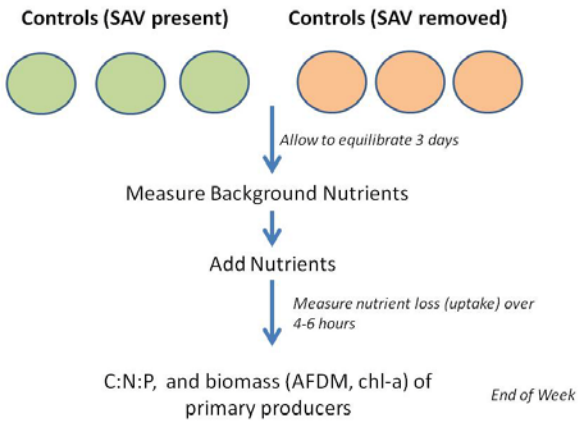
Step	WILLARD SPUR MESOCOSM STUDY
1. Problem Statement	**DESCRIPTION OF PROBLEM:** The Willard Spur project has accomplished much to better understand the dynamics of Willard Spur, how nutrients are cycled within its ecosystem, and the potential impacts from the Perry Willard Regional Wastewater Treatment Plant (Plant). Willard Spur appears to be nutrient limited and have the capacity to assimilate the nutrients it receives, however significant work still remains to 1) understand how it is assimilating nutrients and 2) determine the point where Willard Spur is no longer nutrient limited and impacts from nutrients could be detrimental to the ecosystem. This work is central to achieving this project's objective of determining if and how the Plant's discharge will impact Willard Spur. A research team including Dr. William Johnson and Dr. Heidi Hoven (Principal Investigators), Dr. Ramesh Goel, Dr. Sam Rushforth, and Dr. David Richards is currently investigating the natural variability of Willard Spur's biological responses to nutrients and working to identify thresholds for nutrient response that can be used as potential biological indicators (aka, Willard Spur Nutrient Cycling Study). Their experiments incorporate the natural variability of Willard Spur through the use of unconfined test plots. By contrast, the objective of the Willard Spur Mesocosm Study is to better understand the rate by which nutrients are assimilated within Willard Spur and provide a better understanding of where higher nutrient concentrations could become detrimental to the ecosystem. This will be done through the use of confined chambers that will allow for better control of experimental conditions. Results from this study will be complimentary to both the *in situ* work and the nutrient flux chambers of the university research team. **CONCEPTUAL MODEL** Existing sediment nutrient concentrations in Willard Spur are low, thus most nutrients appear to be provided to the ecosystem via surface water inputs or internal biochemical cycling (i.e., plant senescence). Nutrients are assimilated and cycled throughout the benthos and pelagic zones with feedback loops in these zones and fluxes to the sediment, atmosphere, and export via flows out of Willard Spur. Reflecting the hypothesis that the critical period for Plant impacts is a dry period where there is no outflow from Willard Spur, the experiment will utilize enclosed mesocosms with nutrient spikes to measure uptake capacity in plots with and without SAV. The experiment will generate uptake rates—expressed both spatially and temporally—to enable estimates of the Spur's assimilative capacity (controls). These rates will be quantified in plots with and without SAV (treatments) because in early summer these plants—and associated epiphytes— are the dominant primary producers within the spur. Finally, experiments will be repeated in late summer because previous observations suggest that as SAV begins to senesce, phytoplankton concentrations increase, which could greatly change nutrient cycling processes. **PLANNING TEAM AND DECISION MAKERS** Jeff Ostermiller and Toby Hooker are the principal investigators for this study. Theron Miller and Jim Hagy are representing the Willard Spur Science Panel as technical advisors. Jeff DenBleyker is the DWQ's (DWQ) project manager. The Willard Spur Science Panel will serve to review and oversee the work and provide recommendations to the Willard Spur Steering Committee and DWQ. **AVAILABLE RESOURCES** The current estimated budget for this work is about $35,000. Technical expertise for conducting the experiment is available from DWQ and the Willard Spur Science Panel. Additional technical expertise will be provided by Michelle Baker/Utah State University. Construction of equipment required for the experiment will be completed by the South Davis Sewer District. Analytical laboratory services are

	available from Utah State University and the State Health Laboratory. Staff to monitor the experiment will be provided by the DWQ and Theron Miller. Nutrient cycling expertise and project management support will be provided by the DWQ and the Willard Spur Science Panel with additional review comments by other principal investigators. **DEADLINES** 1. Refine experimental design, install and test prototype in May 2013 2. Construction of enclosures by June 14, 2013 3. Installation and testing of enclosures by June 21, 2013 4. Complete the experiment from June 21 – June 28, 2013 5. Repeat the experiment from August 5 – 12, 2013 (targeting early August) 6. Analytical results will be available by October 30, 2013 7. Draft report will be complete by January 3, 2014 8. Science Panel review comments will be complete by January 31, 2014 9. Final report will be complete by February 28, 2014
2. Decision Statements	**DECISIONS** The specific questions that this study will answer (and associated rationale) are as follows: 1. What is the uptake rate, per unit time and area/volume, for nutrients within the spur? **Why?** Estimate extent of potential impact within the Willard Spur ecosystem 2. To what extent do macrophytes and their associated epiphytes influence uptake rates? ***Why?*** If WQ or other conditions degrade SAV condition there is the potential to alter the cycling on nutrients within the spur. 3. Do uptake rates differ during the "clear" (June timeframe) versus "green water" (August timeframe) phases? ***Why?*** Primary production shifts from a primarily benthic, SAV-dominated, condition to one with increased pelagic phytoplankton, which may significantly alter uptake rates. 4. What is the relative biomass and nutrient content of primary producers under conditions with and without SAV? ***Why?*** Provides measure of the quality of food source to higher trophic levels under experimental conditions (extremes observed within the spur) 5. What is the influence of macrophytes on rates of GPP and ER? ***Why?*** Evaluates the effect of SAV on wetland metabolism and provides a direct link to ecosystem processes with Willard Spur A specific decision will not be made with the data from this study; however, these data will be used in the overall recommendations for the Willard Spur study. **POSSIBLE OUTCOMES:** 1. Information is adequate to quantify the importance of SAV, pelagic algae, and benthic algae/bacteria to nutrient cycling processes and allows for the identification of existing and potential nutrient assimilation rates in Willard Spur. The information and understanding gained inform two possible outcomes: • Nutrient assimilation rates are adequate to assimilate increased water column nutrient loads. • Nutrient assimilation rates are not adequate to assimilate increased water column nutrient loads.

	2. Information is not adequate to quantify the importance of SAV, pelagic algae, and benthic algae/bacteria to nutrient cycling processes and identification of existing and potential nutrient assimilation rates in Willard Spur. The results must be evaluated in the context of other results and the current understanding to determine how they may inform a decision regarding the potential impacts of the Plant's discharge.
3. Inputs to the Decision	**INFORMATIONAL INPUTS** 1. Concentration and speciation of water column nutrients and associated chemical constituents prior to and one week following experimental nutrient spikes. 2. Uptake rates—and among replicate variation—of nutrients (NH4, NO3, PO4) per unit area/time based on 15-minute samples collected for ~4 hours following nutrient spikes, under the following scenarios: a. Ambient conditions (controls) b. Conditions without SAV (treatments) c. During active SAV growth (June) and SAV senescence (August) 3. Measures and among replicate variation of ecosystem metabolism—Gross Primary Production (GPP) and Ecosystem Respiration (ER) under: a. Ambient conditions (controls) b. Conditions without SAV (treatments) c. During active SAV growth and SAV senescence 4. Measures of biotic nutrient sinks prior two and one week following nutrient additions: a. Isotopic characterization of C:N:P from water column algae, benthic algae, epiphytes, and SAV b. Biomass (chl-a & AFDM) of SAV (controls only), phytoplankton (water column), periphyton (benthos), and epiphytes (controls only) **EXPERIMENTAL DESIGN** 1. Study design includes one treatment-control pair across three blocks, where SAV removal is the experimental treatment. 2. Three replicates for both controls and SAV removal treatments. 3. Chambers will be circular in shape, 6 feet in diameter, with walls approximately 32 inches in height. 4. Two experimental spikes will be conducted; one in June and one in early August. 5. There will be two experimental units: a. Chambered control (with existing SAV/algae in place, two treatments [no nutrients added, N&P added]) b. Chambered with SAV—and associated epiphytes—removed 6. Nutrient additions—N (NaNO3 or KNO3) plus P (KH2PO4 or NaH2PO4) —to be added at about 20% above background while keeping N:P approximately equivalent

7. Quantify changes in biomass and C:N:P of primary producers one week following experimental nutrient additions



VARIABLE/CHARACTERISTICS TO BE MEASURED

1. Variables to be measured on continuous basis from deployed data sondes
   a. pH, DO, temperature and specific conductance
2. Variables to be measured prior to and at the end of each one week deployment:
   a. Water chemistry (NH4, NO2 +NO3, TN, TDN, TP, SRP, Chl-a, AFDM, TSS, TVS,DIC, DOC)
   b. Natural abundance C and N isotopic signature and C:N:P stoichiometry of primary producers
   c. SAV assessment (percent cover)
   d. Epiphyte assessment (percent cover)
   e. Surface mat assessment (percent cover)
3. Variables to be measured immediately following nutrient spikes:
   a. Nutrient chemistry every 15-minutes for a period of 4-6 hours (NH4, NO2+NO3, TN, DIN, TP, SRP). [Note- All may not need to be processed]
4. Variables to be measured only at the end of the experiment
   a. Primary producer biomass
   b. Primary producer %C:N:P and isotopic signatures
   c. Phytoplankton assessment (nutrient bags)
   d. SAV and Surface mat assessments

4. Study Boundaries

SPATIAL

The study plots will be located within an area of Willard Spur that historically has remained inundated and sustained an SAV cover for the duration of the study period. The study plots will be located at a site that minimizes any impacts upon the University of Utah experiment, avoids common airboat traffic routes, optimizes access for the study team, and minimizes the likelihood of vandalism. The final location will be determined by DWQ in the field and communicated to the study team, and Willard Spur Science Panel and Steering Committee.

TEMPORAL

The study plots will be constructed and installed by June 14, 2013. The experiment will be conducted over a 1 week period during the peak growing season (June 21 – June28, 2013) and then again during the "green water" phase in early August, 2013. Samples will be collected and measurements and experiments completed according to the prescribed frequency and schedule. Analytical results will be available by October 30, 2013 and a final report issued by February 28, 2014.

	PRACTICAL CONSTRAINTS 1. Water levels are expected to decline as the season progresses. Water levels within the study plots will be maintained to match the surrounding ambient conditions, however water levels could decline more than expected, including the possibility of a complete drying of Willard Spur. 2. Weather conditions could limit the team's ability to conduct any of the required sampling and measurement activities. 3. Storm events could damage equipment and/or flood the study plots. 4. Waterfowl and other aquatic birds could make use of structural elements of the study plots for resting purposes and nesting. This use could damage equipment and/or influence nutrient concentrations within the plots. 5. Airboats and other recreational or regulatory users of Willard Spur could inadvertently collide with the study plots 6. Availability and functionality of boats and other equipment. DWQ will plan for contingencies, however given the remote location it is possible that equipment can fail and not be discovered for a period of several days. 7. Personnel will be assigned to this effort, however emergencies and health conflicts could arise. 8. Unknown experimental artifacts such as scale, shape of plots, wall effects, temperature effects, volume vs depth, etc. 9. Establishing and maintaining the desired nutrient regimes in the water column 10. Given the remote location and inability to provide continuous security at the site, vandalism of the study plots is a possibility.
5. Decision Rules	**DECISION RULES** 1. If information is adequate to quantify the importance of SAV, pelagic algae, and benthic algae/bacteria to nutrient cycling processes, allows for the identification of nutrient assimilation rates in Willard Spur, and to conclude that current and potential nutrient loadings to Willard Spur have a measureable impact on the aquatic system of Willard Spur, then the Science Panel will assist DWQ and the Steering Committee in making recommendations to manage future nutrient loads and protect Willard Spur. 2. If information is adequate to quantify the importance of SAV, pelagic algae, and benthic algae/bacteria to nutrient cycling processes, allows for the identification of nutrient assimilation rates in Willard Spur, and to conclude that current and potential nutrient loadings to Willard Spur have no measureable impact on the aquatic system of Willard Spur, then the Science Panel will assist DWQ and the Steering Committee in making recommendations to manage anticipated nutrient loads, concurrent with water quality and biological monitoring. 3. If information is not adequate to quantify the importance of SAV, pelagic algae, and benthic algae/bacteria to nutrient cycling processes, allows for the identification of nutrient assimilation rates in Willard Spur, and to conclude that current and potential nutrient loadings to Willard Spur have no measureable impact on the aquatic system of Willard Spur, then the Science Panel will assist DWQ and the Steering Committee in evaluating the results in the context of other available information to determine how they may inform a decision.
6. Specify Performance or Acceptance Criteria (Tolerable Limits on Decision Rules)	**TOLERABLE LIMITS ON DECISION RULES** PARCC elements for data • Precision – Unless otherwise noted, field duplicates will be collected representing 10% of samples. • Accuracy - Special efforts will be made to minimize contamination of water chemistry samples through proper collection of field samples, monitoring of sampling-bottle blanks, and the use of appropriate laboratories for analysis. A wetland monitoring crew trained in each method will collect all field samples, complete all field experiments, and complete all field measurements. Site photographs and field notes will be taken of any conditions or specimens that are in question. Few species of vegetation occur within the project area and are easily identified, but questionable

	specimens will be collected and returned to the office for further identification. ● Representativeness – The study site will be selected to represent the SAV dominated, open water wetland system of Willard Spur. Water quality parameters, substrate, and SAV condition and composition are assumed to be consistent among all plots when the experiment begins. It is assumed that the chambers will introduce some experimental artifacts and prevent true representation of natural wetland conditions. Field sampling will occur following standardized sample collection procedures as described in Standard Operating Procedures (SOPs) for each method. Site photos and field notes will be collected at each site and can be used to describe any unusual conditions that may occur. ● Completeness - To ensure the sampling goal of 100% completeness at the end of the experiment, we will identify a study site that will maintain sufficient inundation throughout the experiment. Contingency plans will be in identified in case DWQ's airboat is not operational and/or to complete measurements on the day subsequent to a storm event that precludes sampling on a scheduled sampling day. ● Comparability - All field sampling and analytical procedures will be completed following both previously-tested and newly developed SOPs for each metric, and will be performed by the same field crew throughout the sampling season. Measurement quality objectives for chemical measurements will be identified in a separate document. DWQ QAPP specifies the minimum QA/QC objectives for sample measurement
7. Optimization of the Sampling Design	After detailed consideration of reasonable alternatives, the following design is the most resource effective: 1. Collaboration with South Davis Sewer District and the Jordan River Farmington Bay Water Quality Council for construction of the required chambers and appurtenances required for the study. 2. Utilize bird netting, springs, and spikes to minimize the use of site infrastructure by waterfowl and other aquatic birds. 3. Collaboration with the Willard Spur Science Panel for technical assistance. Notify and discuss unexpected outcomes with project manager and Science Panel as they happen; recommend adjustments or changes and / or request input from the Science Panel; follow up with results from new approach and continue to make adjustments accordingly. 4. Collaboration with the Willard Spur Steering Committee for input and communication/implementation of site safety and security measures to the public, e.g., obtain input from the Airboat Association on study location and communication with boaters to minimize accidental impact with site infrastructure, collaborate with USFWS security personnel to minimize the risk of vandalism, etc. 5. Collaboration with the Jordan River Farmington Bay Water Quality Council for technical assistance and equipment and personnel to assist with installation and maintenance of the study site and collection of required samples. 6. Collaboration with Utah State University for technical assistance and equipment and personnel to assist with installation and maintenance of the study site and collection of required samples. 7. Utilize trained DWQ personnel with oversight from DWQ scientists to conduct installation, maintenance, operation of site infrastructure and complete required sampling, measurements and experiments 8. Utilize established standard operating procedures in the field and laboratory, readily available equipment and vehicles, and data management procedures used for the Willard Spur project. 9. Visit study plots on a frequent basis (minimum of one time per week) to confirm the successful operation of equipment, document conditions, and maintain the site as necessary.