# Fast, Effective & Economical :
# Asia and Malaysia's 1st Re-directive Solutions for Riverbank Repairs and Water Detention at Sg Pedu, Kedah for agriculture needs in dry season

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Water is the "life-blood" of all humanity. More so in farming communities where water and its distribution is key especially during dry seasons when it is desperately needed to "soak" the fields for the padi growing season. Rivers play an important role by conveying waters to where it is needed and help channel waters to alleviate flooding during the rainy season. At times "artificial barriers" are built across certain sections of the river to provide water storage during the dry season where flows are low. The appropriate design is critical for its sustainability and "good health" of the river.

**Background**

Project site is located in the northern State of Kedah, Malaysia,70km east of Alor Setar, and within 20 minutes to Thailand border.

Project is funded by the Malaysian Drainage and Irrigation Department of Kedah (JPS) to address "pressing issues" of Sg. Pedu riverbank protection and water detention for padi field's growing needs at the Bukit Sena Irrigation Scheme.

Pump house was built alongside Sg. Pedu at 38 km downstream from Pedu Dam several years back to provide water to the Bukit Sena irrigation scheme. It was noted that the over the years, water level has receded during the dry seasons to below the "safe level" of the water pump intake thereby diminishing its function.

A multi-level gabion barrier was constructed across the river at downstream of the pump intakes to provide (2m) depth of water detention to facilitate the pumping needs. However, problems develop during high waters in the rainy season when erosive forces were deflected by the gabion barriers across the river, "scouring away" land on the adjacent riverbank. The situation is further aggravated when waters are discharged from the Pedu Dam especially during the rainy season.

Rock revetment was employed at eroded riverbank sections which resulted in further riverbank erosion both at location and at downstream of repairs possibly attributed many factors including poor rock gradation, installation site control and the possibility of the development of secondary river currents during high flows from energy deflections as a result of "deepening from centrifugal friction cells" (research by Rob Davinroy, St. Louis).

**Objectives and Scope of Work**

It was becoming clear that this "site needs" are:

1) sustainable riverbank repairs to halt the loss of orchard land,
2) provide (2m) water detention downstream of pump house during dry season to enable irrigation and community water needs,
3) return this section of river back to its natural "proper function condition" (PFC),

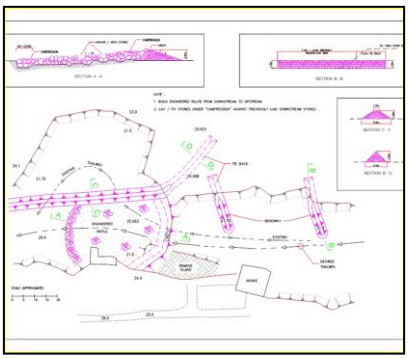
This paper presents the first application of "Re-directive Method" in Malaysia and possibly Asia. It shares experiences and knowledge learnt in building the first "Newbury Rock Riffle", "Bendway Weir" and "Longitudinal Peak Stone Toe Protection (LPSTP)" structures at this JPS project to provide multipurpose solutions at river section located at Bukit Sena Pump Station, Sg. Pedu, Kedah, Malaysia.

The project scope includes providing (2m) height of water detention to facilitate water intake during dry flows at the river section with application of an engineered "Newbury Riffle" that is stabilized during high and turbulent flows, riverbank toe protection with "Longitudinal Peak Stone Toe Protection(LPSTP)" for riverbank toe stability and installation of "Bendway Weirs" to redirect erosive forces (thalweg) away from the

eroded riverbank resulting in riverbank "self-healing" process. The resulting Thalweg is re-positioned away from the eroded riverbank and flow onto the stabilized Newbury Rock Riffle at lamina flow.

**Technical data:**
Engineered Newbury Riffle Structure (NCHRP Report 544): Length 40+m(ends 10+2)m; Structure height, rise from downstream bed to 2.0m high upstream and Width downstream-60+m --to-- upstream-30+m at crest weir.
Bendway Weir Structure: Length 9.5+m x trapezoidal section C-C with Tie-back Anchor Structure: Length 4.5+m x triangular section D-D. Longitudinal Peak Stone Toe Protection (LPSTP) Structure: Length 60+m x trapezoidal section C-C with Tie-back Anchor Structure: Length 35+m x triangular section D-D.

Other techniques highlighted were the application BMPs in water quality monitoring and improvement with Polymer Enhanced BMP.
A (1) day Training and Site visit was arranged to provide technology sharing and transfer to all engineers of JPS Kedah.



**Work Methodology**

**Start Work:** JPS Kedah and MADA were very cooperative throughout the construction. Water levels were kept to the minimum levels for positive construction and progress except when waters were needed to be released for downstream agricultural needs at certain periods, notification were given prior and alternative work conducted during these "off-days".

Project start-work was at 1st week of August 2014 with site visits to rock quarry to ascertain on rock sizes and their availability and confirmation of suitable sizes and quantities of rock for the project. A site visit was made to identify and confirmation on type and availability of construction equipment to be utilize at site.

**Material & Equipment Site Visits:** It was confirmed that the largest rock gradation shall be in vicinity (1) ton as delivery trucks for larger rocks are not locally available and site access poses a major obstacle. The main contractor reinforced several sections and identified specific routing for road accessibility for rock delivery trucks and heavy equipment to the site as most local roads are aggregate base and often dirt road accesses to orchards, padi fields and to the river.

**Work sequence Staging Area & Stockpile**: Due to limited space at the pump house, truck flow pattern ingress and egress was critical for efficient operation. Rocks were stockpile in "slots" according to their gradation sizes. Unloading especially larger rocks was assisted by the smaller excavator.

**Water Quality Monitoring and Mitigation Measures:** As work is conducted at riverbed and riverbank, it is recommended that all work shall cease when water quality readings exceed 50 NTU and mitigations measures applied before recommence. At start work, locations were identified (50m) upstream and downstream of construction site area, where water samples shall be taken (3) times a day during construction from these (2) locations. After daily calibrations, the difference between the downstream and upstream readings of samples shall determine water quality of the workings at the site. Work was stopped on (2) occasions and PE-BMPs (anionic polymer) applied. It was observed on several occasions that water quality upstream has deteriorated outside range of turbidity meter at which case work continued as any mitigation measures would not have made any difference.


**Work sequence:** Access ramp across river was built with dismantling of multi-level gabions structure and rocks were applied together with different gradation rocks and compacted. The loader was used to "feed" rocks to the (2) excavators that position them in accordance to the plan.

**Work sequence:** Ramp was built on the opposite riverbank to gain access in order to build the 1st Bendway Weir. During construction, it was decided with JPS Pg. Abu Bakar approval that due to the "narrow corridor" of riverbank length, (1) Bendway Weir shall be able to re-direct river flow onto the Newbury Riffle rock apron. There was no difference in cost as the rocks for the second Bendway Weir was applied in the LPSTP and Newbury Riffle.

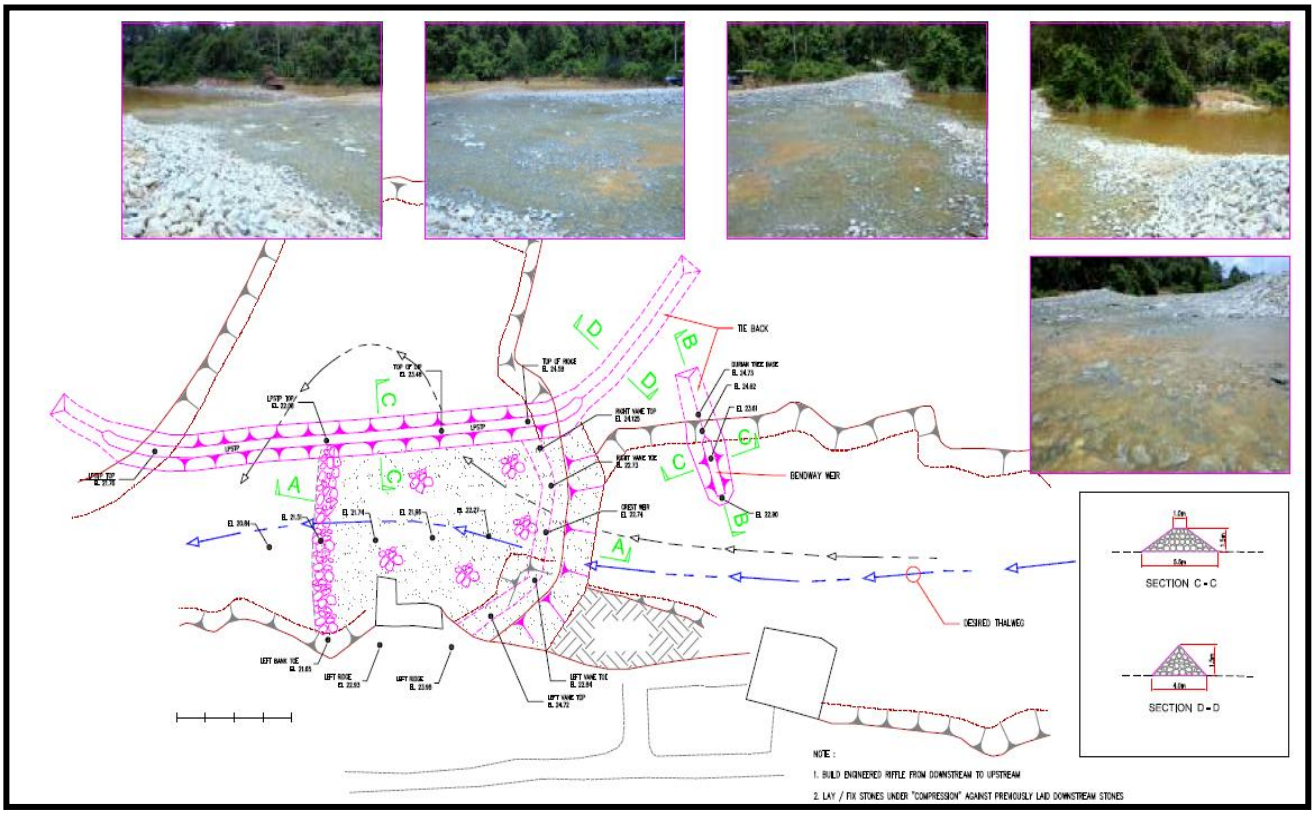
**Work sequence:** Longitudinal Peak Stone Toe Protection (LPSTP) (section C-C) and Tie-Back Key (section D-D) were installed as both equipment were working in unison when water flows were low.

**Work sequence:** Newbury Riffle was constructed by extending installation of specially gradation rocks and compaction-to-grade from downstream ramp across river (built earlier) to upstream "crest weirs and cross-toe ramps", 40m (section A-A at 10+40+2 = 52m length).

**Work sequence:** 26 August 2017 Re-directive Methods Training and Field Visit. Theory explained in class room setting at UUM and "hands-on" knowledge transfer at site visit.

**Work sequence Completion:** Project completed on the second week of September, approximately (5+) weeks from start work and completion well within the (3)months allocated. Approximately 3000m3 (6200+tons) of rocks from gradation (50 to 650)mm size with D50 at (300-400)mm.

**AS-BUILT DRAWING**




**Summary & Experience Learnt :**

**Challenges Weather & Rock Delivery:** Weather played a role in our progress, (3-4) "rain-out" days with several partial rain days where rocks could not be delivered.

The biggest challenge and lesson learnt is the availability of rocks and their delivery vehicles. We immediately realised that although 900kg rocks can be made at the quarry, there were no trucks available nor willing to deliver them to our site. We settled for the (450-600)kg rocks for our upper rock gradation however much delays were experienced as a result of truck "breakdowns" with constant tailgate repairs and we ended with half the number of trucks willing to deliver the large rocks.

**Challenges Communications:** The second biggest challenge experienced on this job. It was extremely difficult to "re-communicate" the principles of Re-directive Method to site work force and operators as the traditonal practice of Resistive or Continuous Method of Rock Revetment where the phenomenon "more rock and bigger rock is better" is difficult to discard. Some time was expensed in reworking sections of riverbanks to re-position rocks onto the engineered riffle.

**Challenges Newbury Rock Riffle Installation Technique:** The most critical component in construction of the engineered rock riffle is i) the mixture of various gradation of rocks and ii) their installation technique where the rocks of various sizes must be "compressed and buttress" together to form homogenous interlock structure. It is important to have as many "contact points" at the interfaces where well graded mixture is so crucial. The final surface, although rough from the angular rock surfaces, is important to maintain lamina flow.

**Summary of Work Progress & Completion:** Work was completed in 5+ weeks and **"As-Builts"** as below. Site visits were made post construction as described below and the project performed well to design aspirations and met the project needs.

**Post Construction site visit on 15 November 2014:** Two months after completion and after several "high flows" sees the Newbury Rock Riffle apron adjusting to the flow patterns. The Bendway Weir has performed well as can be observed on the downstream riverbank aggradating with good signs of deposition and vegetative growth.

**Site visit 15-11-14 photos:**

**Site visit 15-11-14 photos:**

**Site visit 21-5-15 photos:**


**Post Construction site visit on 21 May 2015**: Eight months from project completion on installation of Re-directive Method of Bendway Weir, Newbury Rock Riffle & Longitudinal Peak Stone Toe Protection.

**Quick check on objectives:**

√ Re-direct thalweg from scouring riverbank onto Newbury Rock Riffle,
√ Facilitate scoured riverbank "self healing" with aggradation at riverbank,
√ Riverbank stabilized on both sides after several high water discharges,
√ Provide "life-blood" to agriculture with 2m water retention from Newbury Rock Riffle,
√ BMPs to maintain water quality during construction,
√ Provide training to state of Kedah engineers and "hands-on" site visit during construction
√ Return this section of river back to its natural "proper function condition" (PFC), improve water aeration and habitat for fishes.

**Acknowledgement:** Project could not be achieved without the assistances and cooperation from JPS Kedah Pg. Tn Hj Abu Bakar and his team and their colleagues at MADA.
The control of river water level was very crucial to our work schedule and progress.
Great assistances was received from the main contractor DOL TWO ENTERPRISE Sg. Petani, Kedah who kept the "smooth flow of rocks in their delivery trucks" and equipment maintenance (2 excavators + 1 loader) to the best of their ability and their sub-contractor who was responsible in maintenance of access roads to site.