June, varying between 18.48 °C and 21.0 °C (Salt Lake County Jordan River Water Quality TMDL Assessment, 2004). The increasing temperatures in the river can influence the loss of biodiversity, dissolved oxygen (DO) levels, the rate at which algae and aquatic plants photosynthesize, the metabolic rates of aquatic organisms and how the aquatic organisms are affected by different pollutants, parasites and pathogens. These unnaturally high in-stream temperatures can be the result of both human and natural activities. Such as decreased vegetation cover along the riparian allowing solar radiation to increase ambient water temperatures, increased sediment loads from the failing banks and surface runoff, the confluence of other streams, impervious cover (parking lots and streets) warming surface runoff before it reaches the river. This project segment has only one natural thermal source of energy which is a hot spring near Bangerter highway (Cirrus. 2010c.).

Total Dissolved Solids (TDS)

Currently the Jordan River has a beneficial use classification 4 for Total dissolved solids (TDS). TDS refers to minerals, salts, metals, cations and/or anions that are dissolved within the water column. TDS includes all material that is neither H20 nor particles that are suspended in the water column. TDS concentrations are influenced by surface and groundwater flows or introduced by human influence. Some of the larger known sources of TDS pollution that enter the Jordan River include discharge from Utah Lake, groundwater, wastewater discharge, irrigation return flow, and tributary inflow (Cirrus 2009a). A Mass Balance Summary from the Cirrus 2010a reports shows that 372,762 tons/yr of TDS enters the project segment from upstream. Anthropogenic sources within the segment contribute 43,011 tons/yr, nearly all of which is from SVWRF. Diffuse runoff contributes 9 tons/yr. Groundwater contributes 16,223 tons/yr (Cirrus 2010a). Critical conditions for TDS are strongly affected by loads from Utah Lake and groundwater. Few anthropogenic sources exist.

TDS is considered a mostly conservative pollutant, as mass is generally preserved when TDS is transported downstream in the drainage (Cirrus. 2010c.). The irrigation standard for TDS along the Jordan River is 1200 mg/L. This standard was violated at the Bluffdale sample location (1330.56 mg/L) and the 5400 South sampling location (1332.44 mg/L). In general, TDS levels appeared to decrease as the river progressed downstream with a low of 970.56 mg/L observed at the Cudahy Lane Sample location. As with mean summer TDS, 30-day average TDS concentrations were highest at the Jordan Narrows and gradually decreased as the river progressed downstream. In contrast to patterns observed with temperature, total phosphorous and TSS data, TDS concentrations were highest in the month of August (Varying between 1,208.8 mg/L and 1,708.0 mg/L) and lowest in the month of June (Varying between 803.67 mg/L and 1267.67 mg/L). July TDS concentrations were between August and June concentrations (Varying between 1,038.0 mg/L and 1,348.0 mg/L) Notably 30-day average TDS values exceeded the 1,200 mg/L standard for the Bluffdale and 6400 South sample sites for all three months of this study (Salt Lake County Jordan River Quality TMDL Assessment, 2004). High levels of TDS can negatively influence both livestock health and crop production.

E. coli

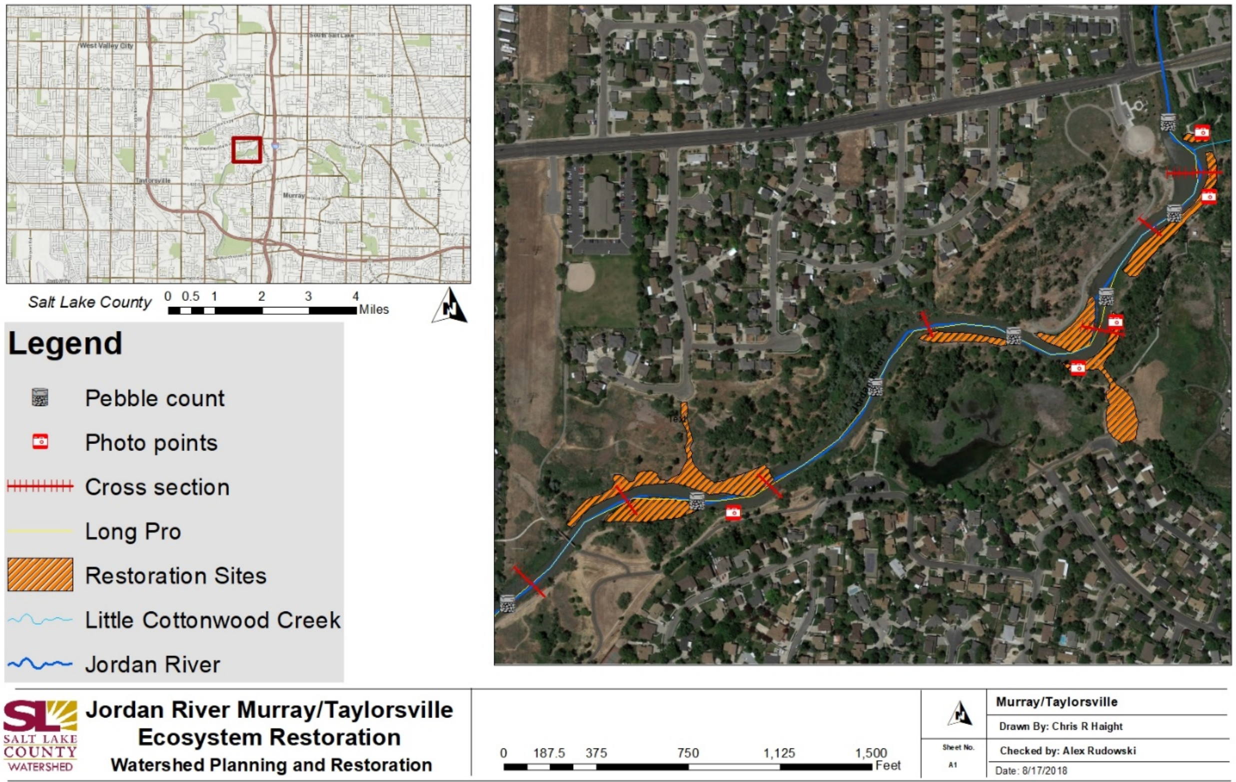
In 2005, E.coli replaced Fecal and Total Coliform as the parameter used to assess recreational use of waters of Utah because E. coli is a relatively reliable indicator of the amount of fecal contamination in water, is more closely correlated with swimming-related gastroenteritis, and is generally safe to work with in the lab (DWQ 2005a). High presence of pathogenic bacteria, including E. coli, can cause illness in humans who come in contact with contaminated waters. E. coli bacteria are generally indicative of human or animal waste sources in a watershed, originating from stormwater outfalls, septic tanks and/or graywater facilities and seepage pits (DWQ 2005b). Ingestion of contaminated water can cause diarrhea, cramps, nausea, headaches, and other symptoms. The E. coli sample maximum standard is 940 colonies/100 ml and a 30-day geometric mean standard of 206 colonies/100 ml for a minimum of five samples collected within a 30-day period. The 2016 303(d) List shows that DWQ Segments1, 2, 3, 4, and 5 are non-supporting of the class 2B beneficial use due to E. coli.

Waterbody Information

The Jordan River hydrologic unit code (HUC) 16020204 is a 4th order stream originating from Utah Lake, a shallow playa, formed during the early Cenozoic era from seismic downward block faulting. The Jordan River, meanders approximately 58 miles from Utah Lake through the Utah Lake valley, Jordan Narrows and Salt Lake valley, before draining into the Great Salt Lake. The Jordan River is approximately 44 miles in length through Salt Lake County. The release of water from Utah Lake to the Jordan River is managed for water supply (irrigation water rights) and flood control purposes. In addition to Utah Lake inflow, the Jordan River receives water from Wasatch and Oquirrh mountain tributary streams, two major water treatment plants, and irrigation diversions.

This sub-watershed crosses multiple jurisdictions and receives the majority of storm water in Salt Lake County. The river contains 2B (Protected for secondary contact recreation such as boating, wading, or similar uses), 3A (Protected for cold-water species of game fish and other cold water aquatic life, including the necessary aquatic organisms in their food chain), 3B (Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain), and 4 (Protected for agricultural uses including irrigation of crops and stock watering) waters. Historically, the Jordan River had a substantial meander corridor with marshes, oxbows, sloughs and ponds; however, it is currently a highly channelized, highly developed, and polluted river. The Jordan River is listed as impaired on the State Division of Water Quality 303(d) List for low dissolved oxygen, high sediment, high temperature, and high bacteria levels.

Map



Map 1: Jordan River Murray / Taylorsville Ecosystem Restoration Phase 1,2 and 3

General Watershed Information

The Salt Lake Countywide Watershed drains 805.6 square miles (515,600 acres). The Watershed is bounded on the east by the Wasatch Mountains, on the west by the Oquirrh Mountains, and on the south by the Traverse Range. Approximately 370 square miles (46% of the land) in the Watershed are in rugged mountain ranges and are largely undevelopable. Approximately 134.3 square miles (16.7%) of the Wasatch Mountains are protected to ensure drinking water quality for Salt Lake City and Sandy City. The Great Salt Lake is the eventual recipient of water in the north-flowing Jordan River. The Jordan River meanders for approximately 58 river miles flowing from the outlet of Utah Lake north to the Great Salt Lake. Seven major tributary streams (Little Cottonwood Creek, Big Cottonwood Creek, Mill Creek, Parley's Creek, Emigration Creek, Red Butte Creek and City Creek) feed into the River as it flows north to the Great Salt Lake. The lowest elevation in the Watershed is found at the Great Salt Lake, which typically has an elevation of approximately 4,200 feet, depending on climate conditions. The highest elevation in the Watershed is Twin Peaks (between Big and Little Cottonwood Canyons) at 11,330 feet. The Wasatch Range to the east of the Jordan River has the highest elevations in the Watershed reaching levels over 11,000 feet. The Oquirrh Mountains to the west of the Jordan River, reach elevations of over 9,000 feet. The land surface between these ranges consists of a series of benches, each of which slope gradually away from the mountains and drop sharply to the next bench.

Land Use

Commercial land uses are expected to expand along the I-15 corridor, and along all major transportation corridors throughout the Salt Lake County. Residential development is expected to expand along the Oquirrh Mountain replacing agricultural, industrial, and open space land uses. Dominant land uses anticipated in 2030 include: Forest (39.3%), Residential (32.2%), and Parks/Agriculture/Open Space (6.7%). Land uses anticipated to comprise less total acreage in 2030 include: Industrial (6.6%), Public/Institutional (4.2%), Transportation (1.8%), Commercial (0.9%), and Other (0.2%). Land use analysis predicts an overall increase of 5,429 acres (3.7%) of impervious surfaces in the Salt Lake Countywide Watershed by 2030. Additionally, by 2030, the Jordan River Corridor is anticipated to have an increase in impervious surface area of I 7.5 percent and a decrease in open space of 33.3 percent

Population

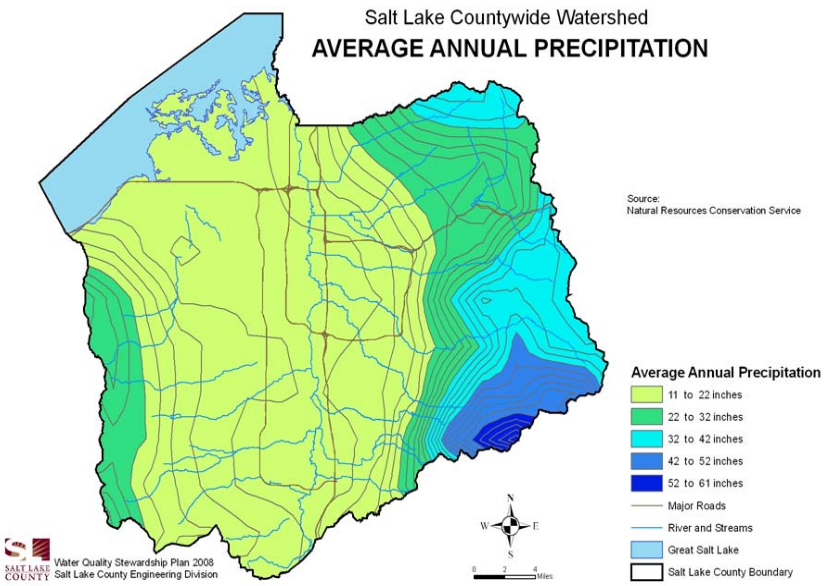
Salt Lake County's population was estimated at 970,612 in 2005. This number is expected to grow to 1,381,519 by 2030, an increase of 410,907 people or a yearly increase of 16,436 people. Although Salt Lake City and the unincorporated area of Salt Lake County are anticipated to continue as the most populous areas of the County, cities in the southwestern region of the County are anticipated to experience the highest percent changes in population by 2030. In 2005, the Jordan River Corridor had a population of 200,236 people. By 2030, it is anticipated the Jordan River Corridor will have a population of 257,465 people, a change in population of 22.3 percent.

Climate

The Salt Lake Countywide Watershed has a semi-arid continental climate with four distinct seasons (NWS, 2005). The climate in Salt Lake County is generally determined by: 1) latitude, 2) elevation, 3) regional storm paths, 4) the distance from moisture sources such as the Pacific Ocean and the Gulf of Mexico, 5) local mountain ranges, and 6) the Great Salt Lake. Additionally, winds traveling inland from the Pacific Ocean must cross the Sierra Nevada and Cascade mountain ranges before reaching Salt Lake County. As moist air travels over high mountain ranges, it is forced to rise to higher altitudes causing condensation and precipitation. Therefore, westerly air currents that reach Utah and the Watershed are relatively dry. In Salt Lake County, summer months are typically hot and dry with low relative humidity (mean humidity is typically less than 60%). Winter months are cold, but usually not severe, due again to the low relative humidity. The average maximum daytime temperatures in Salt Lake City range from 37° in January to 93° in July; however, mountain temperatures can be substantially different due to altitudinal effects or temperature inversions typical in winter months. Average temperatures at the Salt Lake City International Airport range between 51.9° and 54.2° F between 1995 and 2005. Mean daily fluctuations in temperature can vary between 18° Fin the winter months and 30° Fin the summer months.

Precipitation

The average annual precipitation at the Salt Lake City International Airport has varied between 14 and 23 inches per year between 1995 and 2005. On average, the Salt Lake Valley receives less than 23 inches of rainfall per year (see map 2). Precipitation tends to be light and isolated in the summer and fall months and heavy in the spring when frontal storms move inland from the Pacific Ocean. Higher precipitation levels are apparent in the Wasatch and Traverse Mountains where mean annual precipitation levels reach up to 60 inches per year. Interestingly, Upper Emigration, Upper Parley's, and Upper Mill Creek Sub-Watersheds receive lower levels of precipitation than the southern upper watersheds of Big Cottonwood, Little Cottonwood, and Comer Canyon. The highest average monthly precipitation levels are typically in April with a mean of 2.2 l inches per month. The driest month of the year is July with an average precipitation of 0.72 inches, as measured at the airport. Annual snowfall has varied between 22 and 86 inches in the valley between 1995 and 2005. The higher elevation bench areas receive significantly more snowfall. Snow accumulation in the mountain areas can reach depths of 10 feet or more. At some locations, the average annual snowfall is 40 to 50 feet. Due to the state's inland location, Utah's snow is unusually dry, with less than 10% moisture content (NWS, 2005).



Map 2: Salt Lake County Watershed Avg Annual Precipitation

Water Quality Problems

The Jordan River is impaired for sediment, E. coli, dissolved oxygen and temperature. The causes of theses impairments vary but are most likely due to a combination of failing banks, storm water, wastewater treatment effluent, decomposition of excess organic matter and a lack of functioning wetlands surrounding the river. Degraded areas along the Jordan River were first documented in 1985 as a result of channel stability and wetland assessments. This project segment of the Jordan River has been given the following beneficial use designations: 2B (Protected for secondary contact recreation such as boating, wading, or similar uses), 3A (Protected for cold-water species of game fish and other cold-water aquatic life, including the necessary aquatic organisms in their food chain), and 4 (Protected for agricultural uses including irrigation of crops and stock watering) waters. Additionally, the status of the segment of the Jordan River from little cottonwood confluence to 7800 South is listed as impaired for Temperature, E. coli and Total Dissolved Solids (TDS) and has an Integrated Report Category of SA, which means the water quality standard is not attained and is caused by a pollutant. Also, the assessment unit (AU) is a 5, which means the waters are not meeting one or more of its designated beneficial uses and a TMDL is underway (Utah DWQ 2016 Integrated Report, 2016). This project seeks to restore bank stability and the ecosystem of the Jordan River from 5100 S to 4800 S.

The scope of this project was to improve 31 acres of non-functioning riparian habitat and upland areas on one river mile of Jordan River banks from 5100 S to 4800 S (see map 1). Issues that were addressed include: stabilization of failing stream banks, re-establishment of a functioning riparian plant community and eventually (through the increased riparian function) improvement of the river's ability to maintain healthier dissolved oxygen and temperatures on the Jordan River. The E. coli, dissolved oxygen and temperature will take time to adjust as the bioengineering strategies discussed below in the Goals and Objectives are becoming established and rehabilitate the non-functioning riparian community.

Project Goals, Objectives, Tasks

The primary goal of the restoration project along the Jordan River enhanced the functionality of riparian habitat and restore stream bank stability of the river from 5200 South to 4800 S. To accomplish this there were three goals including objectives and tasks implemented for this project.

Goal 1: Stabilized the banks of the Jordan River from 5100 S to 4800 S using streambank bioengineering techniques (natural bank stabilization techniques that use a combination of living plants and inert materials) to minimize sediment loading to the river while allowing the river to handle greater flows sustaining less damage to the riparian community.

Objective 1: WPRP Planed, designed and implemented a riparian restoration project within the Jordan River Watershed in three phases along the Jordan River in priority areas designated by the DWQ. The specific task listed below reduced sediment and nutrient loading, increased the rivers capabilities of handling high flows and improved the fish habitat.

Task 1: WPRP Improved the conditions of the Jordan River by refining the river channel bankfull width/depth ratio and the floodplains, while stabilizing the undercut banks with woody riparian vegetation and Toe Wood structures. River restoration practices utilized heavy machinery to slope back and stabilize vertical eroding banks, install toe wood structures and soil lifts with coconut erosion control (Coir) fabric along the riparian. The riparian and upland areas disturbed during the project had riparian and upland seed mixtures seeded and over seeded during and after construction and willow cuttings were installed along the riparian areas.

Product: One river mile of the Jordan River banks have been improved through three phases creating an area of the river that is capable of handling higher flows while maintaining minimal damage to the riparian communities and reducing the amount of sediment and nutrient loading to the river. The Project manager decided against using Flex-A-Mat before construction began on phase 1 due to the rising costs of the material. Salt Lake County Watershed Program redesigned the Project with the preferred method of a series of Toe Wood structures for each phase based on Dave Rosgen's Natural Channel Design. Each Toe Wood structure was wrapped in coconut fiber to help immediately reduce bank erosion, a riparian seed mixture was spread below and above the fiber and more than 8,000 willow and dogwood cuttings were installed through the coir fabric. The riparian vegetation increased the banks stabilization at the Toe Wood structures and along the floodplain. The root wads used as part of the Toe Wood structures created beneficial ecosystems for fish and waterfowl that use the river.

Goal 2: Established a functioning riparian community on the eroding outside bends from 5100 S to 4800 S using potted and live cutting shrubs and trees that are more effective with nutrient uptake and bank stabilization than existing ones. Created a healthier riparian community to shade the river more effectively.

Objective 2: WPRP used bioengineering techniques including tree revetments, riparian sod, coppicing, potted willows, trees and shrubs to stabilize bank erosion. The techniques were used to rehabilitate the riparian community and increased its capabilities of withstanding flood events without sustaining major damage throughout the reach from 5100 S to 4800 S.

Tasks 2: WPRP determined appropriate bioengineering strategies that were needed to be applied based on, river cross sections, measured and expected velocities, shear stresses and observed water table functions. Based on the findings WPRP installed these bioengineering strategies in each phase of the project area and established and maintained functioning riparian ecosystems.

Product: Using tree revetments, riparian sod, coppicing, potted willows, cottonwood trees and shrubs, 31 acres of nonfunctioning riparian and upland area has been restored creating stronger active floodplains filled with beneficial native plants. These reestablished ecosystems have created pockets along the Jordan River where native plants are flourishing while creating seed banks for other areas along the river and denying non-invasive species the ability reestablish. These improvements to the riparian and upland areas including the active floodplains will intensify the resilience of the riparian to future flood events. This has also increased the rivers ability to maintain healthier dissolved oxygen and temperatures providing shade along the rivers banks and not allowing sediments and higher nutrient loads to enter the river. *E.coli,* dissolved oxygen and temperature will adjust with time as the bioengineering strategies become established.

Goal 3: WPRP used monitoring programs to ensure there was minimum 60% success rate on all live cuttings, potted trees and shrubs that were installed. Monitoring was done on phase one, two and three to ensure the Natural Channel Design is responding correctly through the duration of the contract period.

Objective 3: WPRP used monitoring programs that included; Photo monitoring stations, longitudinal profiles, cross sections and physical inspections to understand and observe any issues that came up during the project. These monitoring programs were used on all the potted vegetation and live cuttings that were installed and have been used to ensure the project is maintaining the expected survival success rate.

Task 3: WPRP Documented each phase of the project including construction, plantings and weeds through monitoring that included physical inspections of the work sites, photo stations and geomorphic surveys. The geomorphic surveys were completed to ensure the project is not changing in the plan profile or dimensions from the deigned state and to document any shifts in the substrate caused by the designed changes. Physical inspections were used to verify the survival rate of the plantings in the project areas and to map any invasive species growing. Measures to eliminate those invasives were based on what types of invasive species were present. Photo monitoring was used as another tool to help keep an eye on the project areas with the help of the community and their photos posted to Twitter. These photos have provided a consistent view of the project areas to help show the evolution of the project area as the year progressed, using a software to stitch together the photos and create a time lapse.

Product: Survival rates of all planted trees, shrubs and live willow cuttings are greatly exceeding the anticipated 60% with an estimated survival rate of over 80%, while invasive species have been held to minimal growth through physical mapping and weed control. Nominal growth of the invasives has been obtained through accurate and timely use of weed mitigation processes, including spraying and mechanical removal. Spraying begins in spring and continues through fall depending on the invasives being targeted, mechanical and hand removal of undesirables from the riparian and upland areas is happening year-round. Continued monitoring of the project area using geomorphic survey is taking place to ensure that the natural channel design used will continue to maintain its plan, profile and dimension. Photo monitoring provided by the community through the photo stations along the project areas is exceeding expectations with more than one hundred pictures sent in using specific twitter hashtags for each site. The photos that are received are providing the ability to observe the project without having to go to the sites and is allowing the creation of time-lapses showing a full year's growth and change at the project sites.

Costs

Phase 1 (2015):

Cost: $138,265.27

EPA 319 Funding: $82,018.21 In-Kind Match: $56,247.06

Phase 2 (2016):

Cost: $ 121,141.26

EPA 319 Funding: $64,169.77 In-Kind Match: $56,971.49

Phase 3 (2017):

Cost: $ 91,839.20

EPA 319 Funding: $52,896.15 In-Kind Match: $38,943.05

Project Total:

Project Cost: $ 351,245.73

EPA 319 Funding: $199,084.13 In-Kind Match: $ 152,161.60

Planned / Actual Milestones

Milestones		Planned/ Actual Deliverables																																			
Goals/Tasks	Output	FY 2015												FY 2016												FY 2017											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Goal 1: Stabilize the stream banks Task 1: Improve the conditions of the river in three phases	Stabilize the Jordan Rivers banks between 5100 S and 4800 South using Natural Channel Designs. While improving the functional river channel width/depth ratio, meander patterns and floodplains, stabilize undercut banks with woody riparian vegetation and woody structures and riparian plant cover for fish habitats.									X	X	X										X	X	X	X										X	X	
											X	X	X									X	X	X	X										X	X	X
Goal 2: Establish a functioning riparian community Task 2: Establish a functioning riparian community on the eroding outside bends of the	Using tree revetments, brush spurs, fascines, riparian sod and coppicing, potted willows, trees, shrubs and seed, 31 acres of nonfunctioning riparian were restored to a functioning riparian.			X	X	X					X	X				X	X						X	X				X	X						X	X	
				X	X	X						X	X	X		X	X						X	X	X			X	X						X	X	X
Goal 3: Moinitoring Task 3: Monitor and document project updates using physical inspections and geomorphic	Monitoring including physical mapping of invasives, potted plants and live willow cuttings ensured a greater than 60% survival rating and less than a 30% concentration of invasive in the riparian communities	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 2: Milestone Table

Evaluation of Goal Achievement

Project work began on time even though there was a redesign which included a need for specific trainings from Wildland Hydrology Consultants to properly design the toe-wood structures. Phased construction was completed November 2017, while monitoring of each phase is still occurring. The Toe-wood structures that were installed have met the WPRPs expectations and have handled a multitude of bankfull events along the river. Erosion occurring along the banks of the JRMT project has slowed significantly. The riparian communities that were installed are thriving and far exceeding the 60% minimum survival rate expected with a greater than 80% survival rate in each phase. Monitoring and weed mitigation is working to keep many of the invasive plants in the project areas to less than a 30% concentration in the riparian communities. Public participation for this project was excellent. Stantec and Tree Utah donated 100’s of man hours and planted thousands of cottonwood and willow saplings throughout the entire project. As monitoring of the project continues public and private interests are taking notice of the work done and the revitalization of the riparian communities. Groups are using this project area as a destination to show how natural channel design has been implemented along the Jordan River and how it can be used to improve other areas along the Jordan River and its tributaries.

Supplemental Information

The various Best Management Practices (BMP’s) used are listed below with their NRCS project number and name

322 – Channel Bank Vegetation: 17,560 trees, willows and shrubs planted, 200 riparian sod mats installed, Spring and fall seeding.

382 – Fencing: 500 feet of fencing used to create protected boxes that shrubs, trees and willows can grow without threat from beavers or humans, creating an undisturbed seed bank for future growth. 500 linear feet of fence used to create an undisturbed riparian area in phase 3 increasing plants survival rates and seed distribution.

998- Natural Channel Restoration: Created a channel that can effectively maintain bankfull flow events with minimal erosion, while protecting the riparian plant community. Created healthier fish habitats and increased the river's ability to maintain healthier dissolved oxygen and temperatures.

Monitoring Results

Before project work began the Salt Lake County Watershed and other agencies developed specific monitoring strategies to record details about the improvement of best management practices in the project area and any modifications. Specifically, WPRP wanted to gauge what impacts the project is having on the banks and riparian communities, sediment transport mechanism and erosion rates of the banks of the Jordan River from 5100 South to 4800 South.

The monitoring program uses geomorphic surveys, physical inspections, mapping and photo point stations to ensure the health of the project.

Monitoring

Monitoring strategies in this project were used to verify that the selected strategies put into place are reducing the sediment loading into the river and allowing riparian communities to thrive in the JRMT project area. Effective monitoring of the project area will include quantitative (e.g. geomorphic survey of the project area) and qualitative (e.g., Visual inspections of the Toe-wood structures, weed mapping, observations of sediment reduction in the water) data collection

Quantitative data collection mainly consists of level III geomorphic assessments. The geomorphic survey results in a description of the rivers condition as it relates to the rivers stability, potential and function (Rosgen, 1996)

Qualitative methods, like the citizen monitoring photo stations, weed mapping and physical inspections are being used to help provide an effective measurement of the projects success. Although these methods do not provide quantitative information on the effectiveness of the projects, they do illustrate progress and can show the success of implementation activities.

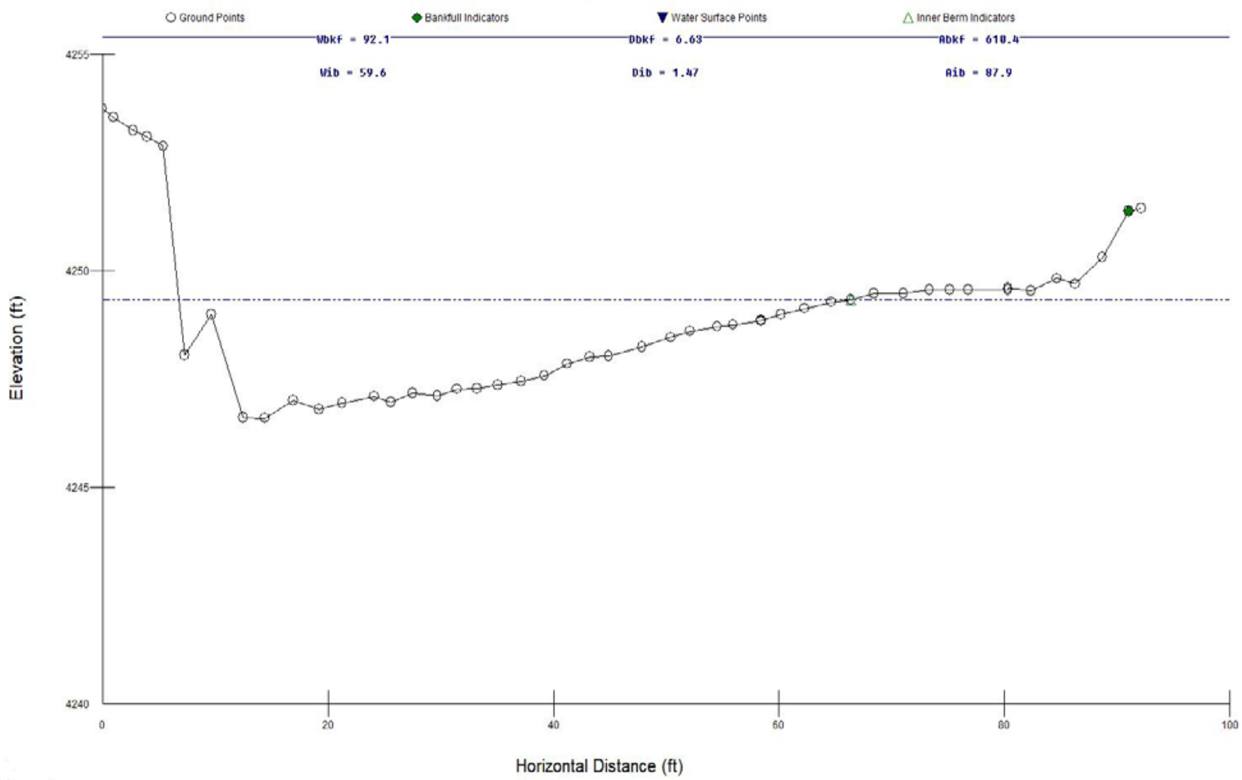
Spreadsheet Tool for the Estimation of Pollutant Load (STEPL) is another tool the is being used to help estimate potential load reductions from the JRMT project site. STEPL is an important tool used to estimate potential load reductions from the various outside bends along the restoration project. (see graph 1 and table 2)

River Physical/Biological/Habitat Monitoring

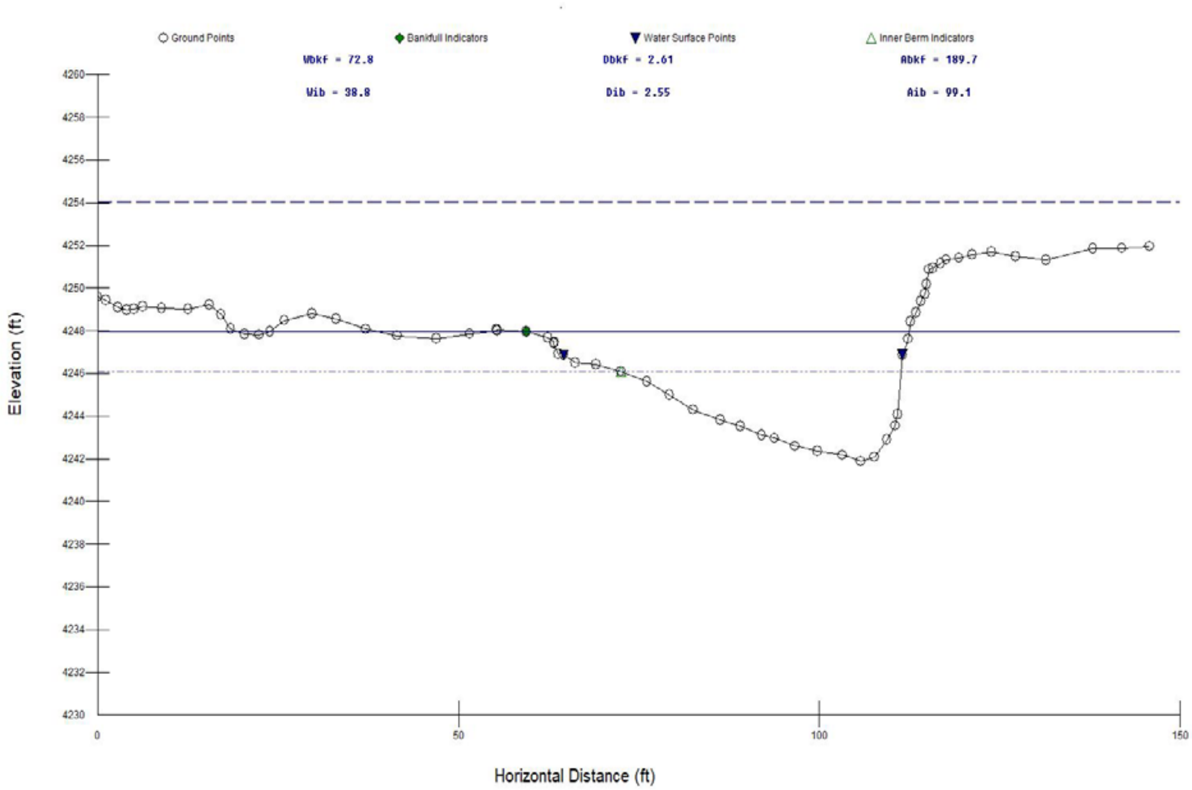
In order to identify any physical changes in river specific to JRMT project area Salt Lake County's WPRP have conducted level III geomorphic survey assessments, the first of which occurred in fall of 2015. Each survey includes a longitudinal profile, cross sections, pebble counts, water surface and bankfull measurements. Habitat and biological monitoring are being accomplished using physical inspections, time lapse photos, below water videos of the Toe Wood structures and crowd sourced photos.

Monitoring using level III geomorphic survey assessments is a critical piece of the monitoring program used by WPRP to observe how the river is responding after the completion of each phase in the JRMT project. WPRP collected cross sections and pebble counts before and after construction through the entire project area from about 5100 South to the Little Cottonwood creek confluence. WPRP surveyed multiple cross section and conducted multiple pebble count measurements at the start of this project and have continued to monitor similar cross sections with surveys and pebble counts for the entirety of the project. Using the before and after cross sections WPRP is able to determine how sediment transportation has been affected, how the bankfull width, depth and area of the project has been affected and whether or not the project has changed the transportation mechanism to distribute fine sediment on the floodplain rather than in the riffles.

Examining the before and after cross sections of phase 2 WPRP was able to demonstrate an increase in the floodplains width on the rivers left bank at this cross section as well as a distinct bankfull elevation on rivers left visible below (Graph 1and 2).

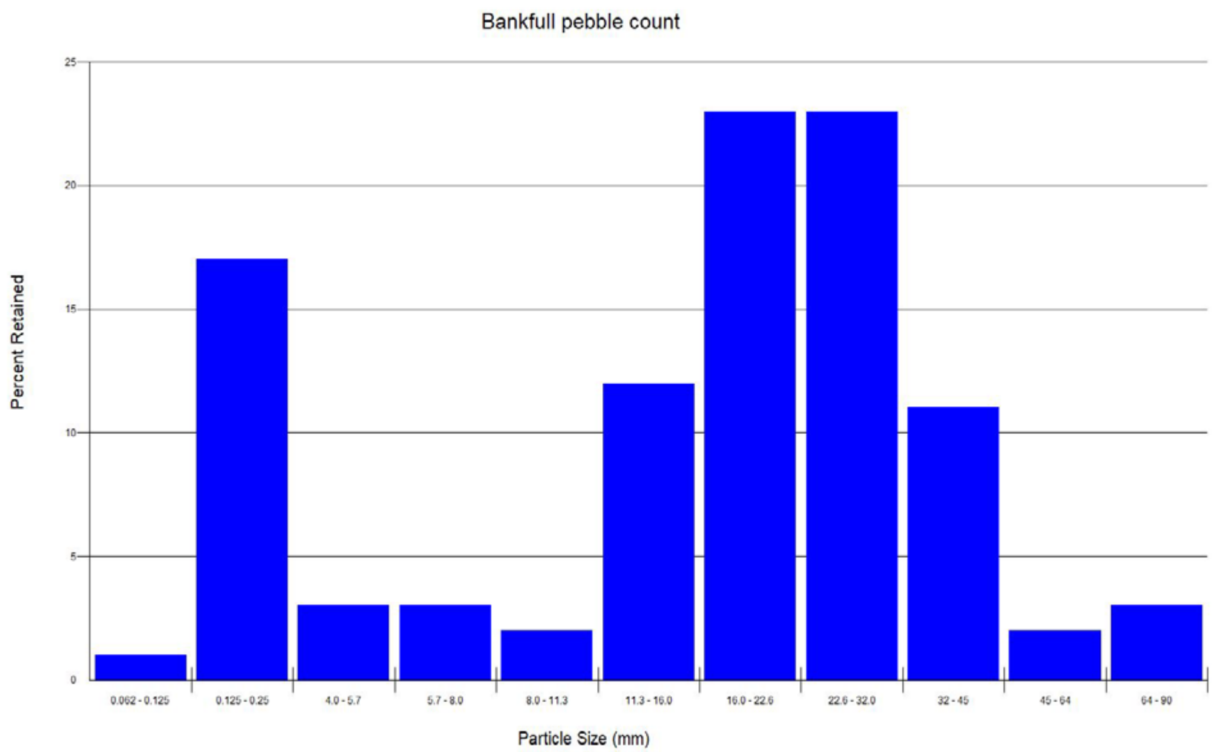


Graph 1: Rivermorph graph of Phase 2 before construction. (measurement was taken right bank to left bank)



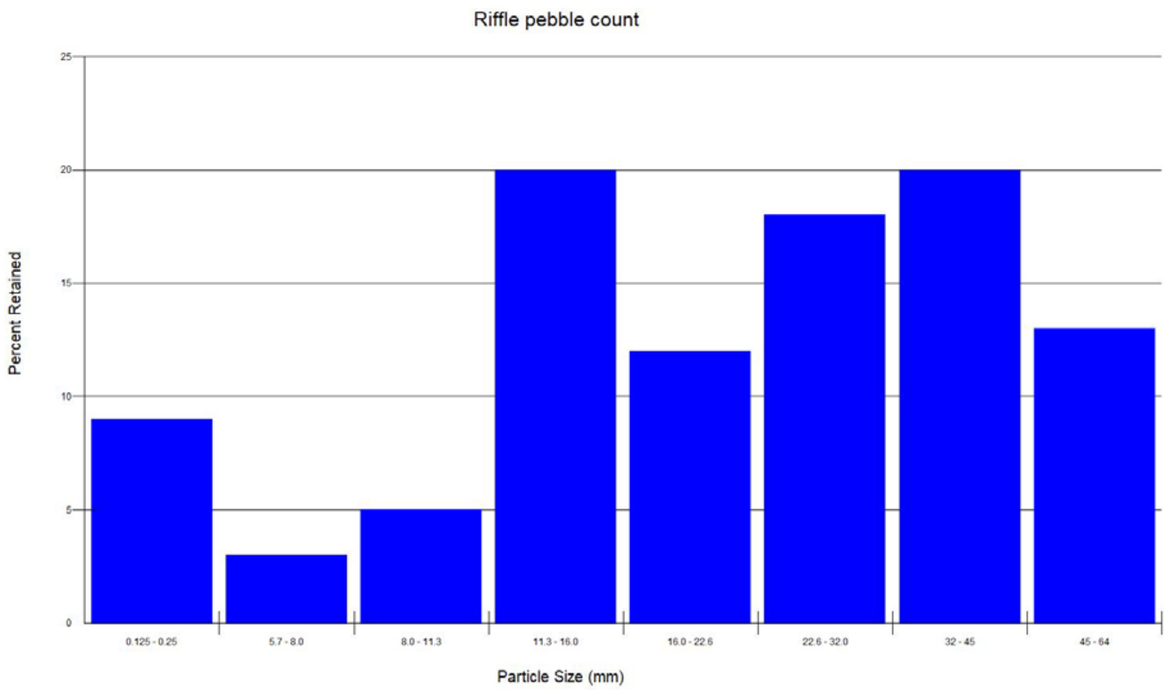
Graph 2: Rivermorph graph of phase two taken in 2018 after construction (measured left bank to right bank)

Using rivermorph to run the numbers from the survey and create a graph (Graph 1and 2) WPRP was able to calculate the current bankfull width (Wbkf), bankfull depth (Dbkf) and bankfull area (Abkf). Comparing the numbers and graphs from surveys conducted at the start of the project and the last survey taking shows that Wbkf has decreased form 85 feet to 72.8 feet, Dbkf has decreased from 2.95 feet to 2.61 feet and Abkf has decreased from 250.9 square feet to 189.7 square feet. Pebble counts were completed at the same time as the surveys and were used to compare the differences in fine sediment and gravel from before JRMT began and after it was completed. Graphs 3, 4 and 5 below have before and after pebble counts that show the difference in material being deposited in the river throughout the project area.



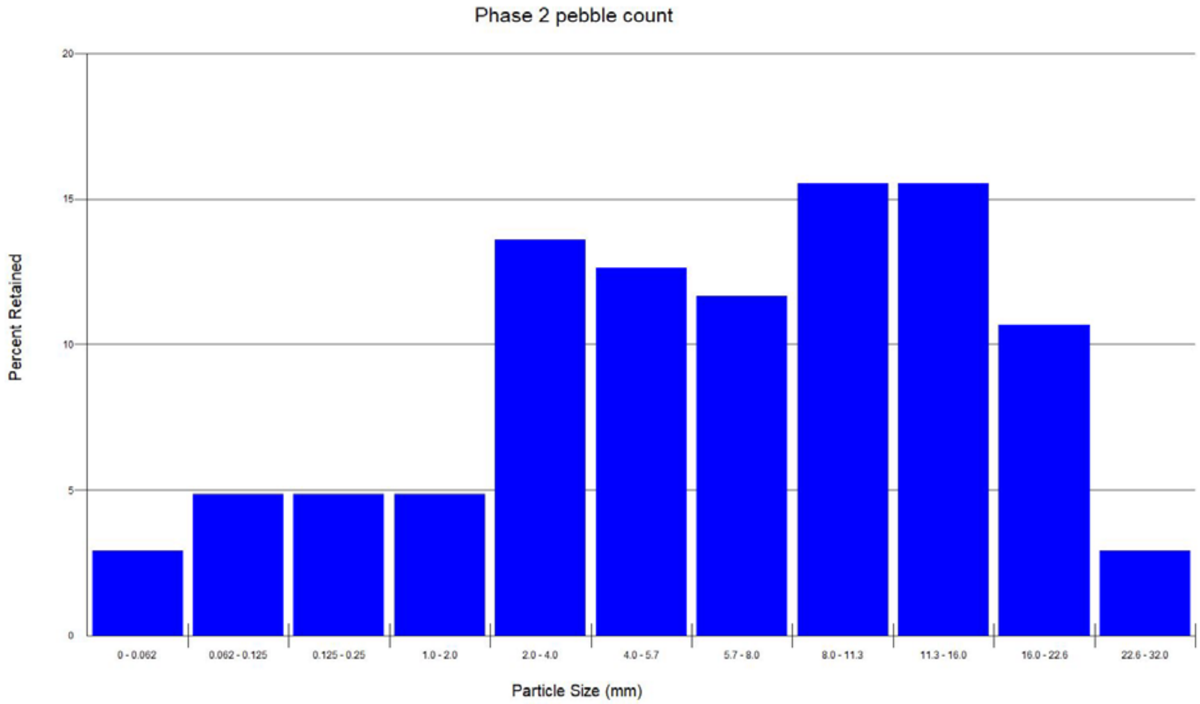
Size (mm)		Type	
D16	.24	Silt/Clay %	0
D35	14.83	Sand %	18
D50	19.44	Gravel %	79
D84	32	Cobble %	3
D95	45		
D100	90	Bolder %	0

Graph 3: Bankfull channel pebble count taken before project



Size (mm)		Type	
D16	10.64	Silt/Clay %	0
D35	15.53	Sand %	9
D50	23.12	Gravel %	91
D84	43.05	Cobble %	0
D95	56.69		
D100	64	Bolder %	0

Graph 4: Riffle surface pebble count before project



Size (mm)		Type	
D16	1.7	Silt/Clay %	2.91
D35	4.53	Sand %	14.57
D50	6.95	Gravel %	82.52
D84	15.27	Cobble %	0
D95	21.31	Bolder %	0

Graph 5: Rivermorph histogram of riffle surface pebble counts in phase two after construction

During the latest pebble count the rivers height was above the normal water level due to the increase in irrigation water entering up river, this caused the pebble count to extend further into the floodplain then past pebble counts that WPRP is using to analyze and compare. These pebble counts that were conducted and analyzed show that there was silt, clay and finer sands at the left water's edge where the natural floodplain continues to develop. The pebble count also showed that these finer sediments were no longer a predominate feature found in bed sediment or along the inner berm slope leading into the thalweg. The observations verified that the silts and finer sands are falling out of the water column where and where they should be, on the floodplain, or being moved along by stronger velocities in the river to the detention basin further down river, helping to improve the sediment transport mechanism in this segment of the Jordan River.

Another aspect of WPRPs monitoring program for the JRMT project area entailed digitizing the past banks of the Jordan River using Google Earth Pro and drawing path lines to represent the banks at certain times of the year from 2006 to present. This digitizing was completed to help WPRP track erosion that occurred and how the project areas responded after construction was completed. Each figure below will have five path lines that represent a different year; December 2006s bank is represented by the blue line, June 2010s bank is represented by the yellow line and the June 2017 banks are represented by the turquoise line.

Figure 2: Phase 1 with digitized banks from past years to show the erosions progression

Phase 1 (Figure 2) of the JRMT project had seen up to 38 feet of erosion along the east bank from 2006 to 2015 which caused a large amount of sediment to enter and remain in the river exacerbating the sediment, nutrient and DO issues along this segment. Construction in phase 1 added twelve feet of floodplain to the east bank that had disappeared due to erosion. The east bank is maintaining a healthy and thriving riparian community composed of native vegetation that has seen very little disruption from multiple bankfull events.

Figure 3: Phase 2 with digitized banks from past years to show the erosions progression

Phase 2 of the JRMT project (Figure 3) had seen over 50 feet of erosion between 2006 and 2016 which forced the east bank of the Jordan River to move into one of the last native cottonwood stands along the river. Since construction finished in 2016 the erosion that was occurring along the east bank has halted and the floodplain that was built along the west bank is functioning as a normal floodplain should allowing sediments to deposit along the floodplain during bankfull, and larger, events. The west bank has seen a natural floodplain continue to develop in size while supporting a large stand of native plants that were planted by the WPRP in the riparian community. The halt of erosion along the east bank and the continued growth of the floodplain along the west bank has decreased the bankfull width in this phase of the project increasing the velocity of the river and ushering sediments that were once deposited along the river bed at normal flow to move on to the floodplain and further down river and into the detention basin.

Figure 4: Phase 3 with digitized banks from past years to show the erosions progression

Phase 3 the largest segment of this project (Figure 4) had seen up to 35 feet of the bank erode into the river from 2006 to 2017 causing an increase in sediments entering the river through this section, exacerbating the issues with sediment transport in this segment of the Jordan river. When construction was completed in this section in 2017 the erosion that was occurring was halted and the floodplain that was constructed is acting as expected allowing the rivers bankfull events to inundate the floodplain, slowing down the velocity of the river and allowing sediments to fall out of the water column. The construction ion this phase has caused the bankfull width to decrease which is causing the velocity of the water to increase in the low flow channel and normal flows and keep the sediment that would fall out of the water column in this area to deposit on the floodplain in high flow events or pass through this segment of the project.

Citizen Science (Crowd Sourced) photo stations

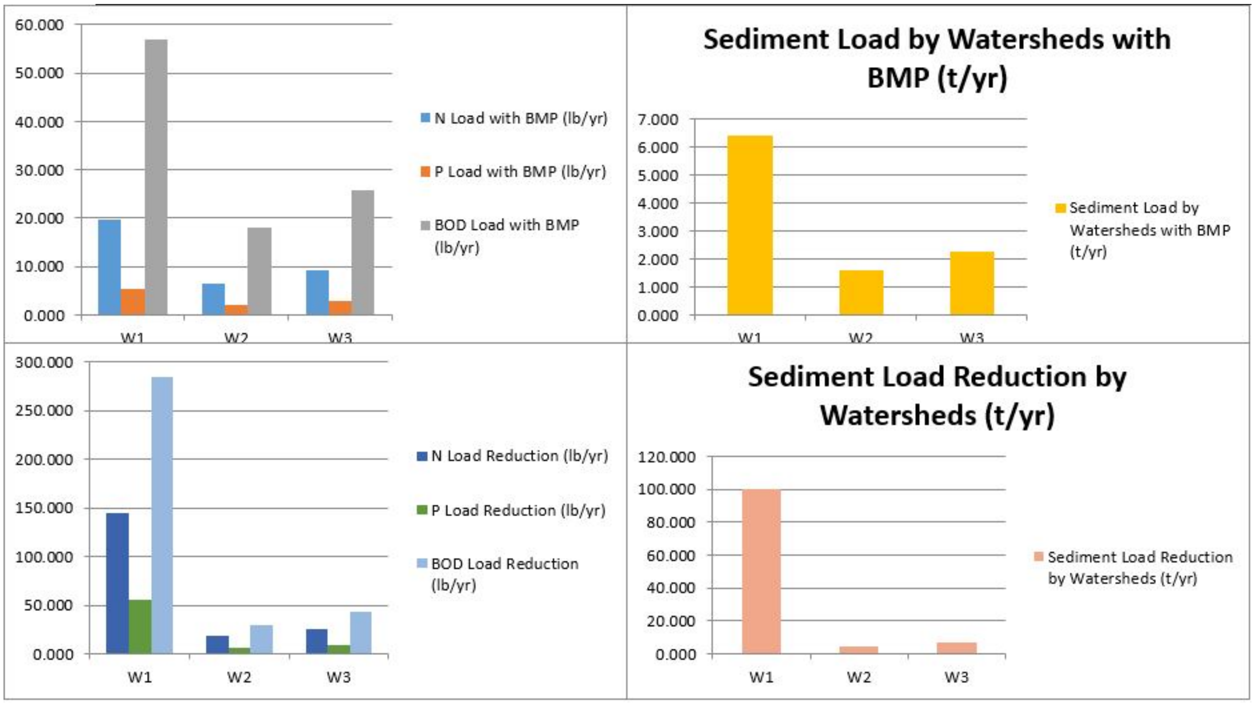
WPRP is using crowdsourced photos to help with the ongoing monitoring of the Jordan River restoration sites at JRMT. Post-project monitoring is an important part of this restoration project and with the new photo stations, citizens are being invited to become part of the monitoring process. This is truly a crowdsourcing effort. This type of photo monitoring is a great way to track the growth and success (or failure) of the plants. Photos taken during high water will show how the floodplains are handling the flows. During winter, when foliage is off and water levels are lower, there will be clearer view of how the reconstructed streambanks are holding up. Hopefully our new network of citizen monitors will be able to create a year-round photographic record of JRMT that will be placed into a time-lapse slideshow.

Figure 5: Crowd sourced photo station and interpretive sign at JRMT

Spreadsheet Tool for Estimating Pollutant Load

The Spreadsheet Tool for Estimating Pollutant Load (STEPL) was used on the segments of the Jordan River that has had project work completed (Phase 1, 2 and 3). STEPL was used to calculate estimates on load reductions based on the best management practices (BMPs) included. All BMPs associated with the Jordan River Murray Taylorsville Project were inserted including; fencing, riparian plantings, floodplain enhancement, etc.

STEPL Estimated Load Reductions



Graph 6: STEPL Estimated Load Reductions

The upper left graph demonstrates the drainage load of N, P, and BOD with the BMP in place. Lower left are the load reductions. Upper right is the sediment load with the BMP in place, while the lower right is the sediment load reduction.

Table 3 shows the total calculated inputs into the project. Load reductions are calculated by separating out the effect of the installed BMPs. Incorporating fencing, stream bank sloping, water velocity decreases, reseeding, and the various planting projects.

1. Total load by subwatershed(s)

Watershed	N Load (no BMP)	P Load (no BMP)	BOD Load (no BMP)	Sediment Load (no BMP)	N Reduction	P Reduction	BOD Reduction	Sediment Reduction	N Load (with BMP)	P Load (with BMP)	BOD (with BMP)	Sediment Load (with BMP)
	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year	lb/year	lb/year	lb/year	t/year
W1	164.2	60.6	342.0	106.5	144.5	55.2	285.0	100.1	19.7	5.5	57.0	6.4
W2	24.6	8.4	48.5	6.3	18.0	6.3	30.3	4.7	6.6	2.1	18.2	1.6
W3	35.0	12.0	69.0	9.0	25.7	9.0	43.2	6.7	9.3	3.0	25.9	2.2
Total	223.7	81.0	459.5	121.8	188.2	70.4	358.4	111.6	35.6	10.6	101.1	10.2

Table 3: Total load by phases and associated reductions for the Jordan River

There is an estimated sediment reduction of **111.6 tons/year** over the river mile. In addition to the reduced sediment load, there is an estimated reduction of **188.2 lbs/year** for nitrogen, a **70.4 lbs./year** reduction in phosphorus and a **358.4 lbs./year** reduction in BOD. As the restoration continues to succeed the total reduction of sediment, nitrogen and phosphorus will be significantly greater.

Coordination

The Salt Lake County Flood Control & Engineering Division coordinated the Jordan River Murray/Taylorsville Restoration Project; however, numerous sponsors and supporting entities were involved in the design, implementation, and monitoring of this program. The Jordan River Watershed Council (JRWC) is the primary stakeholder group that was used to direct this project. Other cooperating entities including the Utah Division of Water Rights, Utah Division of Water Quality, Utah Division of Sovereign Lands, Murray City, Taylorsville City, and Salt Lake County Parks & Recreation.

Coordination Efforts

Due to the nature and location of this project, coordination was key to a successful long-term restoration of the Jordan River. Therefore, this project included initial pre-project meetings, permit drafting and design elements, and Salt Lake Countywide Watershed Council meetings.

Coordination from Local Entities

For this restoration project, Salt Lake County Flood Control & Engineering Division sought local support from:
Murray City: Project Support and Coordination
Taylorsville City: Project Support and Coordination
Salt Lake County Parks & Recreation:

Coordination from State Entities

Utah Division of Water Quality: Funding
Utah Division of Water Rights: Permits
Utah Division of Sovereign Lands: Permits

Coordination from Federal Entities

U.S. Environmental Protection Agency: Funding from the Clean Water Act section 319.

Accomplishments of Agency Coordination Meetings

Agency Coordination meetings were held quarterly by the Jordan River Watershed Council (JRWC). Representatives from partnering agencies would give status updates on potential funding sources, funding source stipulations, engineering updates, project monitoring, potential stream restoration practices, and project updates. When situations warranted the inclusion of additional partners, the JRWC extended invitations.

Without the leadership of the JRWC the amount of partnering agencies would have decreased and the full potential of the Jordan River Murray Taylorsville Improvement Project may not have been realized.

Other Source Funds

Salt Lake County Match

Summary of Public Participation

Public participation has been an important piece to the Jordan River Murray Taylorsville Project. The project received hundreds of volunteer labor hours from Stantec and Tree Utah. Tree Utah brought in volunteers from Verizon Wireless, Wells Fargo and The Boy Scouts of America to help with planting along all three phases of the project. Stantec employees volunteered through the whole project and helped dig holes, plant trees and shrubs in the projects three phases. Together Stantec and Tree Utah volunteers were responsible for planting thousands of trees and shrubs including Willows and Cottonwoods. The JRMT project is a focal point for tours of watershed projects around the county and state and has been spotlighted in multiple media stories.

The citizen monitoring photo stations are proving to be a very useful tool in the monitoring of the JRMT project area. Currently there is five photo stations along the JRMT project that are being used on a consistent basis by residents using the Jordan River Trail. To date there has been 201 pictures sent through twitter from the 5 photo stations along the JRMT project. These pictures are used to create a time-lapse of the area, providing a better understanding of the riparian growth. They also provide qualitative data that is used to look for erosion that maybe occurring and to help map weed growth in each phase.

Aspects of the Project That Did Not Work Well

Phase 1:

- Using Flex-A-Mat turned out to be too expensive due to rising costs, so the project had to go through a redesign using a Natural Channel Design method.
- Earth Anchors used to secure the Toe Wood structure did not work as anticipated due to the pressure exerted by the heavy machinery used to anchor the logs in place.
- Seeds that had been laid along the project area were quickly consumed by waterfowl in the area.
- We received and used a seed mixture that contained Yellow Sweet Clover (Melilotus officinalis) in it, which is not part of the riparian mix we had wanted. This caused extra time to be used to do mechanical removal of the sweet clover to ensure that they do not become part of the riparian vegetation.

Phase 2:

- Unforeseen erosion occurred along the root wads of the toe wood structures due to the project being hit with a ten-year flood before the riparian vegetation had any time to grow. A tree revetment was used to fix the issue
- Used a seed mixture that contained Yellow Sweet Clover (Melilotus officinalis) in it, which is not part of the riparian mix we had wanted. Additional time was used to do mechanical removal of the sweet clover to ensure that they do not become part of the riparian vegetation

- Seed that were spread along the project area was quickly consumed by waterfowl.

Phase 3:

- After construction and planting of phase 3 Taylorsville-Bennion Improvement District purged one of their wells that drained into a storm drain that abruptly ended in a wetland just west of our project. As the wetland filled it began to empty into the Jordan River through Phase 3 and eroded a large area from the wetlands to the river (See figure 3) including pushing one of the toe-wood logs out three feet into the Jordan River. This erosion threatened to cause severe damage to phase 3, if the river reached bankfull erosion could have easily occurred behind the other toe wood structures and causing them to fail. The issue was fixed immediately and a long-term solution for the inadequate drainage has been found.

Figure 6: Erosion through Phase 3 from storm drain west of the project

- During planting on phase 3 we lost multiple potted trees to beavers, they were still planted and are showing signs of new growth. (See figure 23 in Appendix A)

Future Activity Recommendations

There are additional river miles along the Jordan River that will need restoration completed to reduce bank erosion, lower river temperatures, lessen TDS, N and P entering the river while increasing native riparian species and decreasing non-native species. Projects like the JRMT project should have a large impact on the health of the river and the residents of the Jordan River Watershed. With monitoring for this project continuing and the effects of the finished project that are already being observed using WPRPs monitoring programs, which show that project like JRMT can produce an increasingly healthier river that can transport sediments and build healthy riparian systems that function correctly to helping minimize flood damage to the banks of the river it is highly likely that continued projects like JRMT can help restore the Jordan River to a more natural state while still maintaining the flood control aspects of the river and its impaired beneficial uses.

For 2018 the Salt Lake County WPRP is continuing river restoration efforts along the Jordan River and its tributaries.

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Appendix A

Phase 1

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Phase 2

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Figure 13: Bankfull flow before construction looking downstream


Figure 14: Bankfull flow after construction looking downstream

Figure 15: Phase 2 after construction looking downstream

Phase 3

Figure 16: Phase 3 before construction


Figure 17: Phase 3 pre-construction survey


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Figure 20: Phase 3 Toe Wood install and bank grading


Figure 21: Phase 3 during planting


Figure 22: Phase 3 after construction, looking up stream

Figure 23: Beaver Damage to cottonwood trees before planting