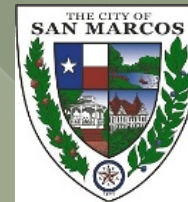


SCIENCE SUBCOMMITTEE

RESEARCH WORK GROUP

MARCH 22, 2017



RESEARCH WORK GROUP

CHARGE

The Work Group's charge consists of: (1) suggesting specific Applied Research projects to be conducted during 2018 and 2019 as part of the Applied Research Program; and (2) suggesting refinements to the methodology proposed for Refugia research projects.

MEMBERSHIP

- Chad Norris
- Tom Arsuffi
- Floyd "Butch" Weckerly
- Conrad Lamon

A report will be created detailing the activities of the work group to be presented to the Science Committee at the May 10, 2017 meeting.



EAHCP RESEARCH PROGRAMS

REFUGIA RESEARCH PROGRAM

- Task 2 of the EAA-USFWS Refugia contract details Refugia research program.

TABLE 1 Species Federally Listed as Threatened or Endangered:	Priority Ranking
Comal Springs Riffle Beetle (<i>Heterelmis comalensis</i>);	1
Comal Springs Dryopid Beetle (<i>Stygoparnus comalensis</i>);	1
Pecks Cave Amphipod (<i>Stygobromus pecki</i>);	1
Texas Blind Salamander (<i>Eurycea</i> (+ <i>Typhlomolge</i>) <i>rathbuni</i>);	2
San Marcos Salamander (<i>Eurycea nana</i>)	2
Fountain Darter (<i>Etheostoma fonticola</i>)	3
Texas Wild Rice (<i>Zizania texana</i>)	3
Species Petitioned for Listing as Endangered	
Texas Cave Diving Beetle (<i>Haideoporus texanus</i>)	4
Texas Troglitic Water Slater (<i>Lirceolus smithii</i>)	4
Comal Springs Salamander (<i>Eurycea</i> sp.)	4

TABLE 2 Research Topics	Priority Ranking
Collection Methods and Techniques	1
Species Husbandry	2
Species Propagation	3
Species Genetics	4
Species Reintroduction Methods	4


- 2017 projects
 - Juvenile Development and Maturation of Peck's Cave Amphipods (*Stygobromus pecki*)
 - Larval Development of Comal Springs Dryopid Beetles (*Stygoparnus comalensis*)



EAHCP RESEARCH PROGRAMS

APPLIED RESEARCH PROGRAM

- 2015 Applied Research Work Group
 - Applied Research workgroup met in Fall 2015 to produce 2016-2019 Applied Research Project Schedule



2018	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48)
		2. Confirm species-specific Tables 4-1, 4-21
		3. Evaluate success of flow-split management
	3. TBD	1. TBD/Contingency
2019	1. Conservation Measures	1. Evaluate success of removal of invasive animal species and reduction of introduction
		2. Evaluate success of Sessom Creek sand bar removal and sediment removal efforts
	2. TBD	1. TBD/Contingency

EAHCP, 2015. Report of the 2015 Applied Research Work Group. Appendix II. 31 pp. Available online at:
http://www.eahcp.org/index.php/administration/work_groups/applied_research_work_group

APPLIED RESEARCH SCHEDULE 2018-2019


► Assumptions

- Life history, husbandry, propagation, sampling, and reintroduction research projects on Covered Species will be covered by the Refugia research program.
- Increase “Request for Proposal” period from 2 weeks to ~ 2 months
- Projects can span 22 months max (Mar 2018 – Dec 2019), if necessary.
- Placeholder(s) will remain for additional statistical research, barring results from the 2017 Applied Research projects.
- Placeholder(s) will remain for Eco Model research, barring examination of the model and conducting needs assessment.



2018 - 2019 APPLIED RESEARCH SCHEDULE – PECK'S CAVE AMPHIPOD

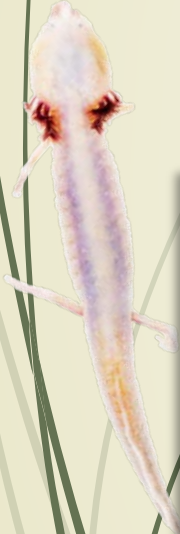
- ▶ Peck's Amphipod quantitative sampling techniques
- ▶ Proposed as part of 2015 Applied Research Work Group for 2018 Applied Research



	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
2018	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48)
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2018 - 2019 APPLIED RESEARCH SCHEDULE – *FLOW SPLIT*

- Evaluate success of flow-split management
 - Proposed as part of 2015 Applied Research Work Group for 2018 Applied Research

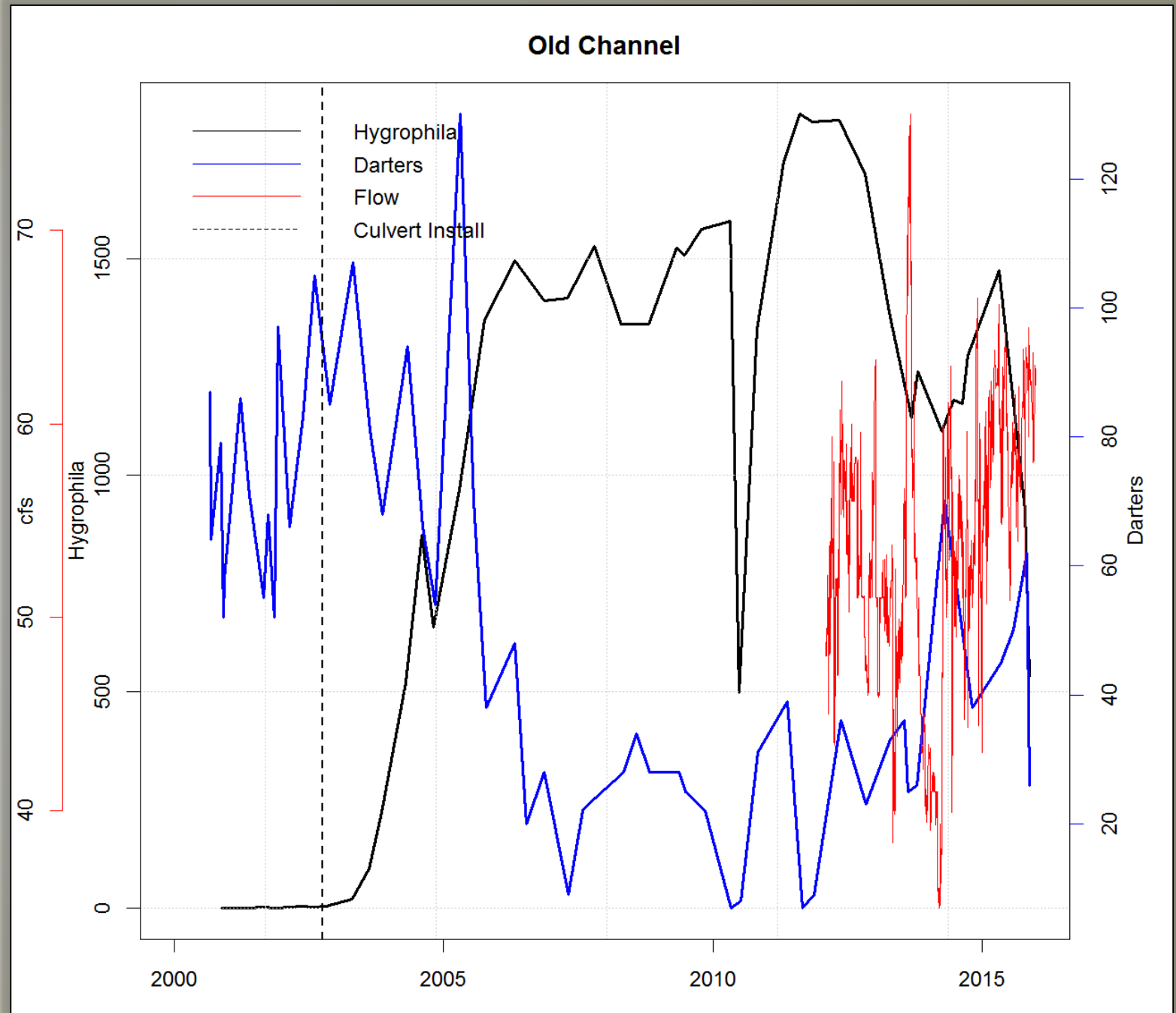


2018	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48) 2. Confirm species-specific Tables 4-1, 4-21
		3. Evaluate success of flow-split management
2019	3. TBD	1. TBD/Contingency
	1. Conservation Measures	1. Evaluate success of removal of invasive animal species and reduction of introduction 2. Evaluate success of Sessom Creek sand bar removal and sediment removal efforts
	2. TBD	1. TBD/Contingency

EVALUATE SUCCESS OF FLOW-SPLIT MANAGEMENT

Hygrophila coverage (m²), fountain darters collected by timed dip-net, and USGS gauged (GS-08168913) flow along the Old Channel

Section 2.3 of SAV Analysis and Recommendations Report



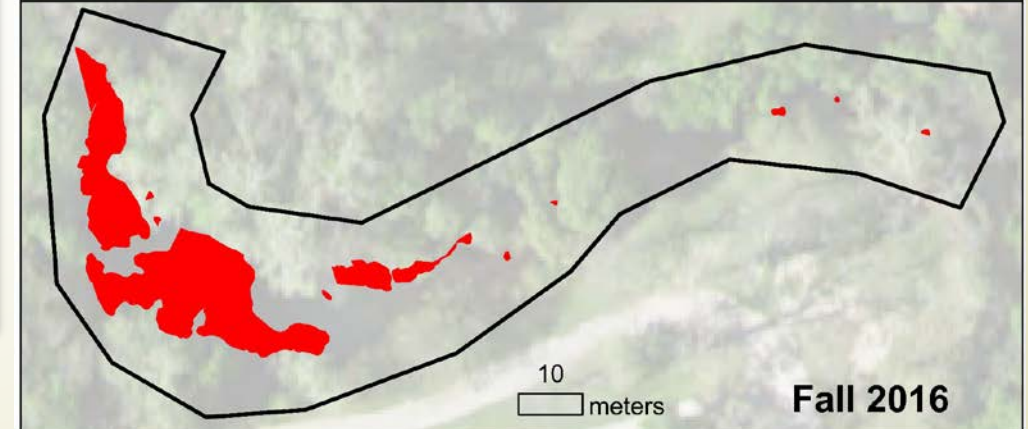
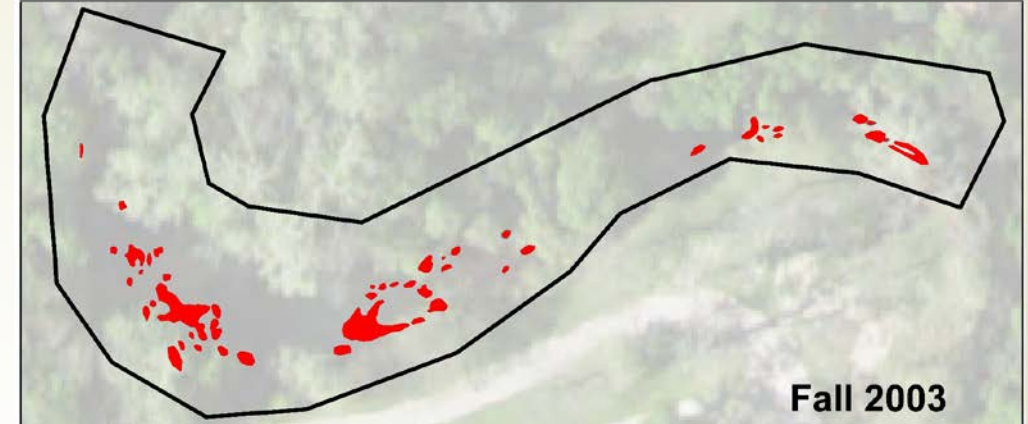
Hygrophila coverage along the Old Channel biomonitoring reach in Fall 2003, 2011, and 2016.

Flow-split management for Old and New Channels recommended as part of 2016 Non-Routine Adaptive Management

Total Comal Springflow (cfs)	Old Channel (cfs)		New Channel (cfs)	
	Fall, Winter	Spring, Summer	Fall, Winter	Spring, Summer
350+	80	60	270+	290+
300	80	60	220	240
250	80	60	170	190
200	70	60	130	140
150		60		90
100		60		40
80		50		30
70		50		20
60		40		20
50		40		10
40		30		10
30		20		10


BIO-WEST and Watershed Systems Group, 2016. Submerged Aquatic Vegetation Analysis and Recommendations, 145 pp. Available online at:
http://www.eahcp.org/index.php/administration/adaptive_management

Hygrophila in the Old Channel



2018 - 2019 APPLIED RESEARCH SCHEDULE – SESSOM CREEK

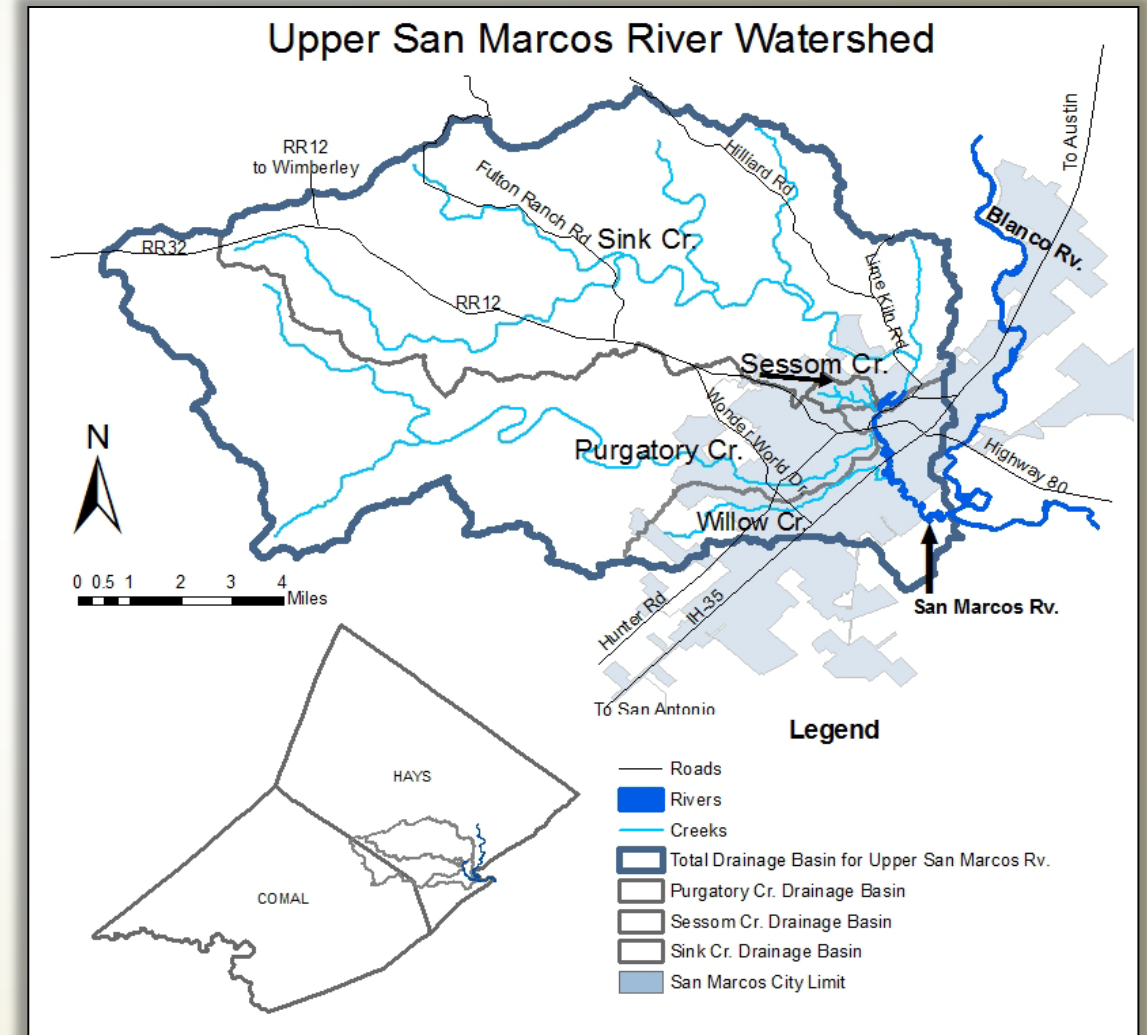
- ▶ Evaluate success of Sessom Creek sand bar removal and sediment removal efforts
- ▶ Proposed as part of 2015 Applied Research Work Group for 2019 Applied Research



2018	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48)
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2018 - 2019 APPLIED RESEARCH SCHEDULE – SESSOM CREEK

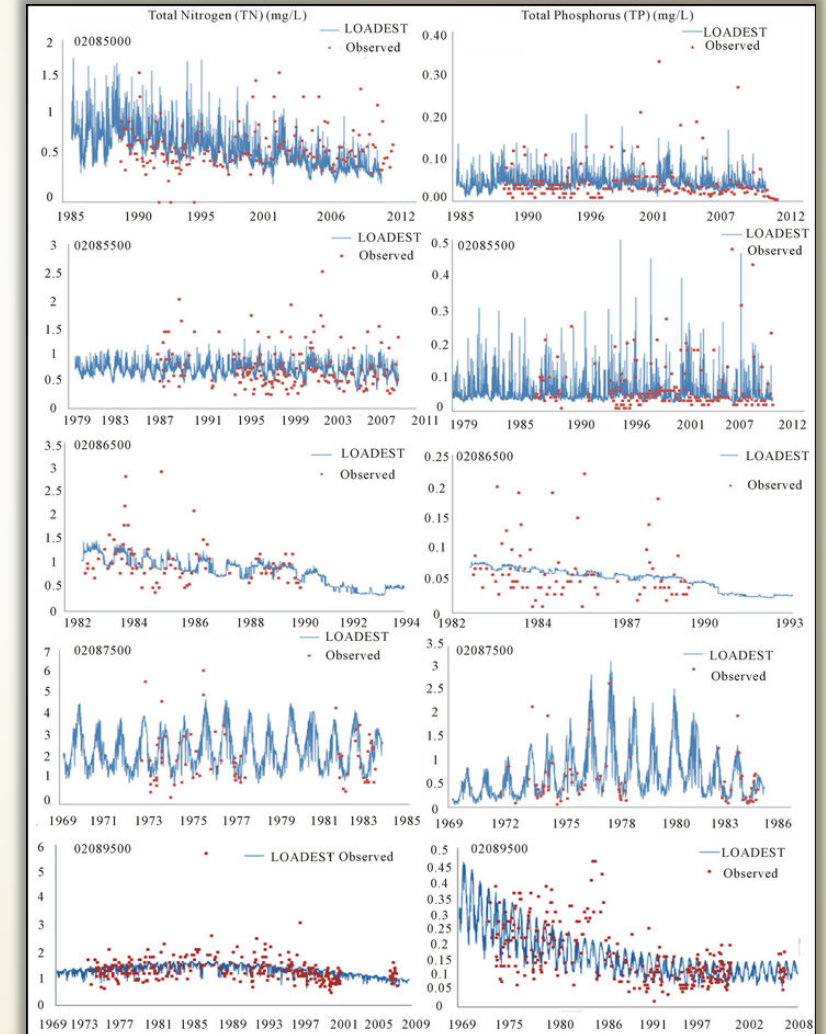
EAHCP is undergoing nonroutine adaptive management to partner with the City of San Marcos and Texas State/MCWE to install engineered solutions (BMPs, LID, etc.) along the middle portion of Sessom Creek, aimed at reducing upland sediment loads.



2018 - 2019 APPLIED RESEARCH SCHEDULE – *SESSOM CREEK*

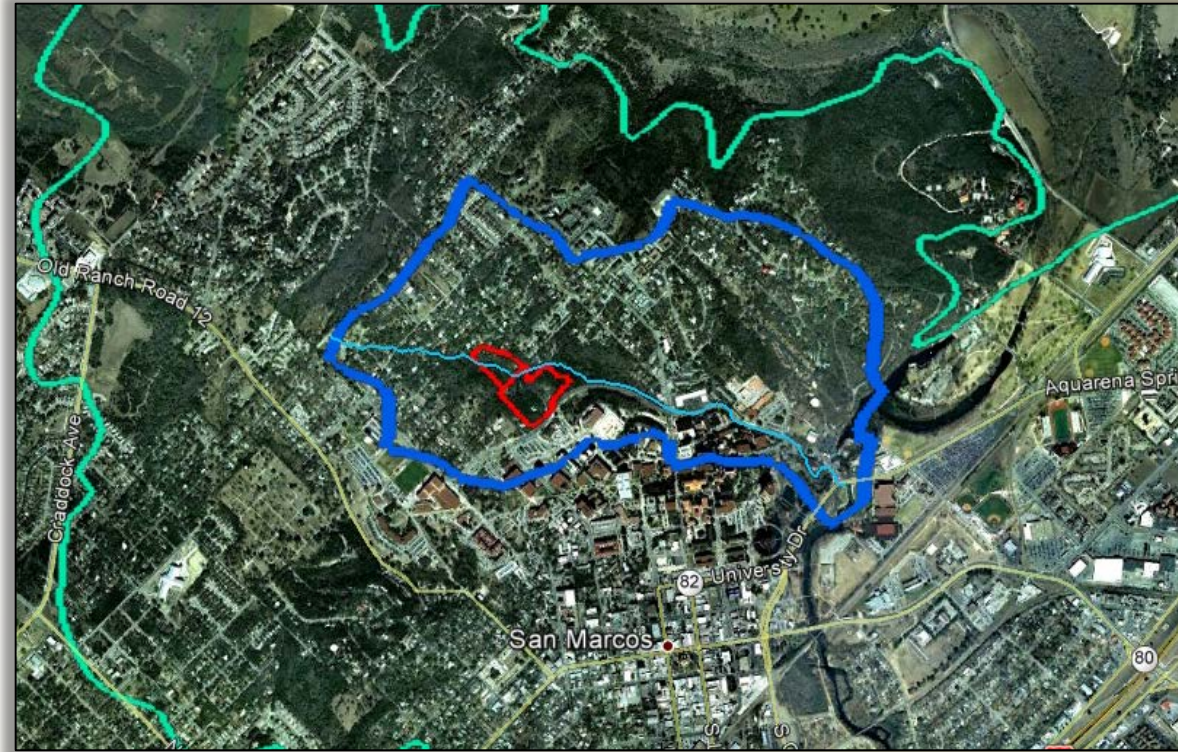
A proposed goal of the project is to characterize watershed and stream conditions, create sediment & constituent load rating curves, and understand physical factors (i.e. antecedent conditions) that contribute to those loads.

Data generated from the study would serve as a baseline for evaluating future upland improvements aimed at combating soil loss.



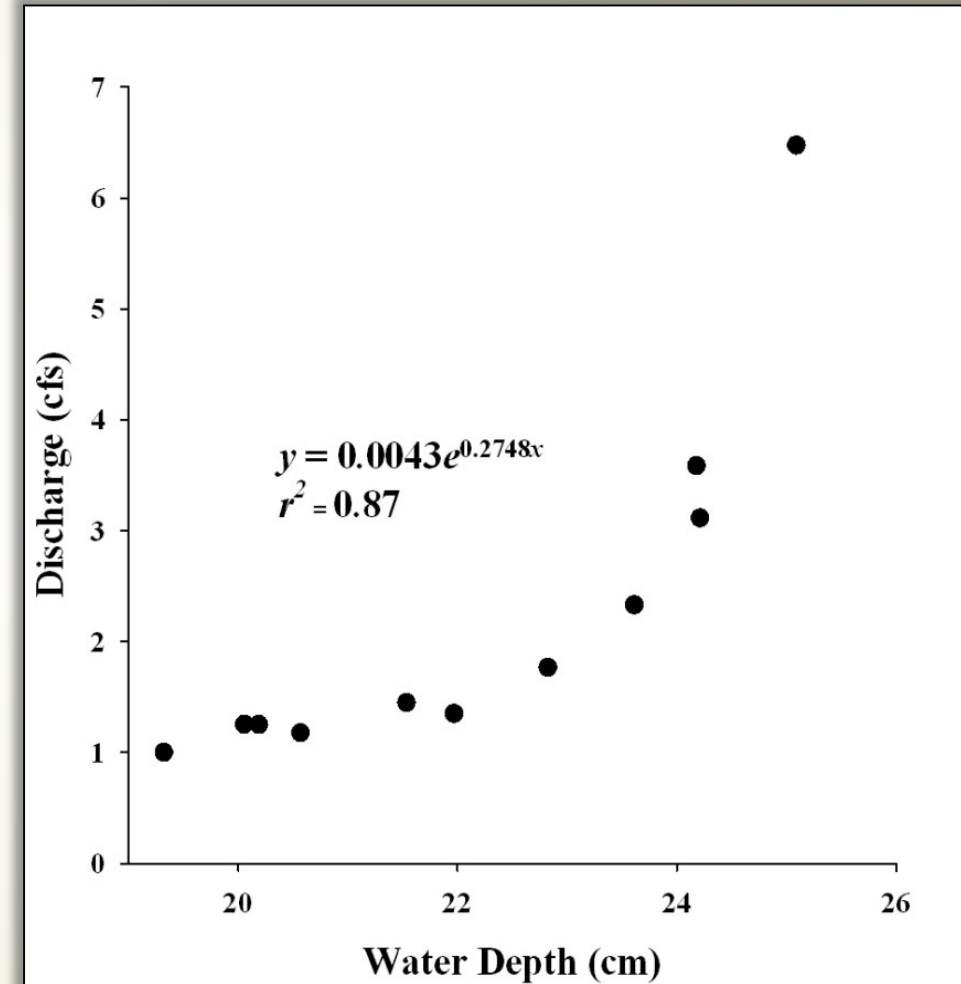
2018 - 2019 APPLIED RESEARCH SCHEDULE – *SESSOM CREEK*

- ▶ Potential Key Elements to project
 - ▶ Organize, document, & evaluate previous work conducted as part of SMOS, EARDC, WPP, WQPP, COSM, and MCWE
 - ▶ Provide a detailed physical description of the creek
 - ▶ Provide a detailed physical description of the watershed



2018 - 2019 APPLIED RESEARCH SCHEDULE – SESSOM CREEK

- ▶ Potential Key Elements
 - ▶ Set up flow gauge on Sessom Creek and continue to refine rating curve
 - ▶ Measure storm events along Sessom Creek using automated ISCO type samplers, and test samples for appropriate constituents
 - ▶ Develop loading curves
 - ▶ Examine the storm events and produced constituent loads with respect to storm mechanics and antecedent conditions



Water depth (cm) – Discharge (cfs) rating curve for the Sessom Creek gaging station.

2018 - 2019 APPLIED RESEARCH SCHEDULE – INVASIVES

- Evaluate success of removal of invasive animal species and reduction of introduction
- Proposed as part of 2015 Applied Research Work Group for 2019 Applied Research

2018	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48)
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	3. TBD	1. TBD/Contingency
	1. Conservation Measures	1. Evaluate success of removal of invasive animal species and reduction of introduction
2019		2. Evaluate success of Sessom Creek sand bar removal and sediment removal efforts
	2. TBD	1. TBD/Contingency

2018 - 2019 APPLIED RESEARCH SCHEDULE – LONG-TERM BIOLOGICAL GOALS

- Confirm species-specific Tables 4-1, 4-21
 - Proposed as part of 2015 Applied Research Work Group for 2018 Applied Research

2018	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
	2. Conservation Measures	1. Evaluate success of SAV restoration & TWR enhancement (coincides w/ 5 yr SAV mapping) (NAS 44, 47, 48)
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2018 - 2019 APPLIED RESEARCH SCHEDULE – LONG-TERM BIOLOGICAL GOALS

- ▶ Section 4.1 of the HCP contains the “Long-Term Biological Goals and Objectives”
- ▶ “Long-term biological goals are the rationale behind the minimization and mitigation strategies and, conversely, minimization and mitigation measures are the means for achieving the long-term biological goals and objectives.”
- ▶ Table 4-1 and 4-21 detail the habitat based and population measurement goals for the Fountain Darter in the Comal and San Marcos Rivers, respectively. These tables were redrafted per recommendations from SAV Non-Routine Adaptive Management



Fountain darter habitat (aquatic vegetation) in meters squared (m ²)							TOTAL
Study Reach	Bryophytes	<i>Potamogeton</i>	<i>Ludwigia</i>	<i>Cabomba</i>	<i>Sagittaria</i>	<i>Vallisneria</i>	
Upper Spring Run	1,750		25	25	850		2,650
Landa Lake	3,950	25	900	500	2,250	12,500	20,125
Old Channel	550		425	180	450		1,605
New Channel	150		100	2,500			2,750
Total	6,400	25	1,450	3,205	3,550	12,500	27,130
Fountain darter median density (number/m ²)							
	Bryophytes	<i>Potamogeton</i>	<i>Ludwigia</i>	<i>Cabomba</i>	<i>Sagittaria</i>	<i>Vallisneria</i>	TOTAL
	20	3.3	7	7	1	1	
# darters * veg total	128,000	83	10,150	22,435	3,550	12,500	176,718

Fountain darter habitat (aquatic vegetation) in meters squared (m ²)							TOTAL
Study reach	<i>Ludwigia</i>	<i>Cabomba</i>	<i>Potamogeton</i>	<i>Sagittaria</i>	<i>Heteranthera</i>	<i>Zizania</i>	
Spring lake Dam	100	50	200	200	100	700	1,350
City Park	150	50	1,450	300	100	1,750	3,800
IH-35	50	50	150	150	50	600	1,050
Total	300	150	1,800	650	250	3,050	6,200
Fountain darter median density (number/m ²)							
	<i>Ludwigia</i>	<i>Cabomba</i>	<i>Potamogeton</i>	<i>Sagittaria</i>	<i>Heteranthera</i>	<i>Zizania</i>	TOTAL
	7	7	5	1	5	5	
# darters * veg total	2,100	1,050	9,000	650	1,250	15,250	29,300

REVISED LONG-TERM BIOLOGICAL GOALS FOR FOUNTAIN DARTERS

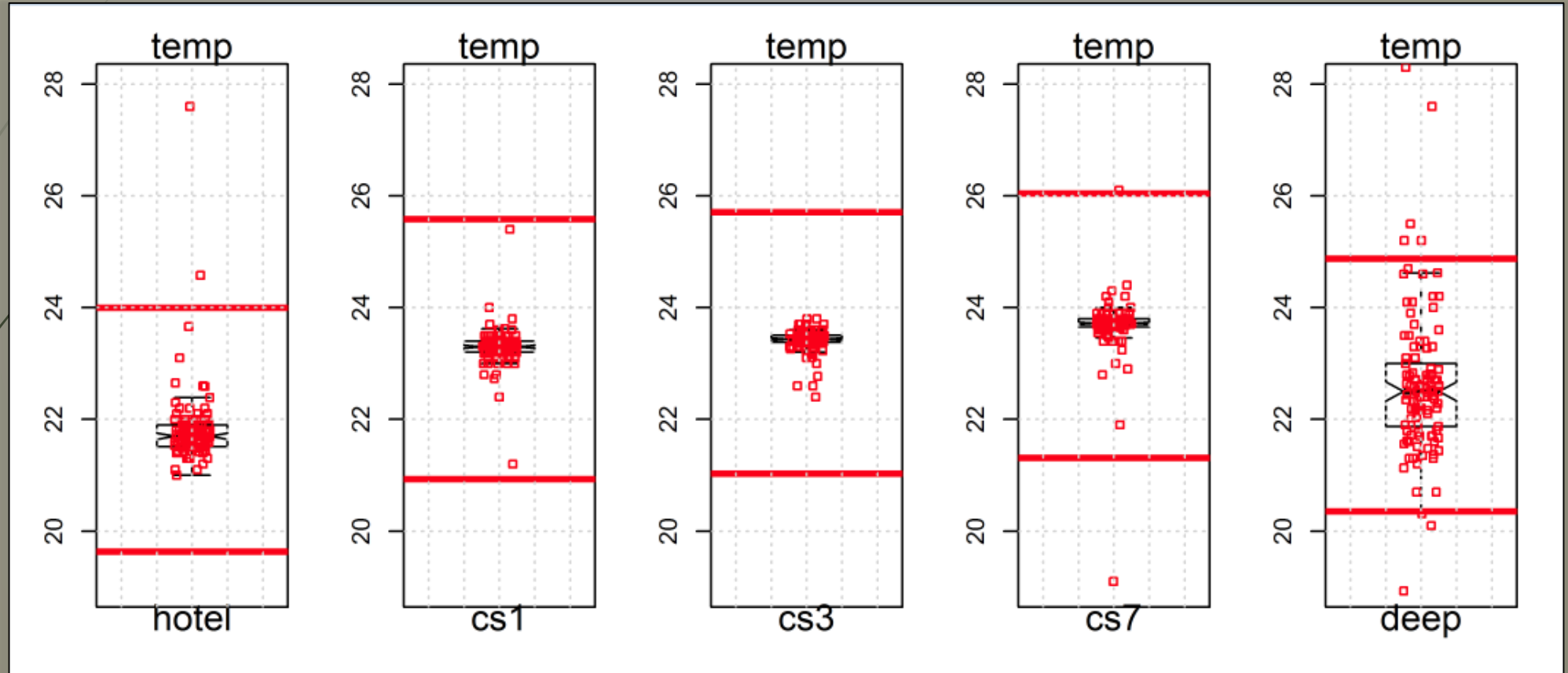
BIO-WEST and Watershed Systems Group, 2016. Submerged Aquatic Vegetation Analysis and Recommendations, 145 pp. Available online at: http://www.eahcp.org/index.php/administration/adaptive_management

2018 - 2019 APPLIED RESEARCH SCHEDULE – LONG-TERM BIOLOGICAL GOALS

- To achieve LTBGs for several species, Key Management Objectives concerning acceptable deviation from historically recorded water quality conditions are outlined. Thresholds on dissolved oxygen and temperature are also defined. As part of the 2016 Water Quality Work Group, datasets from which the *average* historic water quality conditions would be calculated are defined.

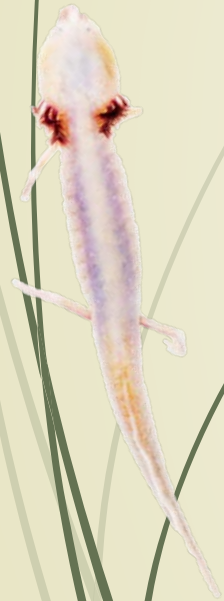
Species Type	Data Source	Comal River Ecosystem	San Marcos River Ecosystem	Justification
Fountain Darter	<i>Variable Flow study Fountain Darter Drop-net Sampling, 2000-2012 (biannual)</i>	<ul style="list-style-type: none"> Upper Spring Run Landa Lake Old Channel Reach New Channel Reach 	<ul style="list-style-type: none"> IH-35 City Park Spring Lake Dam; initiated in 2013 	<ul style="list-style-type: none"> Long-term Consistent with EAHCP Measurements taken at multiple water column levels, including sediment-interface, which is to be used for Fountain Darter analysis.
Comal Springs Riffle Beetle, Comal	<i>EAA monitoring data of Comal spring openings</i>	<ul style="list-style-type: none"> Spring Run 1 Spring Run 3 Spring Run 7 		<ul style="list-style-type: none"> Long-term
Springs Dryopid Beetle, Peck's Cave Amphipod				
Texas Blind Salamander	<i>EAA monitoring data of Spring Lake spring openings</i>		<ul style="list-style-type: none"> Deep Spring Hotel Spring 	<ul style="list-style-type: none"> Long-term

2018 - 2019 APPLIED RESEARCH SCHEDULE – *LONG-TERM BIOLOGICAL GOALS*



Temperature data from EAA monitoring of spring openings (1993-2016)

SUMMARY OF LTBGs AND KEY MANAGEMENT OBJECTIVES



Covered Species	Biological Goal(s)	Key Mgmt. Objective(s)	Comments
Fountain Darter	Maintain \geq median densities darter/veg type observed over past 10 years in Variable Flow (quantified by proxy through areal SAV coverage)	<ul style="list-style-type: none"> Active SAV restoration and protection in LL and OC (per reaches defined in 2016 AMP) 10%-rule on base flow WQ Water temps $<25^{\circ}\text{C}$ DO >4.0 mg/L 	Areal coverage of SAV (habitat) within 4 (Comal) and 3 (SM) representative reaches
Comal Springs Riffle Beetle	<ul style="list-style-type: none"> Maintain silt-free habitat conditions throughout 3 samples reaches (via indirect Measures) Maintain \geq median densities beetle/lure observed over past 6 years in Variable Flow 	<ul style="list-style-type: none"> Active riparian restoration adjacent to Spring Run 3 and Western Shoreline 10%-rule on spring openings WQ 	Beetle/lure densities as measured at Spring Run 3, Western Shoreline, and Spring Island area
Comal Springs Dryopid Beetle	<ul style="list-style-type: none"> 10%-rule on spring openings WQ Table 4-2 spring flows 	-	Species considered largely subterranean and little known; hence goals limited to WQ and flow
Peck's Cave Amphipod	<ul style="list-style-type: none"> 10%-rule on spring openings WQ Table 4-2 spring flows 	-	Species considered largely subterranean and little known; hence goals limited to WQ and flow
Texas Wild-rice	Areal coverage m^2 in 4 river segments (Table 4-10)	<ul style="list-style-type: none"> Minimum TWR areal coverage per segment during DOR-like conditions Recreation awareness throughout river at all flows with designated control below 100 cfs total discharge at sites per Table 4-12 Active restoration and expansion efforts and monitoring focused on high-quality habitat areas 	-
San Marcos Salamander	<ul style="list-style-type: none"> "Silt-free gravel and cobble substrate \geq 90% of each study area Maintain \geq median densities salamander/m^2 observed over past 10 years in Variable Flow 	<ul style="list-style-type: none"> Aquatic gardening similar to past 10 years efforts in Spring Lake will continue Recreation control eastern spillway, especially at total discharge of <100 cfs 	Maintain silt-free habitat conditions throughout 3 samples reaches (via indirect Measures). "Indirect Measures" are springflow, riparian protection, and recreation control.
Texas Blind Salamander	<ul style="list-style-type: none"> 10%-rule on Spring Lake spring openings WQ Table 4-13 flow objectives 	-	Species considered largely subterranean; hence goals limited to WQ and flow

2018 - 2019 APPLIED RESEARCH SCHEDULE – *LONG-TERM BIOLOGICAL GOALS*

➤ EAHCP staff suggests:

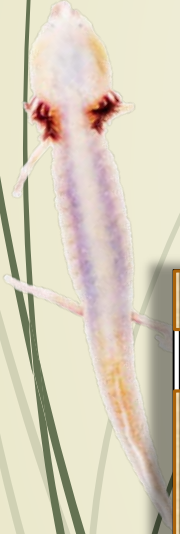
1. Comparing LTBGs with the data collected as part of the Biomonitoring program and
2. Calculating average historic water quality conditions recommended by the WQWG and comparing with data collected as part of the Biomonitoring program/ EAA monitoring.

➤ EAHCP staff suggest this as an internal project.



2018 - 2019 Applied Research Schedule - *Submerged Aquatic Vegetation (SAV)*

- ▶ Evaluate success of SAV restoration and TWR enhancement
- ▶ Proposed as part of 2015 Applied Research Work Group for 2018 Applied Research



	1. Habitat Quality & Requirements	1. Peck's Amphipod quantitative sampling techniques
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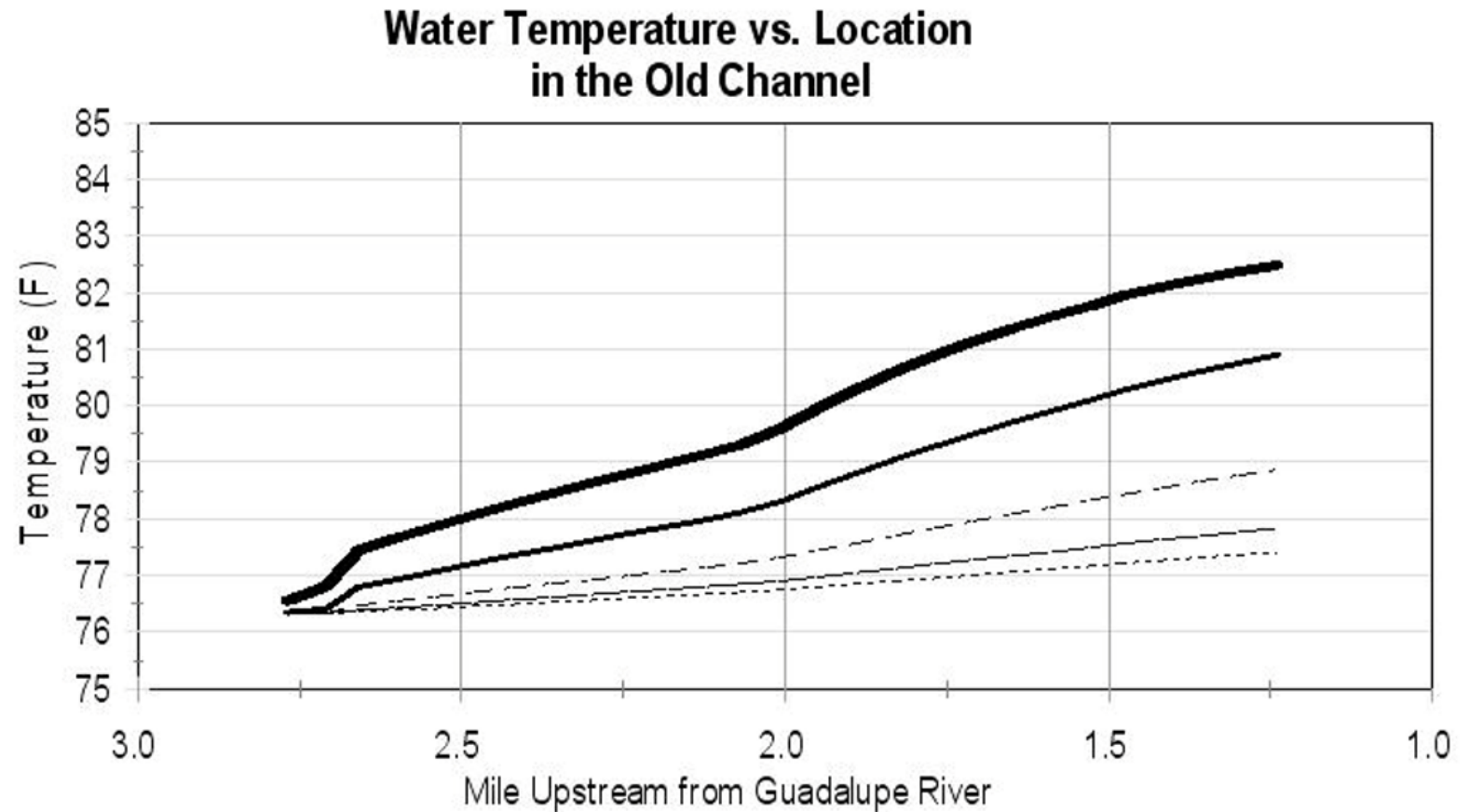
2018 - 2019 APPLIED RESEARCH SCHEDULE – *QUAL2E VALIDATION*

- ▶ QUAL2E temperature modeling validation
- ▶ As part of the technical assessment in support of the “J Charge” hydrodynamic modeling exercises were conducted to provide physical habitat modeling, construct habitat suitability curves, and develop water quality and temperature predictions under different modeling regimes (Hardy, 2009).
- ▶ Low flows experienced outside of the original model calibration range occurred during the 2011-2014 drought, and provide the opportunity to examine predicted temperature output with experienced temperatures during this drought period.

Hardy, T.B., 2009. Technical Assessments in Support of the Edwards Aquifer Science Committee “J Charge” Flow Regime Evaluation for the Comal and San Marcos River Systems. 159 pp. Available on line at: <http://www.eahcp.org/documents/Appendix%20D.pdf>



MODELED
TEMPERATURE VERSUS
RIVER MILE FOR OLD
CHANNEL UNDER
VARYING FLOW
REGIMES



..... Total = 300 cfs : Old channel = 75 cfs

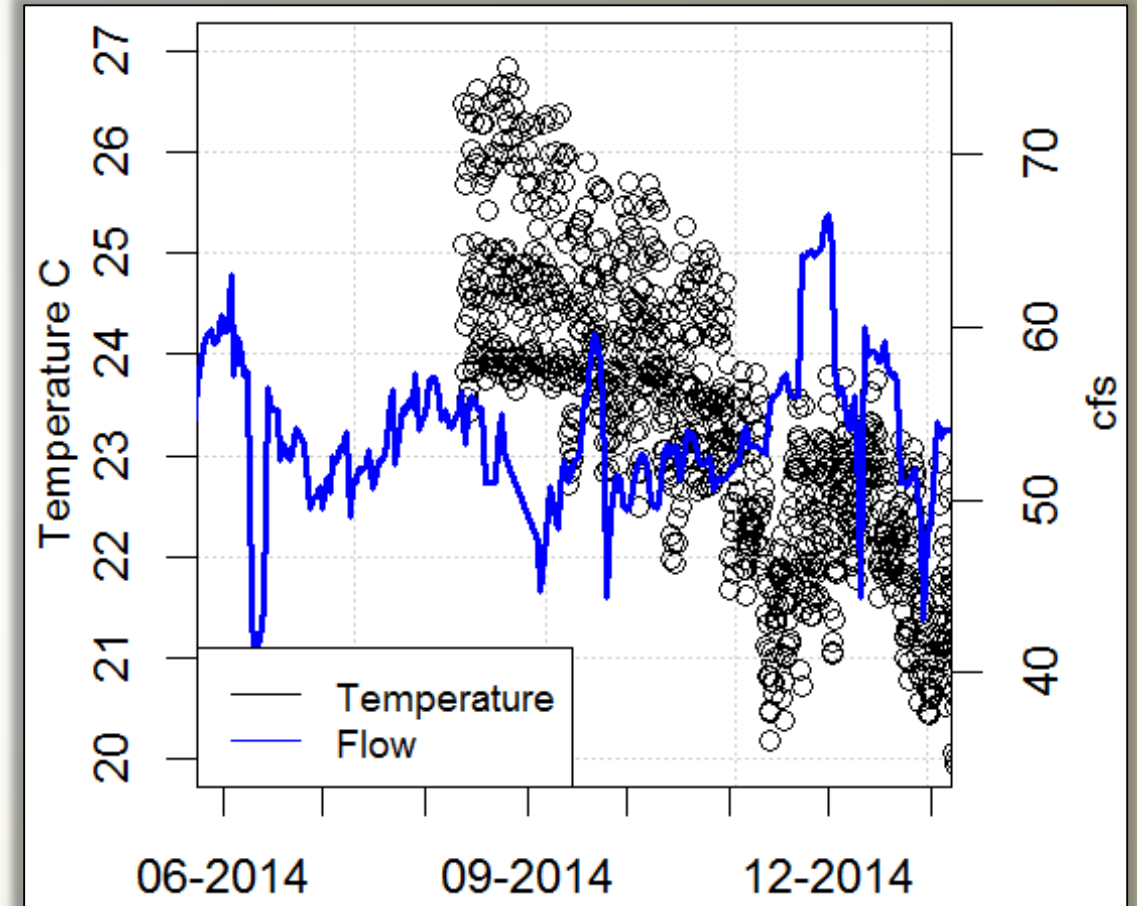
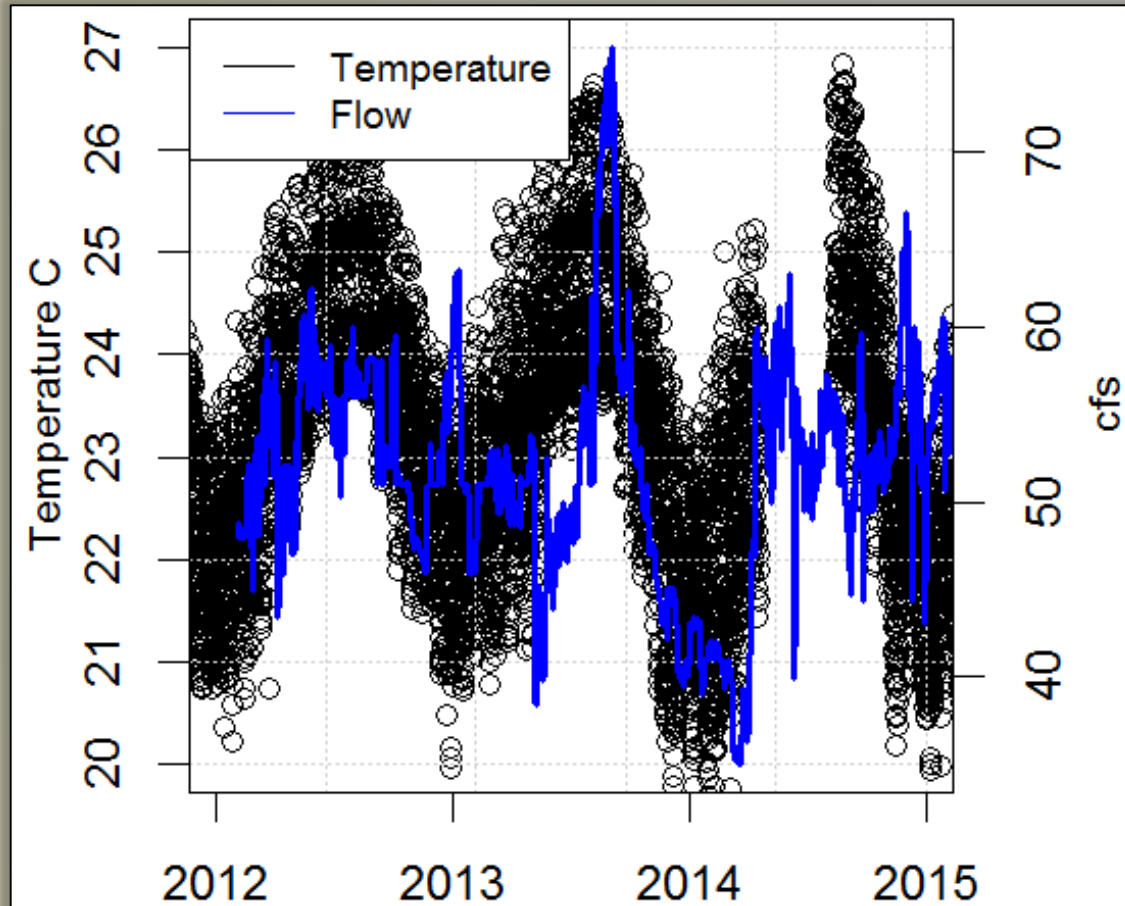
— — Total = 150 cfs : Old channel = 50 cfs

- - - Total = 100 cfs : Old channel = 25 cfs

—— Total = 60 cfs : Old channel = 10 cfs

———— Total = 30 cfs : Old channel = 5 cfs

2018 - 2019 APPLIED RESEARCH SCHEDULE – *QUAL2E VALIDATION*



Flow (GS-08168913) and temperature measurements along the Old Channel

2018 - 2019 APPLIED RESEARCH SCHEDULE – *QUAL2E VALIDATION*

- ▶ EAHCP staff recommend conducting this type of analysis throughout both systems to understand the validity of model assumptions related to temperature and flow.



2018 - 2019 APPLIED RESEARCH SCHEDULE - *DROUGHT*

- ▶ Debrief of the Edwards Aquifer 2011-2014 drought
- ▶ The state of Texas experienced prolonged drought from the Fall of 2010 through the Spring of 2015 (U.S. Drought Monitor). The drought during the calendar year of 2011 was the most intense one-year drought experienced since at least 1895 (Nielsen-Gammon, 2011).
- ▶ In 2014, the Comal system experienced the lowest flows recorded in a quarter century with surface habitat drying in numerous spring runs (BIO-WEST, 2015).

U.S. Drought Monitor, 2017. Supplemental Info – Maps and Data. Accessed March 2017. Available online at: <http://droughtmonitor.unl.edu/Home.aspx>

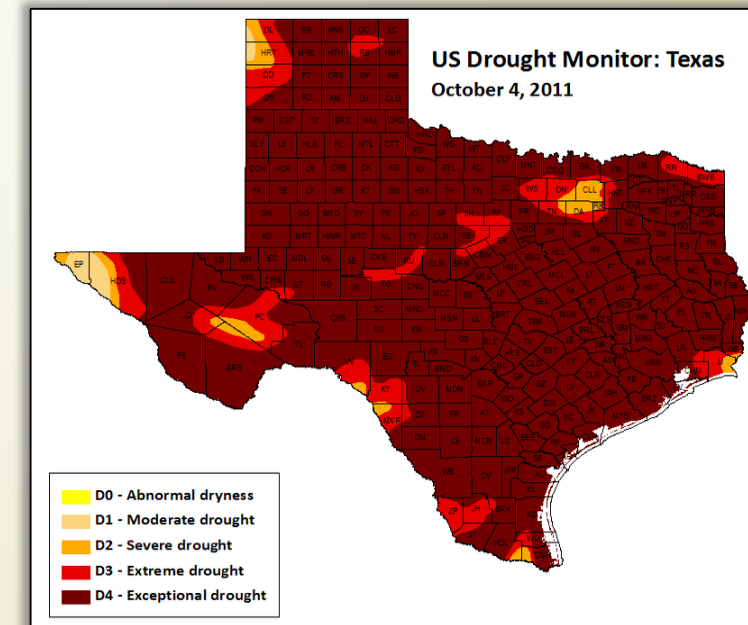
Nielsen-Gammon, 2011. The 2011 Texas Drought – A Briefing Packet for the Texas Legislature October 31, 2011. Available online at: climatexas.tamu.edu/files/2011_drought.pdf

BIO-WEST, 2015. Habitat Conservation Plan Biological Monitoring Program – Comal Springs/ River Aquatic Ecosystem – 2014. 276 pp.



2018 - 2019 APPLIED RESEARCH SCHEDULE - *DROUGHT*

- Purpose of project
 - Produce a document describing the hydrometeorological conditions that led the region into the drought and document instream flows/ biological impacts.
 - Examine the benefits provided by EAHCP spring flow protection measures
 - Serve as reference document under future drought conditions.
- Potential sections include
 - Meteorological patterns and rainfall
 - Surface and near surface hydrology
 - Groundwater hydrology and springflow
 - Instream flows and biology



2018-2019 Applied Research Schedule

Project	Action
Evaluate Success of SAV restoration and TWR enhancement	TBD – Examine 2018 full system mapping and consult SC
Statistical Analyses of EAHCP data	TBD – Examine 2017 App Research results and consult SC
EcoModel Research	TBD – Examine final EcoModel and consult with SC
Validate QUAL2E thermal modeling	Continue to scope project with intent to conduct Applied Research
Debrief of the 2010-2015 drought	Continue to scope project with intent to conduct Applied Research
Establish Sessom Creek loading curves	Continue to scope project with intent to conduct Applied Research
Evaluate Flow-Split Success	Monitor through biomonitoring program
Examine progress towards meeting Long-Term Biological Goals	Continue to scope project with intent to conduct Applied Research