Willard Spur Project: Background

An introduction for the Science Panel
August 2011

Sociopolitical Setting

- Original limits assumed discharge to GSL (sans numeric criteria)
- Formal and Informal Legal Challenges
  - Utah: Categorical Protection for Willard Spur
  - Federal: Protections against discharges into Federal Wildlife refuges
  - Local: Major expense, challenges were too late
- Current standards/boundaries for WMAs are defined politically (rule), not ecologically (intent)
- Many concerns over GSL, most with little empirical support for all points of view
- Homes constructed without wastewater treatment options unless the plants can begin operating
- Mechanical plants are superior to lagoons/septic systems, but the receiving water changed

Preliminary Evaluation

Primary Questions

Science: How will the Willard-Perry effluent affect the Willard Spur ecosystem?

Regulatory: Will the Willard-Spur effluent degrade the designated beneficial uses, or cause a violation of Utah's narrative standards?

Policy: How to meet the regulatory requirements with the available science?

Short term (today) and Long term…

What pollutant concentrations are protective of the use in the short term?

What pollutant concentrations are protective of the use in the long term?

Study Limitations & Assumptions

- A paucity of background data for Willard Spur
- Chemical-Biological linkages for GSL are poorly understood
- No information regarding year-to-year nutrient retention via biogeochemical processes nor hydrologic removal

In Short…Many Unknowns

“There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.”

Preliminary Risk Assessment

- Identify parameters of concern
- Estimate the concentration of key pollutants from the discharge (Paul Krauth)
- Estimate the anticipated year-to-year increases in the concentration of key pollutants (Nick von Stackelberg)
- Estimate pollutant concentrations that pose a risk to Willard Spur biota (Jeff Ostermiller)

Parameters of Concern: Currently a Nutrient Focus. Others?

Why Nutrients?

- Evidence from other wetland investigations suggest that eutrophication can cause a degraded “stable state”.
- Nutrients are known to exist in relatively high concentrations in POTW effluent, unless treatments specifically address reductions.

HOW MIGHT THE DISCHARGE AFFECT NUTRIENT CONCENTRATIONS AT LOW LAKE LEVELS?

Purpose and Approach

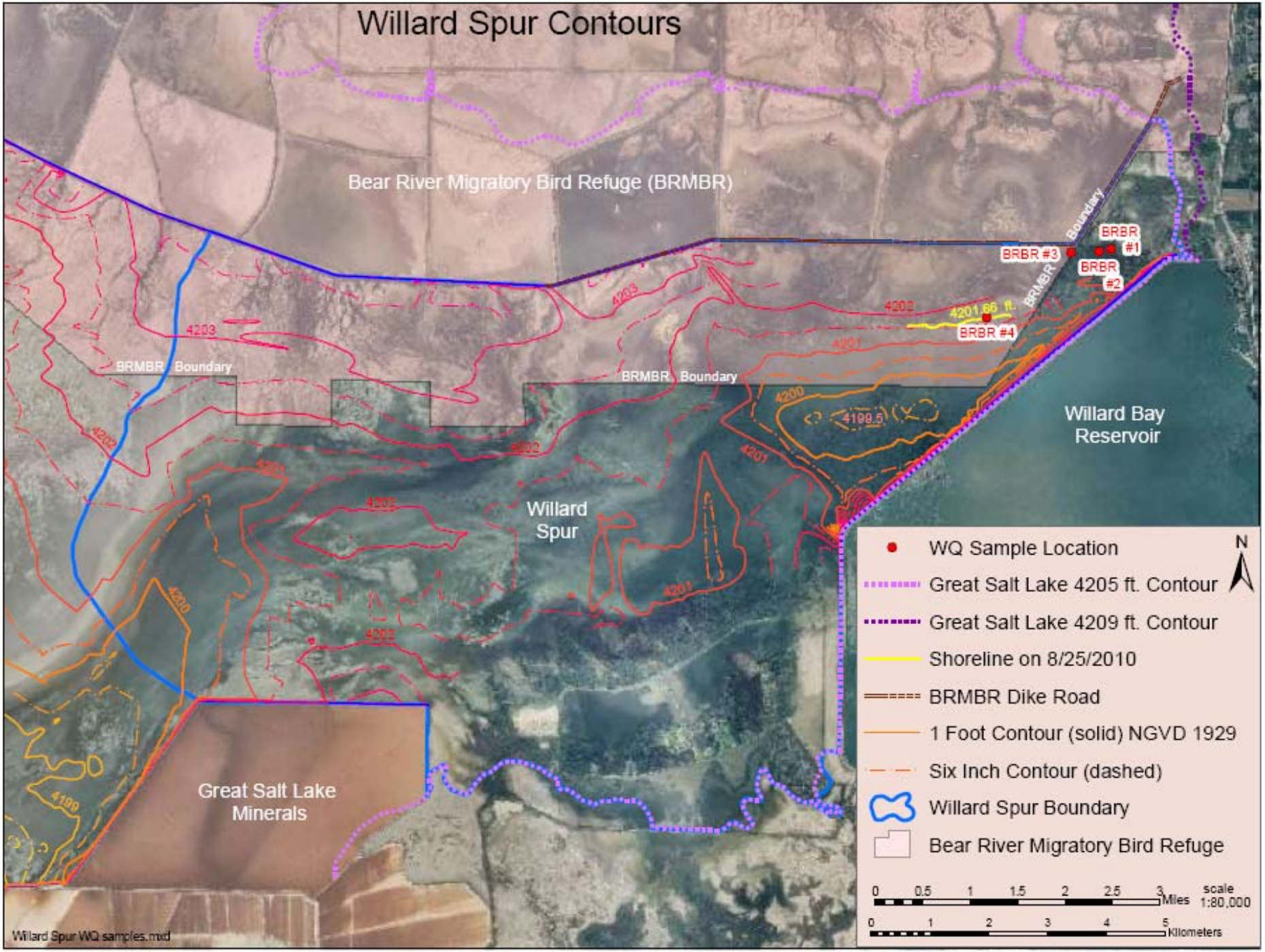
- Identify potential nutrient concentration in Willard Spur in short-term horizon (5 years)
- Limited data and time to calibrate a biogeochemical model
- Simplified mixing analysis approach
- Due to uncertainty, some conservative assumptions were made

Assumptions

Assumption	Conservative
Full mixing of POTW effluent in Willard Spur	No
Current background conditions in Willard Spur represent most limiting conditions, i.e. low water level and high nutrient background concentration	?
Initial water volume in Willard Spur for each year remains constant	Yes
No net increase in evapotranspiration	No
No net increase in biological uptake of nutrients	Yes
No sedimentation and resuspension	Yes

Water Volume in Willard Spur

- Bathymetric map of Bear River Bay with 6-inch contours
- Provided by BIO-WEST Consultants
- Water surface elevation based on limited field mapping conducted in August 2010
- 11.7 million cubic meters


Willard Spur Contours
Bear River Migratory Bird Refuge (BRMBR)
BRMBR Boundary
BRMBR Boundary
BRMBR Boundary
BRBR #1
BRBR #2
BRBR #3
BRBR #4
4201.66 ft.
4199.5
Willard Bay Reservoir
Willard Spur
Great Salt Lake Minerals
WQ Sample Location
Great Salt Lake 4205 ft. Contour
Great Salt Lake 4209 ft. Contour
Shoreline on 8/25/2010
BRMBR Dike Road
1 Foot Contour (solid) NGVD 1929
Six Inch Contour (dashed)
Willard Spur Boundary
Bear River Migratory Bird Refuge
N
0 0.5 1 1.5 2 2.5 3 Miles
scale 1:80,000
0 1 2 3 4 5 Kilometers
Willard Spur WQ samples.mxd

Constituents of Concern

- Total Nitrogen (TN)
- Nitrate + Nitrite (NO3)
- Ammonia (NH4)
- Total Phosphorus (TP)

Background Conditions

- Four samples collected in Willard Spur on August 4, 2010
- Used average of 4 samples for background concentration

TP	TN[1]	NO3[2]	NH4[2]
0.126	3.64	0.05	0.04

1: Based on analysis for dissolved nitrogen.
2: Readings below detection limit assumed at half of detection limit
(NO3 = 0.10 mg/L; NH4 = 0.05 mg/L).

POTW Operation Scenarios

- STM-Aerotor™ treatment process
- Most probable operation is medium discharge and medium nutrient concentration

Discharge:

Discharge Level	Discharge Rate (MGD)	Projected Operation
Low	0.35	2010 – Perry Only
Medium	0.60	2011 – Perry and Willard
High	2.00	Max. Capacity (2030)

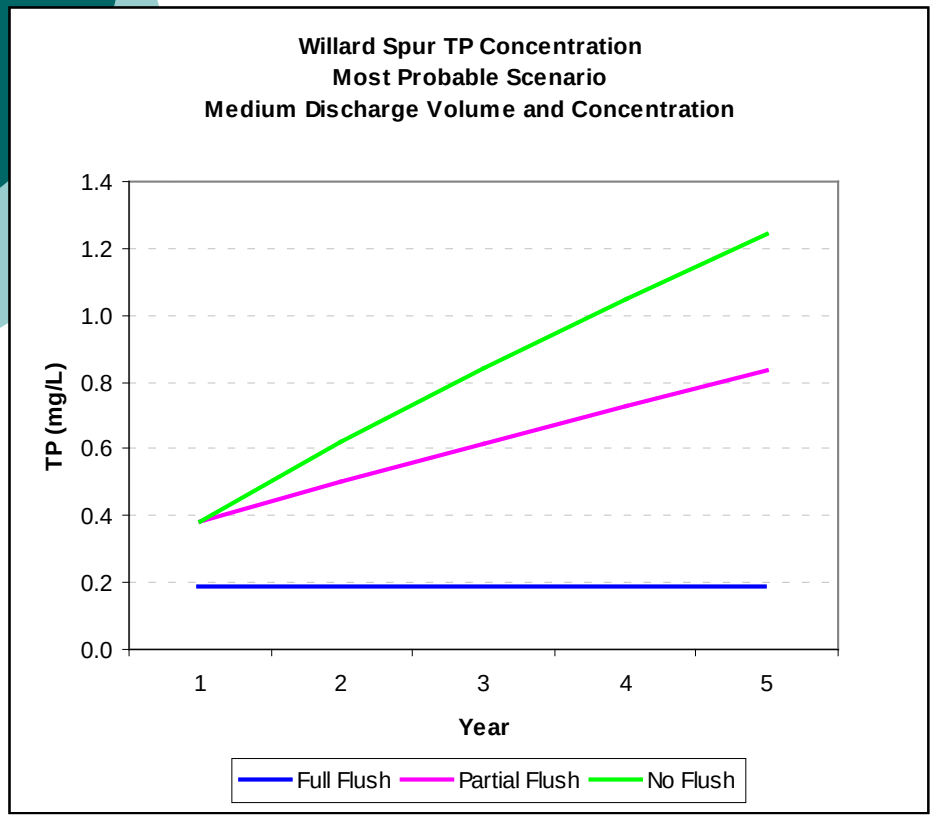
Nutrient Concentration:

Discharge Level	TP	TN	NO3	NH4	Probability
Low	2.5	10	8	0.1	Very low – manufacturer's specification
Medium	4.0	20	16	1.0	Most likely
High	5.0	30	24	3.0	Low - conservative

Flushing Scenarios

- Full Flush Scenario
  - Willard Spur was assumed to completely flush with Bear River flows each spring. Therefore, effluent was assumed to only accumulate during the critical summer months of June-July-August and no change in year-over-year background concentration.
- Partial Flush Scenario
  - Willard Spur was assumed to partially flush each year. Therefore, background concentration in year n+1 was assumed to be the average of the final mixed and background concentration of year n. The analysis was carried out over five years.
- No Flush Scenario
  - No flushing of Willard Spur was assumed to occur. Therefore, initial concentration in year n+1 was assumed to be the final mixed concentration in year n. The analysis was carried out over five years.

Results – Most Probable Operation



Results – Most Probable Operation

POTW Short-Term Operation Scenarios

- Discharge Rate
  - Willard City only – 0.2 MGD
- Nutrient Concentration
  - TP = 3.0 mg/L
  - TN = 10 mg/L
  - NO3 = 8 mg/L
  - NH4 = 0.1 mg/L
- Both seasonal and continuous discharge
- Results presented in Table 5 of Technical Memorandum

Potential Effects to Aquatic Life Uses

An evaluation of relative risk utilizing existing data

Estimating Effects to Biota

Methods

- Use existing wetland Multi-Metric Index (MMI)
- Compare measures of measures of biological condition with measures of chemical condition to develop risk thresholds
- Compare these thresholds with estimated nutrient increases under conservative scenarios.

Assumptions and Limitations

- The MMI is a preliminary tool that we are in the process of more extensively evaluating
- The MMI was developed from managed, impounded Great Salt Lake wetlands
- The lines of evidence used in the current MMI may not represent the best biological conditions
- Relationships reflect correlation, not causation

Biological Response Metrics used for Risk Evaluations

SAV

- Maximum SAV cover
- Percent loss prior to waterfowl arrival (early senescence)
- Cover upon waterfowl arrival

Surface Mats

- Percent algae cover (season maximum)
- Percent duckweed cover (season maximum)

Surface Mats

- Extensive surface mats of algae and/or duckweed occur at some, but not all ponds.

- Sometimes the mats cover the entire surface of the ponds and can be inches thick

- Field notes indicate that when the mats die they often create a blanket that crushes SAV

- Thick mats, they block light sometimes below the requirements of SAV.

- These are a big part of the complaints of duck club stakeholders: gross, stinky, difficult to walk or boat through.

- Presence may inhibit wildlife use.

- Directly mentioned in Utah's narrative standards.

The SAV Story

- Duck club and DWR ponds are managed for SAV as a source of duck food
- When ducks arrive in autumn, they eat most remaining SAV, which then reached peak abundance in July or August
- At some ponds SAV has a tendency to “tank” before the ducks arrive.

SAV Metrics: Ties to Standards

Aquatic Life Uses

- *Direct*- measure of desirable part of foodweb
- *Direct*- Food for both ducks and invertebrates
- *Indirect*- Habitat for invertebrates
- *Indirect*- Nutrient sequestration; improve conditions for aquatic organisms; pollutant filtration & deposition (all relates to ties within the food chain)

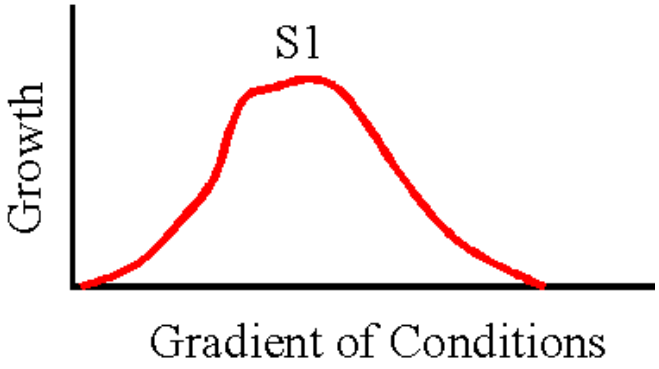
Recreation Uses

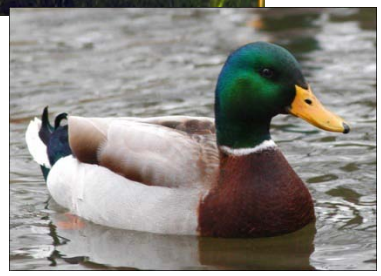
- Duck hunting is much better at ponds with SAV, which is why they are heavily managed for SAV production.

Response Variable: A Chemical Index

- Screen summary statistics for each parameter
- Rescale to equivalent units
- Evaluate redundancy among parameters
- Combine chemical metrics

Summary Statistics for Concentrations





Low Concentrations

reference conditions

High Concentrations

stressful conditions
(direct tie to standards)

Central Tendency

average conditions

Analytical Parameters in the Response Index

DO

minimum & % saturation

TSS

minimum, maximum, & geometric mean

Chl-a

minimum, maximum, & geometric mean

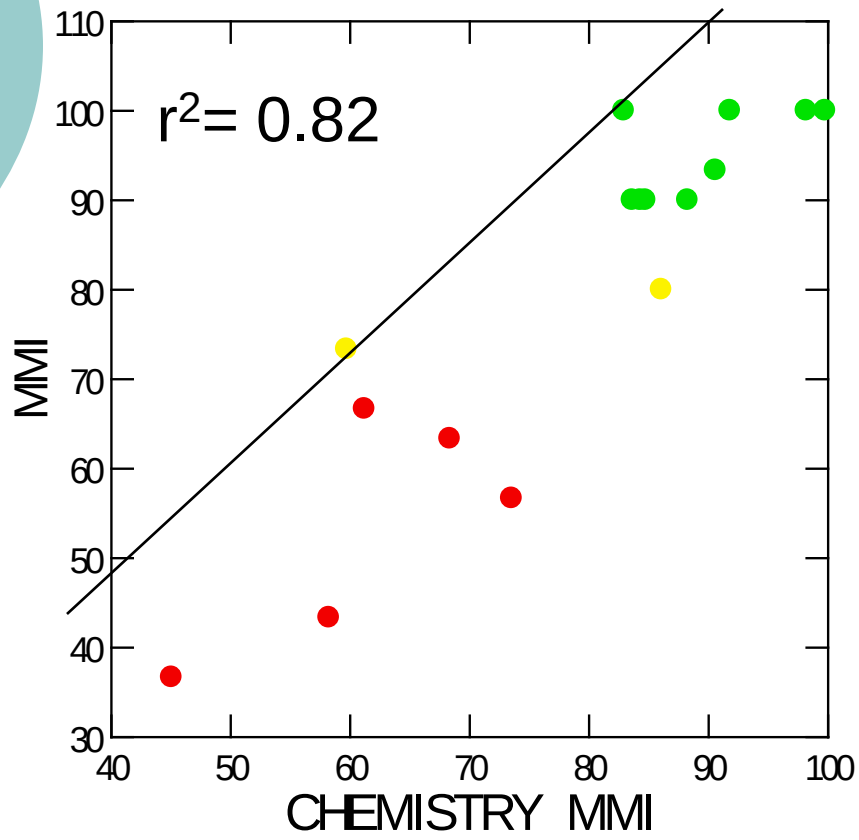
P (total, dissolved, and total in mud)

minimum, maximum, & geometric mean

N (NH_4, NO2/NO3, ON, and total in mud)

minimum, maximum, & geometric mean

Results: Biological and Chemical Relationships

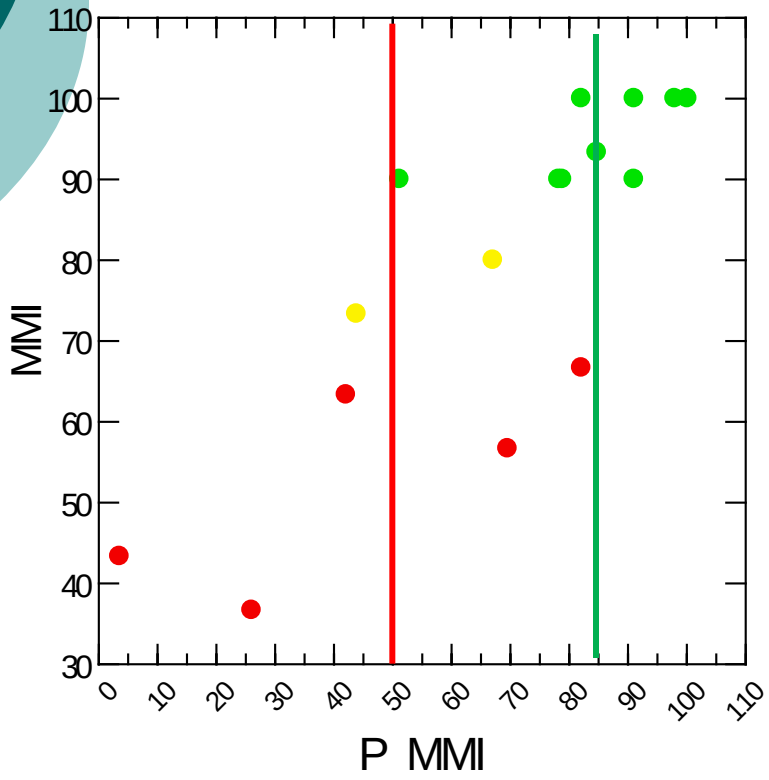


- The Chemistry index ranged from 45-100 among sites.
- The index is strongly correlated with independently generated measure of biological condition.

Evaluating Risk Thresholds

- Thresholds vary depending on predictors and responses evaluated, so we used multiple lines of evidence
- Biological responses: mats, SAV, and combined
- Chemical Predictors: N, P, and overall chemistry
- Results should be interpreted as screening values, not effluent requirements or standards

Determining Thresholds



BPJ

Low Risk

Never observe problems

High Risk

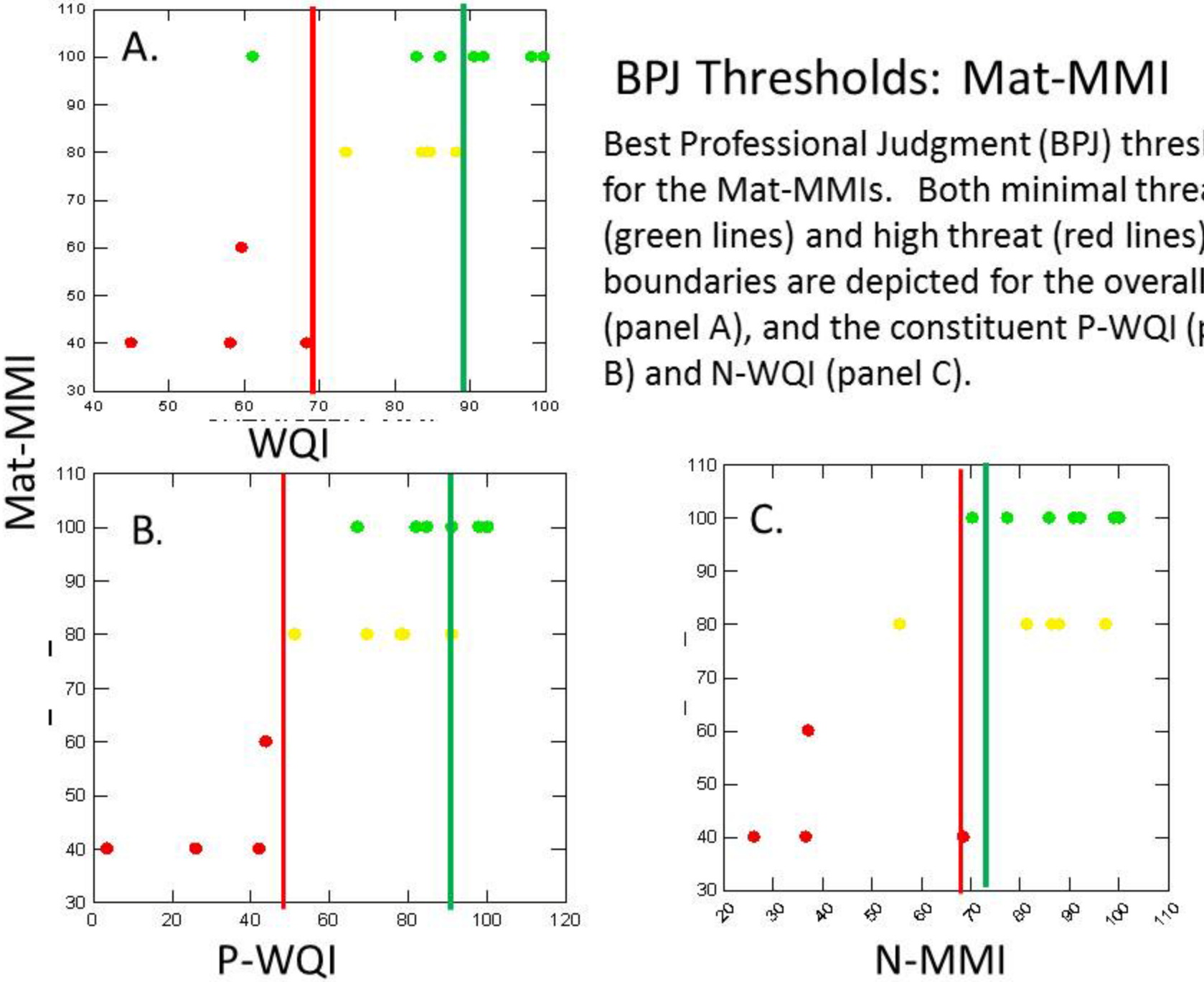
Always observe problems

Statistical

Moderate (most probable) Risk

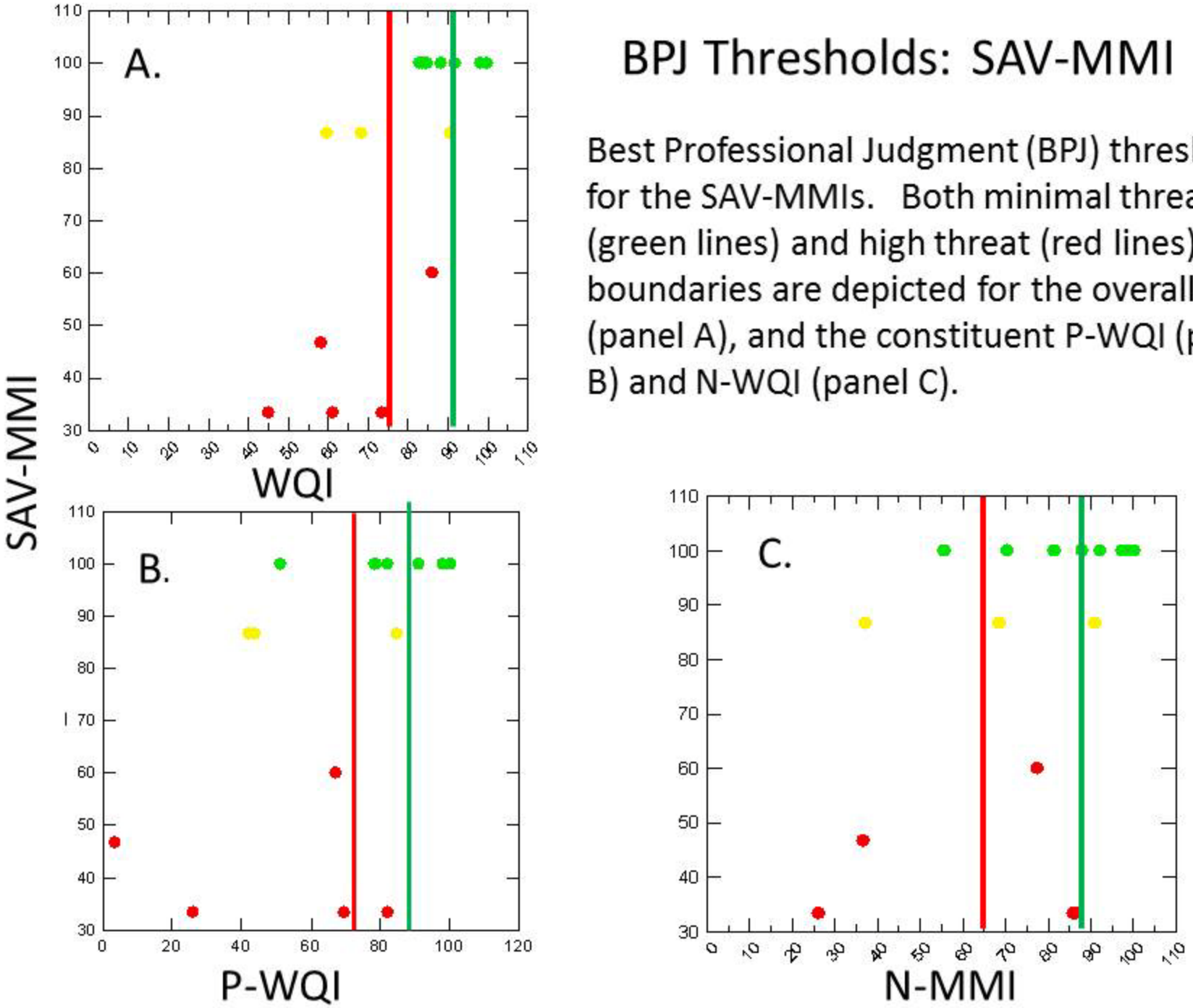
BPJ Thresholds: Mat-MMI

Best Professional Judgment (BPJ) thresholds for the Mat-MMIs. Both minimal threat (green lines) and high threat (red lines) boundaries are depicted for the overall WQI (panel A), and the constituent P-WQI (panel B) and N-WQI (panel C).



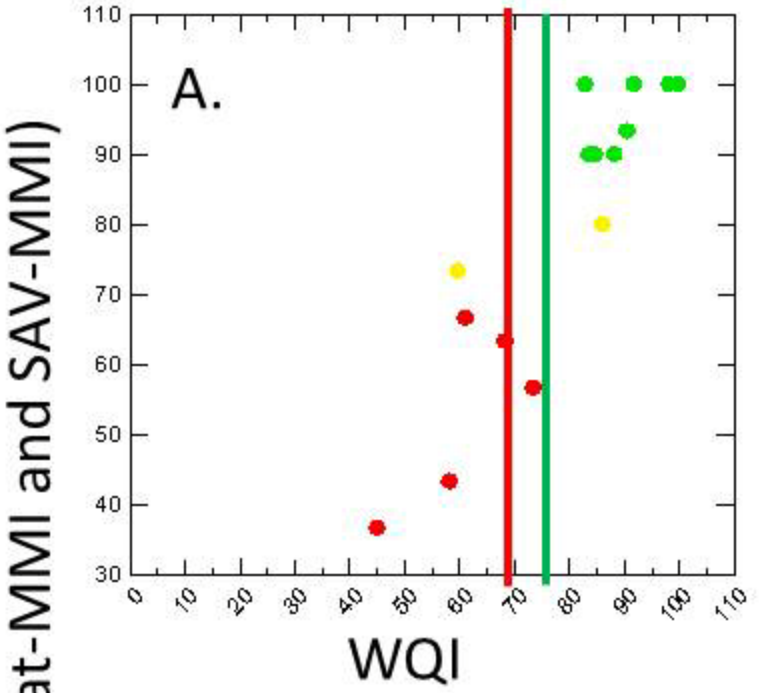
BPJ Thresholds: SAV-MMI

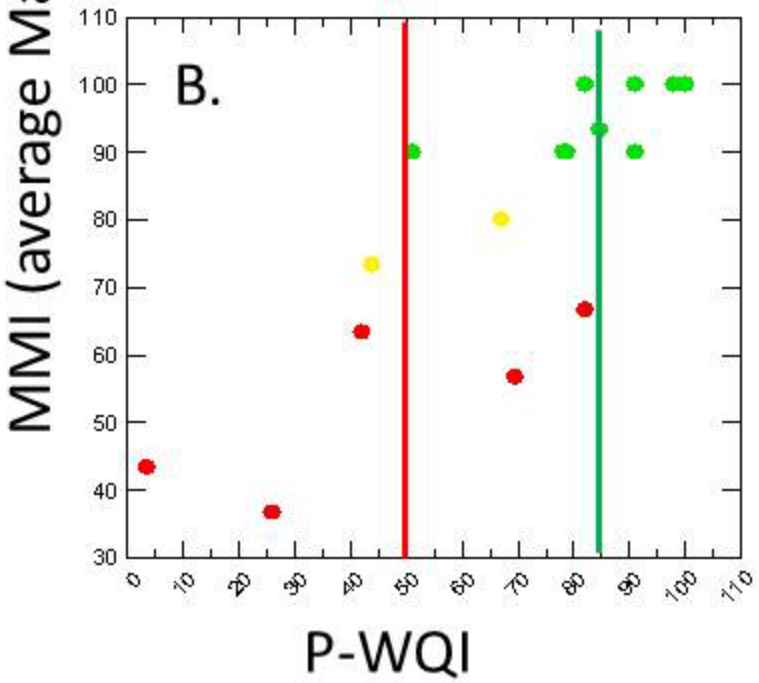
Best Professional Judgment (BPJ) thresholds for the SAV-MMIs. Both minimal threat (green lines) and high threat (red lines) boundaries are depicted for the overall WQI (panel A), and the constituent P-WQI (panel B) and N-WQI (panel C).

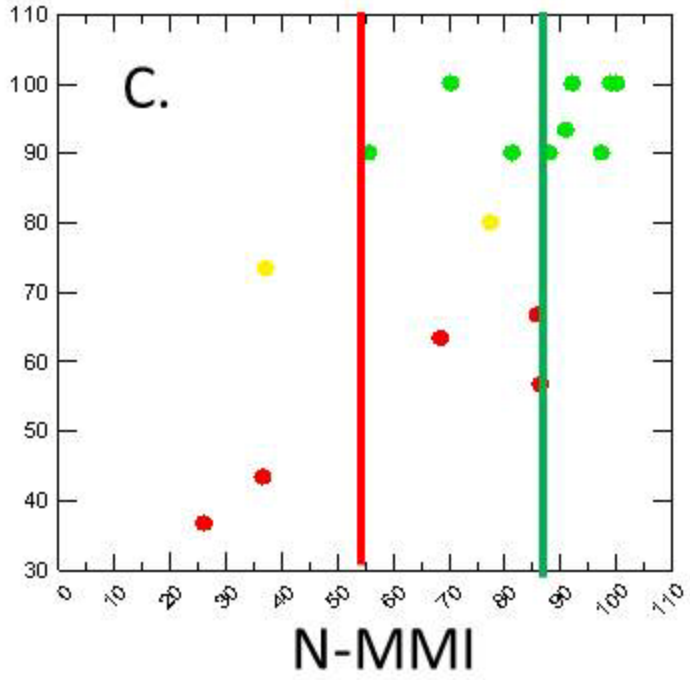


BPJ Thresholds: MMI

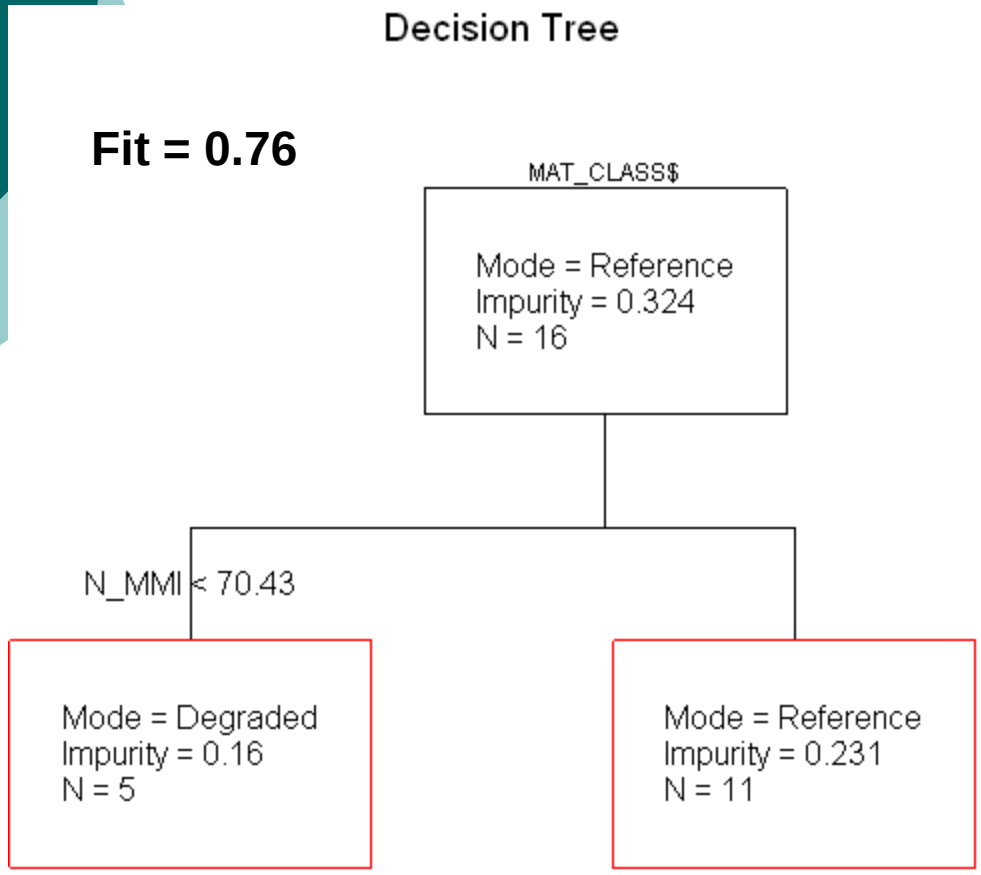
Best Professional Judgment (BPJ) thresholds for the overall (average) biological condition of impounded GSL wetlands. Both minimal threat (green lines) and high threat (red lines) boundaries are depicted for the overall WQI (panel A), and the constituent P-WQI (panel B) and N-WQI (panel C).







Statistical Methods



- Recursive partitioning
- Predict into previously defined groups:
  - MMI >90
  - MMI 61-89
  - MMI <60

Overall Results: Table 5 Technical Memo

Next slide summarizes results from all lines of evidence…

Table 5.
Relative risk thresholds calculated and associated predicted geometric means of chemical constituents (mg/l) generated for three measures of biological condition: Submerged Aquatic Vegetation (SAV-MMI), Surface Mats (Mat-MMI) and the average of surface mats and SAV (Overall). High risk = concentrations always associated with degraded conditions, Moderate risk = empirical techniques used to determine the most likely threshold that leads to degraded conditions, Low risk = conditions always associated with the best biological conditions.

WQI	MMI	Risk	Threshold	TP	NH4	NO3	ON
P-MMI	Overall	High	50	0.4	NA	NA	NA
N-MMI	Overall	High	55	NA	0.3	1.6	2.4
Chemistry	Overall	High	75	0.3	0.2	1.1	1.9
Chemistry	Overall	Low	83	0.2	0.2	0.8	1.5
P-MMI	Overall	Low	85	0.1	NA	NA	NA
N-MMI	Overall	Low	87	NA	0.2	0.5	1.3
P-MMI	Overall	Moderate	78	0.2	NA	NA	NA
Chemistry	Overall	Moderate	83	0.2	0.2	0.8	1.5
N-MMI	Overall	Moderate	88	NA	0.2	0.5	1.3
N-MMI	SAV	High	65	NA	0.2	1.2	2.1
P-MMI	SAV	High	70	0.2	NA	NA	NA
Chemistry	SAV	High	75	0.3	0.2	1.1	1.9
P-MMI	SAV	Low	83	0.1	NA	NA	NA
N-MMI	SAV	Low	87	NA	0.2	0.5	1.3
Chemistry	SAV	Low	91	0.1	0.2	0.6	1.1
P-MMI	SAV	Moderate	78	0.2	NA	NA	NA
Chemistry	SAV	Moderate	83	0.2	0.2	0.8	1.5
N-MMI	SAV	Moderate	88	NA	0.2	0.5	1.3
P-MMI	Surface Mats	High	45	0.4	NA	NA	NA
N-MMI	Surface Mats	High	68	NA	0.2	1.1	2.0
Chemistry	Surface Mats	High	69	0.4	0.3	1.3	2.2
P-MMI	Surface Mats	Low	62	0.3	NA	NA	NA
N-MMI	Surface Mats	Low	71	NA	0.2	1.1	1.9
Chemistry	Surface Mats	Low	89	0.1	0.2	0.7	1.2
P-MMI	Surface Mats	Moderate	67	0.3	NA	NA	NA
Chemistry	Surface Mats	Moderate	74	0.3	0.2	1.1	2.0
N-MMI	Surface Mats	Moderate	78	NA	0.2	0.8	1.6

Final Relative Thresholds: All Nutrients

Table 6.
The geometric means and standard deviation (σ) of threshold nutrient concentrations within impounded wetlands of Great Salt Lake. Data are depicted for thresholds derived for two levels of relative risk. Low risk indicates average nutrient concentrations that were never associated with biological degradation in these wetlands (as measured by SAV-MMIs and Mat-MMIs). High risk indicates nutrient concentrations that were always associated with degraded biological conditions.

Relative Risk	TP	NO_3	ON	NH_4
Low Risk	0.16 (σ = 0.07)	0.70 (σ = 0.20)	0.19 (σ = 0.02)	1.39 (σ = 0.27)
High Risk	0.33 (σ = 0.07)	1.23 (σ = 0.17)	0.24 (σ = 0.02)	2.07 (σ = 0.20)

Until we know better, we'll use these data to help put recent observations in context.

Relations with Loading Scenarios

We also evaluated the amount of time where nutrients could potentially become a concern under various discharge scenarios:

Table 7
Estimated year following the discharge into Willard Spur in which nutrient concentrations are projected to exceed high risk thresholds under 3 hypothetical nutrient increase scenarios: Status Quo = partial flush, medium nutrients, 5-year estimated discharge volume. Status Quo, High Nutrients = partial flush, high nutrients, 5-year projected discharge volume
Proactive Scenario = partial flush, minimize nutrient inputs, minimize discharge into Willard Spur

Discharge Scenario	TP	NO_3	NH_4
Status Quo	Year 2-3	Year 2-3	>5 Years
Status Quo, High Nutrients	Year 1	Year 1	>5 Years
Proactive Scenario	>5 Years	>5 Years	>5 Years

Final Resolution

- Hold Perry and Willard Cities harmless financially
- Implement immediate to the maximum extent possible (chemical additions)
- Formation of steering committee and science panel to determine what changes, if any, are needed to ensure long-term protection of the Willard Spur ecosystem
- Can this project inform the greater need to modify standards for wetlands surrounding GSL?