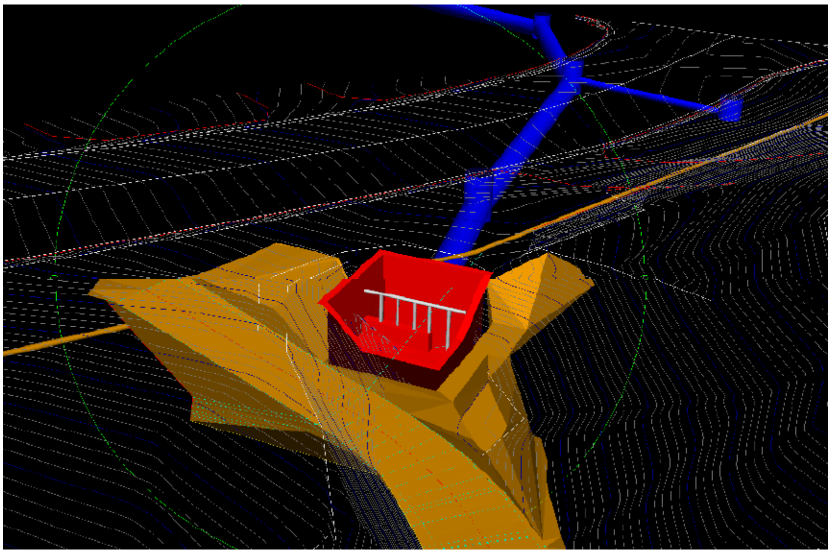
Creek Stabilisation

Thirroul, NSW



Drop structure walls and trash rack. Note excavator access pad on left of structure and sediment capture sump on right

Wollongong City Council

Jason Cooper

CLIENT: Internal

SCOPE:

Stabilisation of eroding creek

12d DIMENSIONS:

- Volumetrics

Project Summary

The stabilisation of an eroding creek at 4 Cornock Avenue, Thirroul. This was a project with a number of challenges to be overcome.

Challenge 1

Erosion much more severe than commonly observed in creek reaches of this nature and context.

Solution 1

Creation of a TIN from the initial survey highlighted the distinct and localised nature of severe erosion. Analysis of the existing surface TIN identified several areas where the erosion pattern was inconsistent (areas where the creek had proven more resistant). Additional survey work was conducted to develop a finer terrain model around creek features which had resisted or altered erosion patterns. The final TIN of existing ground surfaces showed features such as boulders, trees, bedrock outcrops and constructed weirs which had demonstrated erosion resistance, as well as a line midway up the eroded banks which showed the pre-erosion toe of bank levels. To minimise cost of works and risk of disturbing unstable banks, the presence of stable 'nodes' and a pre-erosion bed definition were used as a starting point around which the rest of the creek stabilisation was designed. Analysis of the existing TIN also revealed a distinct change in creek bed level at the upstream end of the eroded zone (a 'headcut'), precipitating investigation into possible incipient factors for this type of erosion (headcut erosion of this magnitude relative to the starting creek depth is not often associated with natural geomorphology).

Further investigation included introduction of existing utility and drainage models into the 12d environment, which revealed that the root cause of the problem was lowering of the creek bed at the inlet to a road culvert, which was in turn lowered to below the grade of the surrounding terrain to pass beneath a sewer. The lowered creek bed level was not effectively stabilised, and the erosion headcut had moved 60m upstream over 40 years. Defining the likely root cause of the erosion was an important step in developing a cost-effective treatment, and in determining the likelihood that erosion would continue, which in turn informed cost/benefit factors for intervention options.

Location of the creek

For more information

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12d® Model

Challenge 2

Site access very difficult due to existing erosion, surrounding landform and bank instability.

Solution 2

Recognition of erosion mechanisms as described above identified an ideal course of treatment including stabilisation of the erosion headcut prior to filling the creek back to pre-erosion levels and creating a formal drop structure at the culvert inlet. Construction is most economical, and diverted creek flows easier to manage, if headcut stabilisation precedes bed filling. The existing channel section is typically 0.5m-1m wide at the bed with near vertical banks 1m-2m high either side, then steep banks (around 1:1 to 1.5:1) grading up to a top of bank 3-5m above the creek bed. The existing creek profile did not allow plant access. Plant access was required as far as the site of the headcut, around 60m upstream of the culvert inlet. At no point were the bank gradients trafficable in their existing condition, even at the culvert inlet banks (near vertical 2m-3m high). Excavation in the vicinity of the culvert inlet was constrained by an existing sewer buried perpendicular to the creek and immediately behind the headwall to the culvert inlet. Excavation to widen an access path in the creek bed was prohibited by steep, unstable banks either side. Removing material from creek banks to reduce bank grades was constrained by the presence of existing houses and outbuildings close to top of bank on each side (translate functions were used to create TIN surfaces related to the ZOI for existing structures in order to check proximity of excavations to building foundation zones). 12d Model software was used to design a two-stage filling regime, the first stage of which provides an access track from a cut through the creek embankment 20m upstream of the culvert inlet to the point where the headcut is to be stabilised. 3D design, visualisation and rapid incorporation of alignment changes and associated volume recalculations allowed the access track to meet the following functional objectives:

- Provide reliable access by incorporating width, grades and curve geometries identified as suitable for likely construction plant with safe batter heights and grades.
- Avoid any excavations with the potential to further destabilise banks; also avoid any excavations with potential to destabilise material within the zone of influence of adjacent structures.
- Effectively balance cut and fill including volume allowance for imported rock material to stabilise the track surface.
- Fill over existing surface to achieve required geometries with no excavation.
- Maintain grade and crossfall sufficient to allow for a constant flow diversion trench to be incorporated into the access track formation.
- Minimise removal of tree branches while allowing room for plant operation.
- Minimise cut and fill required to bring access road surface to final subgrade levels for creek reconstruction (ideally, riprap should be placed directly over the access road where possible, so access track surface levels should be 'finished creek levels minus riprap thickness', but only where possible, subject to grade and geometry requirements).

To the novice observer during construction, this access track resembled a pile of dirt. In design, getting this 'pile of dirt' to meet each of the mandatory objectives and approach the desireable ones is a significant feat of constraint, juggling which is only really possible with access to rapid iterative modelling and analysis. The adopted design approach for this element would not have been cost-effective without stacking redesign and analysis operations in 12d Model - including template design, interface, volume analysis, and TIN analysis tools. Getting this element of the design right is crucial to the success of the overall concept in this instance. Without good, safe access to the creek and a hassle-free flow diversion, the rest of the works become much more risky and costly.

Nearby views - across Thirroul

Challenge 3

Significant trees in the vicinity of works.

Solution 3

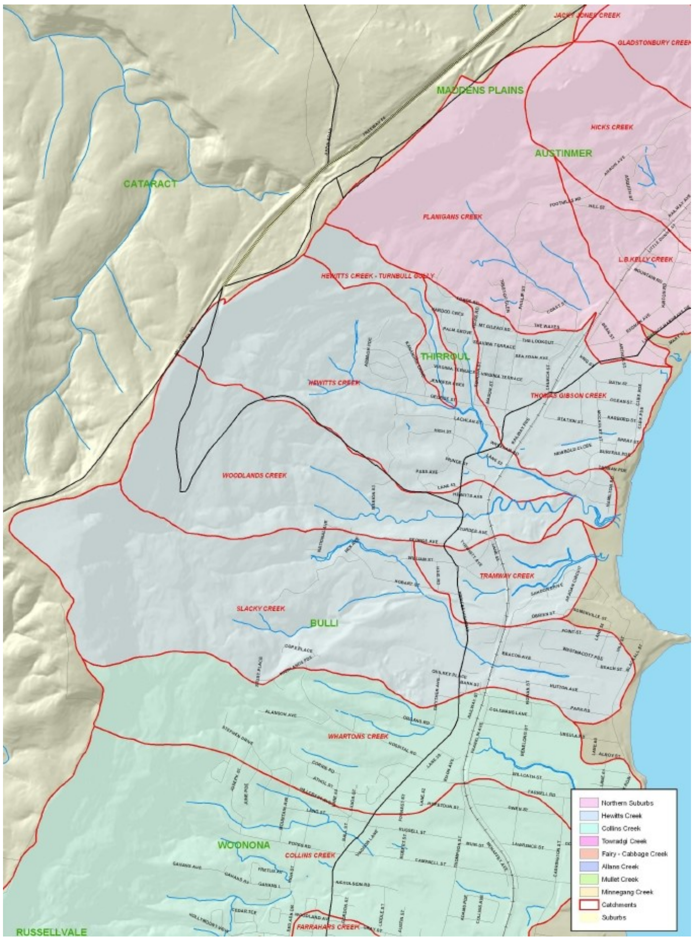
Based on advice from a riparian vegetation specialist, additional survey also captured attributes of significant trees to be retained including location, surrounding ground levels, likely extent of root zone, limbs potentially conflicting with plant movement envelopes, and canopy spread. This information was included in the 12d terrain model and used to ensure that existing ground levels in the immediate vicinity of significant trees were preserved, and that the proposed revegetation scheme following creek reconstruction would be compatible with likely shading patterns from old growth trees. The position and attributes of existing trees exerted a significant influence on the geometry of the design creek, which in turn had an effect on the hydraulic parameters influencing design of riprap and the drop structure. Once again, rapid iterative analysis was instrumental in preparing a design creek geometry that ticked the hydraulic and constructability boxes without jeopardising significant trees.

Challenge 4

Constant flow through work site.

Solution 4

As previously noted, a flow diversion was incorporated into the access track formation. The flow diversion remained in place throughout riprap armouring works and will eventually form the preferred path for interstitial trickle flows through the riprap, allowing for greater control over long term erosion potential. Iterative terrain modelling was again employed, along with TIN flow analysis and export of design geometries to a separate hydraulic modelling package, to design the access track formation so as to capture flows from areas disturbed during construction and deliver these to a single point sediment control facility. Further refinement of grades and levels with 3D design allowed development of a sediment capture pit as an integral component of the excavation and backform works for the drop structure without compromising safe batter excavation parameters or exceeding plant reach distances. The sediment capture pit remains in place as sacrificial backform and permanent backfill drainage adjacent to the walls of the concrete drop structure.



Hewitts Creek Catchment

Challenge 5

High potential for debris.

Solution 5

Records from previous major storm events and observation of catchment conditions indicated high energy flows and significant potential for blockage by medium to large boulders and woody debris. 3D design was used to model excavations and plant reach distances to enable design of debris control measures within the drop structure which maximise the utility of available space within geotechnical and plant reach constraints, to provide effective deflection of debris into an offline storage area which can be readily accessed by the plant commonly used for reactive debris clearing works in the wake of storm events where larger machinery is not always readily available. The finished levels adjacent to the drop structure included a permanent access pad for advantageous positioning of the cleanout plant.

Challenge 6

Need to quantify hydraulic impacts on piped and overland flow regimes.

Solution 6

Cross sections taken from design channel geometry were used, along with calculated interstitial flow and roughness parameters to model design creek flows. Unacceptable hydraulic impacts were identified, necessitating changes in the final channel geometry. Due to the streamlined design processes and operation stacking developed during formation design, the changes in surface profile could be readily translated into changes in formation models. This approach encouraged the designer to preserve functionality of the formation design without resorting to shortcuts such as changing riprap design away from the ideal, or adding additional depth of riprap to make final geometry changes easily. Shortcuts taken with the riprap to meet hydraulic considerations can reduce confidence levels in the final design and increase construction costs by using more rockfill than necessary and/or using a riprap grading mix other than the most economical blend of graded and ungraded rock. To model impacts on piped drainage systems, 12d Model's interoperability with DRAINS was used to export data for hydraulic modelling of the piped drainage system. Terrain model data was also exported to define geometries of overland flow routes used to assess major storm impacts when the pipe and creek system are surcharged.

Picturesque Thirroul (photo credit: WeekendNotes)

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