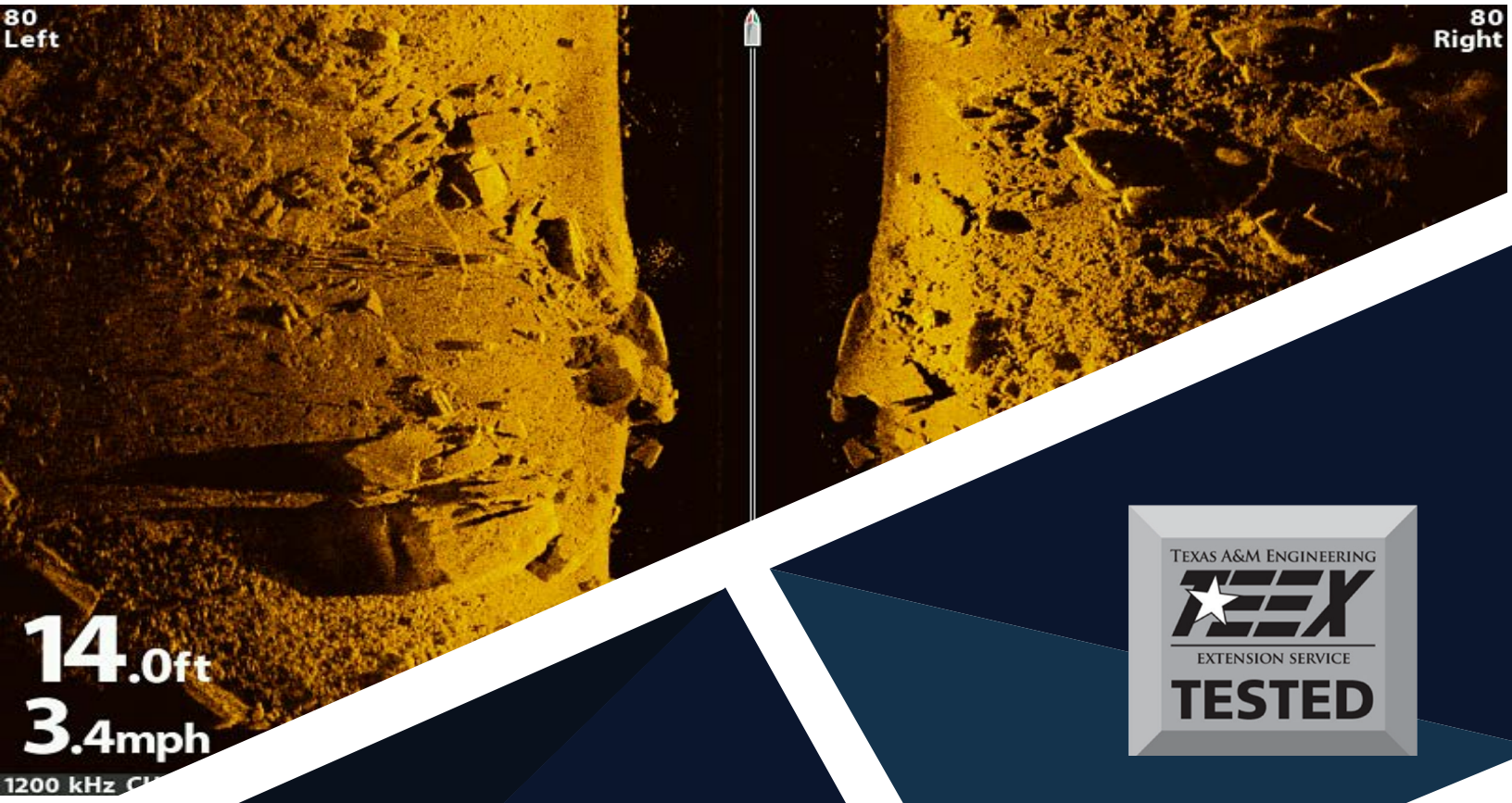


Texas A&M Engineering TEEX Extension Service TESTED

TEEX TESTED® Remotely Operated, Swift Water Rescue and Flotation Device with Autonomous Sonar Capabilities

HYDRONALIX

TEXAS A&M ENGINEERING EXTENSION SERVICE
PRODUCT DEVELOPMENT CENTER
200 Technology Way | College Station, TX 77845-3424
P.O. Box 40006 | College Station, TX 77842-4006
Toll-Free 800.541.7149 Tel. 979.458.6710 Fax 979.458.6727
www.teex.org

Hydronalix's E.M.I.L.Y. is a TEEX TESTED® Remotely Operated, Swift Water Rescue and Flotation Device with Autonomous Sonar Capabilities

Hydronalix's Emergency Integrated Lifesaving LanYard (EMILY) is a TEEX TESTED® Remotely Operated, Swift Water Rescue and Flotation Device with Autonomous Sonar Capabilities.

Hydronalix's Emergency Integrated Lifesaving LanYard (EMILY) was a selected winner into the Defense to Response Technology Transition Program (D2R), sponsored by the Domestic Preparedness Support Initiative (DPSI). Hydronalix has worked with Texas A&M Engineering Extension Service's Product Development Center (TEEX PDC) over the past 9 months to navigate the Think|Build|Sell process to navigate to public safety market. Hydronalix's EMILY is a TEEX TESTED® Remotely Operated, Swift Water Rescue and Flotation Device with Autonomous Sonar Capabilities.

EMILY is a TEEX TESTED® Remotely Operated, Swift Water Rescue and Flotation Device that successfully navigated and hovered in 80,000 GPM current moving 4.67 MPH

EMILY was deployed in multiple exercises throughout the Spring of 2019 and the sonar showcased its capabilities finding a car, boat and even a body. The Sonar capability introduced new markets for Hydronalix in Department of Transportation Agencies and major water way shippers.

All swift water testing was executed on June 10th, 2019 at the Tarrant County College Swift Water Training facility in Ft. Worth, Texas. The testing facilities provided multiple scenarios for evaluation including a channel section to simulate fast moving water with underwater obstructions creating uneven water surfaces. A low head dam was also used for testing both above and below the dam.

Sonar EMILY Testing and Scenarios

TEEX PDC had the privilege of working with Paige Day, Director of Sales at Hydronalix throughout the entire D2R program. Spring of 2019 proved to be an active and engaging period for the EMILY to showcase its newest capabilities with the Hummingbird Side Sonar. Additionally, Mrs. Day delivered and trained major clients on their new EMILYs, notably:

- New York Fire Department, February 2019
- Austin Fire Department's RED Team, March 2019
- Michigan Department of Transportation, April 201

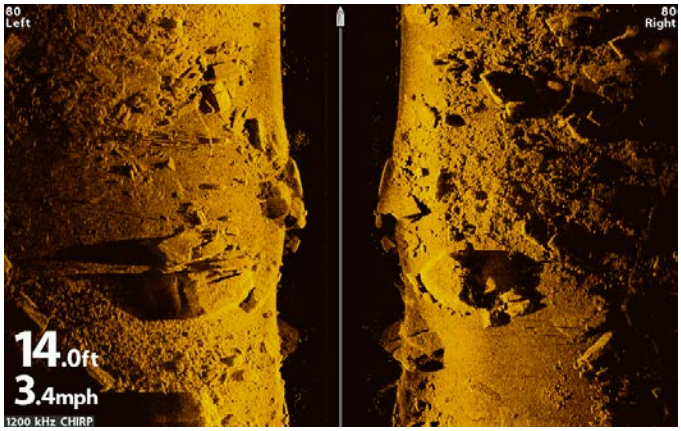
Figure 1: AFD RED Team, March 2019

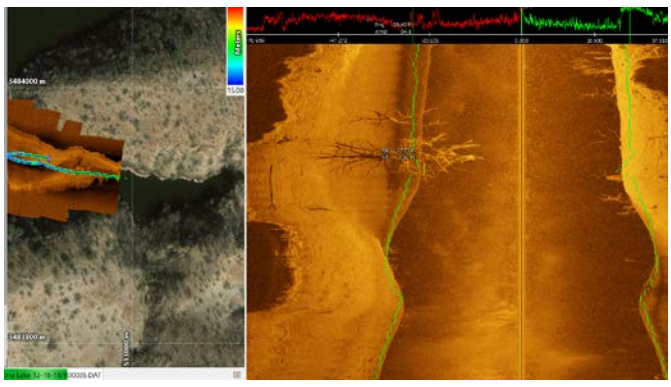
Figure 2: FDNY, February 2019

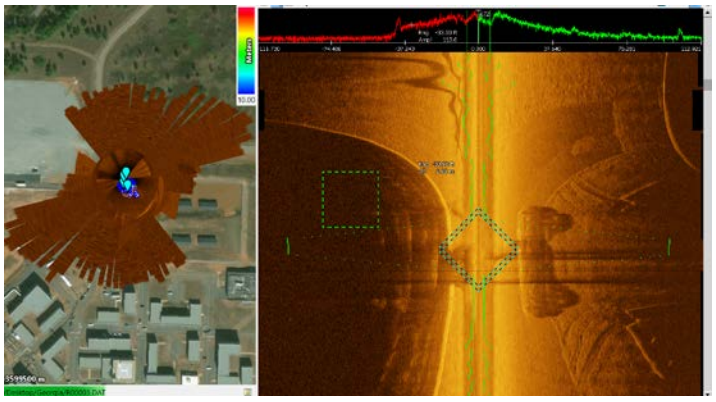
Figure 3: MDOT, April 2019

EMILY was included in scenarios and events that included Under Fire | Response Innovation Showdown, the Camp Creek Exercise and Winter Institute with the Center for Robot-Assisted Search and Rescue. Additionally, with an introduction from TEEX PDC, Hydronalix sponsored the U.S. Lifesaving Associations' Annual Conference in San Antonio, Texas in April 2019. Through these different scenarios and exercises, Sonar EMILY showcased its versatility and value proposition locating a boat, car and even a body.

Figure 4: Car located at bottom of Disaster City® Lake







TEXAS A&M ENGINEERING EXTENSION SERVICE
PRODUCT DEVELOPMENT CENTER
200 Technology Way | College Station, TX 77845-3424
P.O. Box 40006 | College Station, TX 77842-4006
Toll-Free 800.541.7149 Tel. 979.458.6710 Fax 979.458.6727
www.teex.org

Swift Water Rescue and Flotation Device Testing

Tarrant County College's Swift Water Rescue Training Facility hosted EMILY's Swift Water and Flotation Device testing. The water delivery system was adjustable and measured in percentage of capacity. Full capacity of the water delivery system was 80,000 gallons at 100 percent. Water velocity was measured using a Hach Portable Velocity Meter (Model FH905.1) by taking multiple measurements along the test area, 1 foot below the surface, and averaging the speed across that area.

Hydronalix completed testing at Tarrant County College on June 10th, 2019. In both scenarios the Hydronalix's EMILY performed maneuverability testing and was able to complete the expected requirements. EMILY was able to travel upstream and hover against a 4.67 mph current while maintaining control.

Testing Scenarios

TEEX PDC and Hydronalix agreed to all testing procedures for all testing prior to each scenario. Initial testing plan is made available as **Attachment A** to this report.

Testing Conditions – The swift water training facility was operating properly with no issues. Maximum capacity was 80,000 gallons per minute through the channel to the bottom of the low head dam. The overall facility is 561 feet long, however only smaller sections were used for the testing area. The channel section was 65 feet long and an average of 10 feet wide. The bottom of the low head dam was 30 feet by 30 feet for the testing area.

Channel testing area

Below low head dam testing area

Temperature – 70 at 7:30 am to 81 degrees at 3:00 pm, full sun.

Winds – From the North 10-15 mph

Humidity – 60% at 7:30 am

Channel Scenario – EMILY began down stream of the testing area and proceeded up stream against the current. Three tests were conducted at each level of water velocity. The first test was a speed test to navigate the channel at best speed. The second test was a lower speed test to evaluate maneuverability through the test area. The third test was a station keeping test, entering the test area and maintaining position in the channel, performing lateral movements on station in the channel and then accelerating out of the channel.

Three test velocities were initially identified prior to testing. The first test at 40% would be the initial test to determine relative capability against that flow rate. This number was used because it is typically the lowest setting utilized in swift water training courses conducted on this prop. The second level was 83% capacity, which is the standard capacity utilized by Tarrant County for swift water training. The final level was 100% capacity, which is the full volume of the system capable of delivering through the system safely. This maximum level is also used in swift water training by the College. All three are representative of varying conditions found during real world swift water events.

Low head dam Scenario – Conditions below the low head dam, specifically in the boil, were used to determine capability and maneuverability in an area of significant aeration of the water. Four tests were conducted to demonstrate a rescue scenario of a victim trapped in the boil directly below a low head dam.

The first and second tests were conducted similarly, with the only variable being the volume of water over the dam. The first test was at 83% capacity, or 66,400 gallons per minute. The second test was conducted at 100% capacity or 80,000 gallons per minute. In both tests, EMILY entered the area and maneuvered to determine the quality of control and potential for an effective rescue before proceeding to the third and fourth tests utilizing a rescue swimmer.

The third test was conducted without a tether line attached to EMILY to determine the capability of the unit to enter, approach and act as a flotation device for a victim. An optional portion of the test was to remove the victim from the boil under power. This test

was conducted with the understanding that the EMILY is not marketed or described as capable of removing a victim from the scenario under its own power.

The fourth test was conducted with a tether line attached, as identified in EMILY documentation and training. This test more closely resembled the intended use of the EMILY in the scenario. The EMILY entered the boil, approached the victim, acted as a flotation device for the victim and the tether line was utilized to remove both the victim and EMILY from the test area.

Test Scenario Observations

Testing on both the channel and the low head dam were conducted successfully. Observations were made by TEEX staff as follows:

Test #1 - Channel:

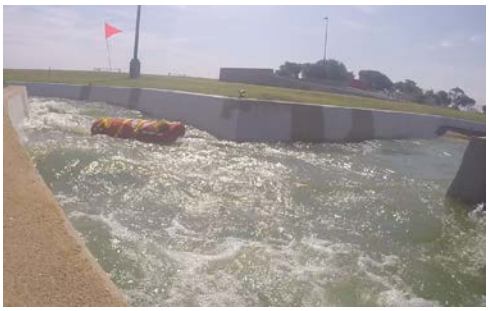
- Pump – 40%; 32,000 gallons per minute; 71.3 cubic feet per second; 4.7 feet per second water velocity (3.2 mph/5.15 km/h).
- Run 1 - EMILY performed well against the current. No significant control issues, a few minor issues against swift water features.
- Run 2 – effective control, but very affected by swells and other swift water features
- Run 3 – Station Keeping - effective control, some stability issues on features
- Summary – EMILY was able to navigate and advance effectively against this current level. The v-bottom hull may have played a role in the influence of swift water features on the navigation of the boat.

Test #2 - Channel:

- Pump – 83%; 66,400 gallons per minute; 117 cubic feet per second; 5.68 feet per second water velocity (3.87 mph/6.23 km/h).
- Run 1 – first attempt EMILY was unable to overcome instability against water features to advance through the test. Second attempt was able to advance but continued to struggle with standing wave. Second run utilized a more controlled and maneuver based approach, capitalizing on the S-Turn requirement to navigate the water features to advance. Maintained power and forward movement throughout test.
- Run 2 – Station Keeping – finessed through the standing wave, had no issuing advancing through the test area.
- Summary – At this volume/velocity of swift water, EMILY required much more coordination of movement through the water features

than power alone. A finessed, managed approach, transition and exit provided for a quick movement through the test area. Any attempt to power through the area was met with uncontrolled departures from initial heading and several seconds to reestablish control. These are very valuable observations as training can be focused on proper navigation and throttle use for effective navigation.

Test #3 - Channel:



- Pump 100%; 80,000 gallons per minute; 178 cubic feet per second; 6.85 feet per second water velocity (4.67 mph/ 7.52 km/h).
- Run 1 – full throttle run test failed. Reduced throttle and forward velocity provided marked improvement in control and was able to complete test. The second attempt required the use of maneuvering (s-turns) and as such accomplished the second run of the test per the testing plan.
- Run 2 – Station Keeping – was able to hold position and maneuver, did have difficulty navigating certain features such as the standing wave. Maneuvering to a better approach around this feature was beneficial and allow for advancement and completion of the run.
- Summary – It was very apparent from the channel testing that EMILY is much better at partial throttle maneuvering against the current. At 6.85 feet per second, the EMILY was able to advance rapidly enough to remain effective for rescue.

Test #4 – Low Head Dam:

- Pump 83%; 66,400 gallons per minute.
- Water above dam velocity – 11.87 feet per second (8.09 mph/ 13.02 km/h)
- Run 1 – EMILY was able to enter boil area and maneuver. Propulsion had difficulty in areas of high aeration of the water as expected. Operator made multiple passes through boil area to identify maneuverability tactics and limits of unit in various water features.
- Summary – EMILY was able enter the boil and maneuver effectively. This test provided valuable information on maneuverability within areas of high aeration of water. It was shown that EMILY is most effective under power moving across areas of aeration, using the momentum of unit to cross and regain thrust on the other side of boil.

Test #5– Low Head Dam:

- Pump 100%; 80,000 gallons per minute.
- Water above dam velocity – 13.47 feet per second (9.18 mph/ 14.78 km/h)
- Run 1 – EMILY was able to enter boil area quickly and maneuver effectively. Higher volume of water did create larger boil area and affected maneuverability to a greater degree than observed in Test #4. Test provided more intelligence on the conditions for maneuverability and observing areas of control for EMILY prior to victim tests.
- Summary – EMILY was able enter the boil and maneuver effectively. The aeration of the water was shown to have a significant effect on propulsion and should be incorporated into training for effective operators.

Test #6 – Low Head Dam:

- Pump 100%; 80,000 gallons per minute.
- Water above dam velocity – 13.47 feet per second (9.18 mph/ 14.78 km/h)
- Run 1 – Rescue – No Tether Line – EMILY was able to enter boil area quickly and approach victim. Victim was able to make contact and hold on to EMILY until other measures could be taken to perform a rescue. When EMILY entered the area immediately below the dam, the operator was unable to exit the area due to the force of the water holding the unit in place.
- Summary – EMILY was able enter the boil and maneuver effectively to a struggling victim. While this test did not utilize a tether line as recommended by Hydronalix, it did prove the capability of the EMILY to act as a flotation device for a victim. The EMILY operator did attempt to use the motor to perform the rescue, the aeration of the water did not provide enough power to overcome the water's effect on the victim and the victim could not be effectively rescued.

Test #7 – Low Head Dam:

- Pump 100%; 80,000 gallons per minute.
- Water above dam velocity – 13.47 feet per second (9.18 mph/ 14.78 km/h)
- Run 1 – Rescue – Tether Line – EMILY was able to enter boil area smoothly and approach victim. Victim was able to make contact and hold on to EMILY. Once the victim had a grasp on EMILY, the tether was utilized to pull both EMILY and victim out of test area. Rescue was effected by one operator.
- Summary – EMILY was able enter the boil and maneuver effectively to a struggling victim. This test utilized a tether line attached to EMILY prior to launch, as recommended by Hydronalix. This is the most effective method to rescue a victim from the given scenario utilizing the EMILY.

Summary of Results

The testing conclusively determined the EMILY could operate at water velocities of 6.85 feet per second (fps) or 4.67miles per hour (mph). This was measured with the system at 100 percent capacity or 80,000 gallons per minute (gpm).

In addition, EMILY performed maneuverability and station keeping tests at various water flows to demonstrate the ability to work against significant currents and maintain control.

Finally, EMILY was able to operate below a 15-foot low head dam at full capacity and retrieve a victim from the area known as the boil.

Figure 5: Hydronalix's Robotic Command Vehicle at Tarrant County College's Swift Water Training Facility, June 2019

Attachment A:
Hydronalix Testing Plan

June 10th, 2019

Objectives

- Obtain swift water speed capabilities – objective water speed calculations
  - Channel swift water
  - Low Head Dam
- Obtain still water towing capability – one person across still water
- Obtain Subjective maneuverability data
  - Channel swift water
  - Low head dam
  - Eddies, transitions, etc.
  - Towing capacity against current (if time allows)

Deliverables

- Test Data
- Media of Testing
- Written Testing Report

TEEXPDC.COM/D2R

Testing Protocol – Channel

- Set flow rate and stabilize speed
- Obtain measurement of water velocity in channel
- Have Emily proceed up stream against current
- Emily must maintain forward momentum against current with aid to successfully complete
- Water velocity measurement will be recorded for each established flow rate.
- One failure will constitute a retest. Second failure will constitute inability to complete test

Example of channel at test facility

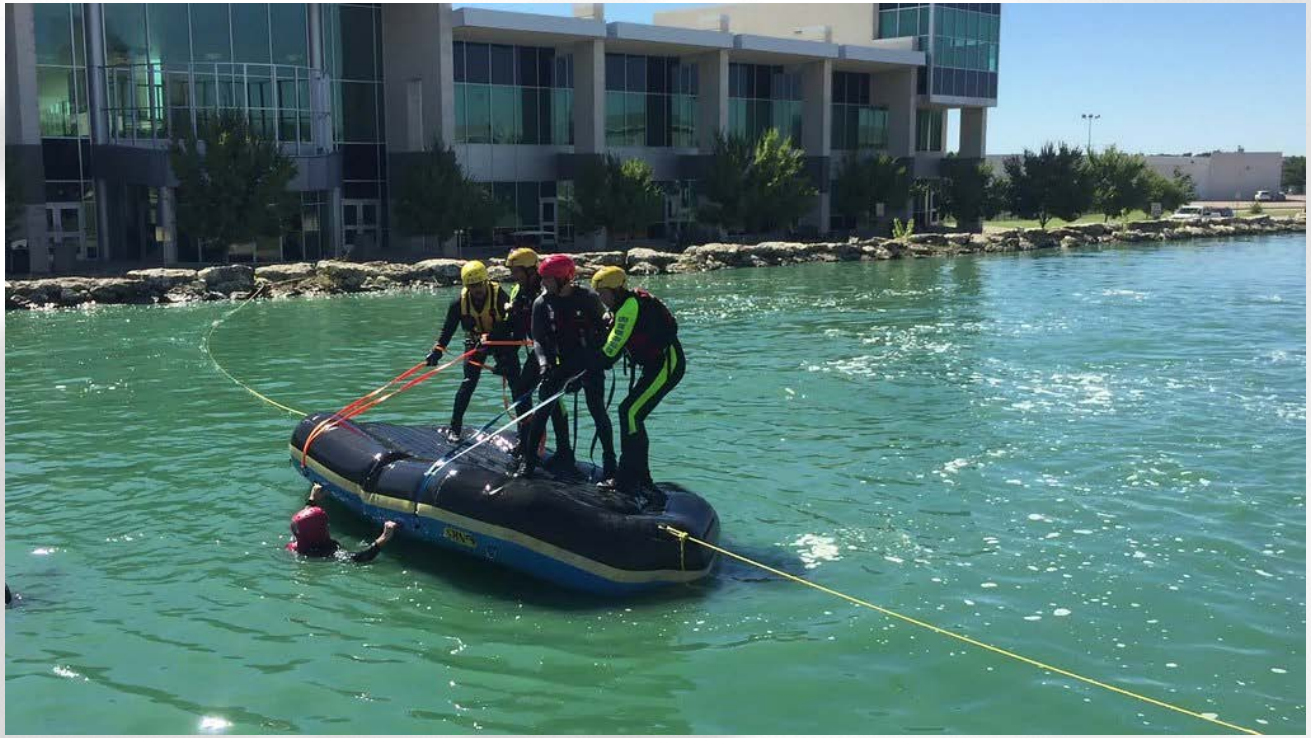
Testing Protocol – Low Head Dam

- Set flow rate and stabilize speed
- Obtain measurement of water velocity in channel
- Have Emily proceed up stream against current below the dam
- Emily must maintain forward momentum against current without aid and cross the dam with momentum to successfully complete
- Water velocity measurement will be recorded for each established flow rate.
- One failure will constitute a retest. Second failure will constitute inability to complete test

Example of low head dam at test facility

Testing Protocol – Still Water Towing

- Establish a victim in water
- Emily approaches victim
- Victim grabs Emily
- Emily drags victim to entry/exit point in still water area to complete test
- Subjective assessment of capability from perspective of rescuers and victim
- One failure will constitute a retest. Second failure will constitute inability to complete test



Example of still water area at test facility

TEEXPDC.COM/D2R

Testing Protocol – Subjective Maneuverability Testing

- Establish flow rate/velocity
- Emily will maneuver through test area to complete three objectives:
  - Perform 2 complete S turns through test area
  - Enter area at speed, reduce speed to maintain station keeping (match water velocity to hold position), increase speed to exit testing area
  - Perform 2 lateral passes while station keeping across the test area. Passes can be independent of each other.
- Low head dam – Emily will be tested for station keeping immediately above and below the low head dam, not on the dam spillway itself.
- Special Condition areas – Eddies/transitions/etc.
  - Verification of the ability to enter, operate in and exit special condition areas
- Rescue (If time and functionality allows)
  - See Still Water Towing for procedure
  - Rescue from Special Condition Areas
  - Rescue from current
  - Rescue from low head dam


TEXAS A&M ENGINEERING
TEEX
EXTENSION SERVICE
PDC
D2R
DEFENSE TO RESPONSE
TEEXPDC.COM/D2R

www.teexpdc.com

@teexpdc