# Mary River – Understanding processes and values to inform planning and restoration

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**Key Points**

- Understanding the system wide geomorphic processes, the likely future trajectory and the stakeholder values of a river is critical in developing an effective, long term, cost efficient stream management program
- Setting clear and measurable objectives with stakeholders reduces ambiguity for designers, management agencies and landholders and increases the likelihood of community acceptance of restoration works
- Combining the system understanding and stakeholder values using a risk based approach ensures cost effective prioritisation of stream restoration works

## Abstract

The Mary River is a major river system of southeast Queensland with important economic, social and environmental values. Since European settlement the river has supported a thriving agricultural industry and supplied sand/gravel to aid development of the region. Clearing of riparian vegetation and sand/gravel extraction has resulted in substantial erosion of the river causing ecological degradation and damage to agricultural land and public infrastructure. Ongoing degradation of the river threatens the endangered Mary River Turtle and Mary River Cod and municipal water supplies.

Multiple stakeholders including the local council, water authority and the local catchment group combined to develop the Mary River restoration plan which aimed to restore a key section of the Mary River near the township of Kenilworth to:

- Protect habitat for Mary River turtles and other terrestrial and aquatic fauna,
- Increase the erosion resistance of the river to protect infrastructure, and
- Protect and improve water quality and supply

The project included detailed assessment of the historic and contemporary river processes. Stakeholders were also engaged to gather an understanding of the multiple values of the river and set objectives for stream restoration planning. Based on the understanding of the processes, their likely future trajectory and the multiple values of the river a risk assessment was undertaken to develop a cost efficient stream management program. In 2015 a major project was implemented as the first stage of the broader program.

## Keywords
Stream planning and restoration, understanding processes and values, risk assessment, Southeast Queensland

## Introduction
The Mary River is a major river system of southeast Queensland with important economic, social and environmental values. The river rises in the Conondale Range near Maleny, flows in a northerly direction, through Gympie, and discharges into the Great Sandy Strait near Fraser Island. The Mary River catchment area is approximately 9,595 km$^2$, with an approximate main channel stream length of 300 km. The study area is located in the upper reaches of the Mary River, inland from the Sunshine Coast near the township of Kenilworth (Figure 1).

Since European settlement the river has supported a thriving agricultural industry and supplied sand and gravel to aid development of the region. Within the study reach the river abuts public and private land, including parklands, agricultural lands and roads, it is the drinking water source for the town of Kenilworth, and it is has been identified as containing important Mary River turtle nesting habitat and habitat for the endangered Mary River Cod. Clearing of riparian vegetation and extensive extraction of the alluvial sands and gravels that dominate the channel and floodplain substrate has resulted in substantial erosion of the river causing ecological degradation and damage to adjacent agricultural land and public infrastructure.

Major flooding occurred in the Mary River catchment in January 2011 and January 2013. The large flows caused substantial erosion of the bed, banks and floodplain of the river. A geomorphic assessment of a 32 km study reach near the town of Kenilworth was undertaken to assess the geomorphic condition and trajectory of the reach and a restoration plan to prevent further damage due to erosion was developed. Due to the diverse uses of the river the restoration plan took into account the objectives of various stakeholders including the Mary River Catchment Coordinating Committee, Burnett Mary Regional Group (BMRG), Seqwater, Sunshine Coast Council (SCC), Department of Natural Resource Management and Mines (DNRM) and the local community.

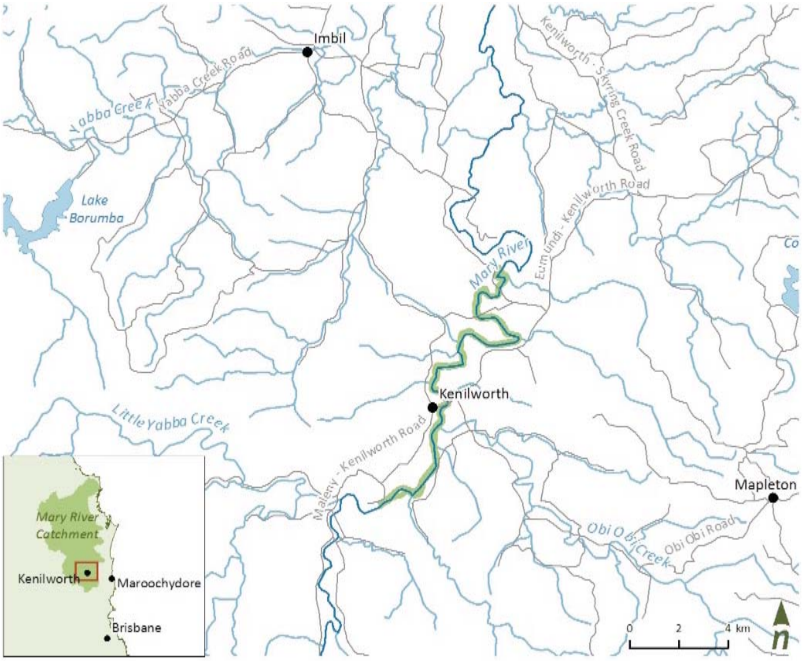


**Figure 1. Location of the study reach**

## Changes since European settlement

Prior to European settlement dense gallery rainforest is likely to have grown on the floodplains in the study area. The arrival of European settlers in the 1840s led to significant land use changes. By the late 1840s the upper and lower Mary River catchment was under pastoral land use, dominated by cattle and sheep (Brizga, 2001). Riparian vegetation was predominantly cleared throughout the study reach, sand and gravel extraction and livestock grazing was extensively practiced from within the channel. These pressures lead to significant changes to the depth and planform of the river (Figure 2). The changes to the Mary River were summarised by the local historian Tutt (1994):

*(The river has) "changed beyond comprehension to those who knew it even 50 years ago. It has changed from a deep clean stream guarded by shaded scrub (rainforest) which reached back to the ranges, or by the open forest flats saddle high in the native kangaroo grass, to sand clogged watercourse fighting for its life between eroded banks held by thinly scattered trees."*

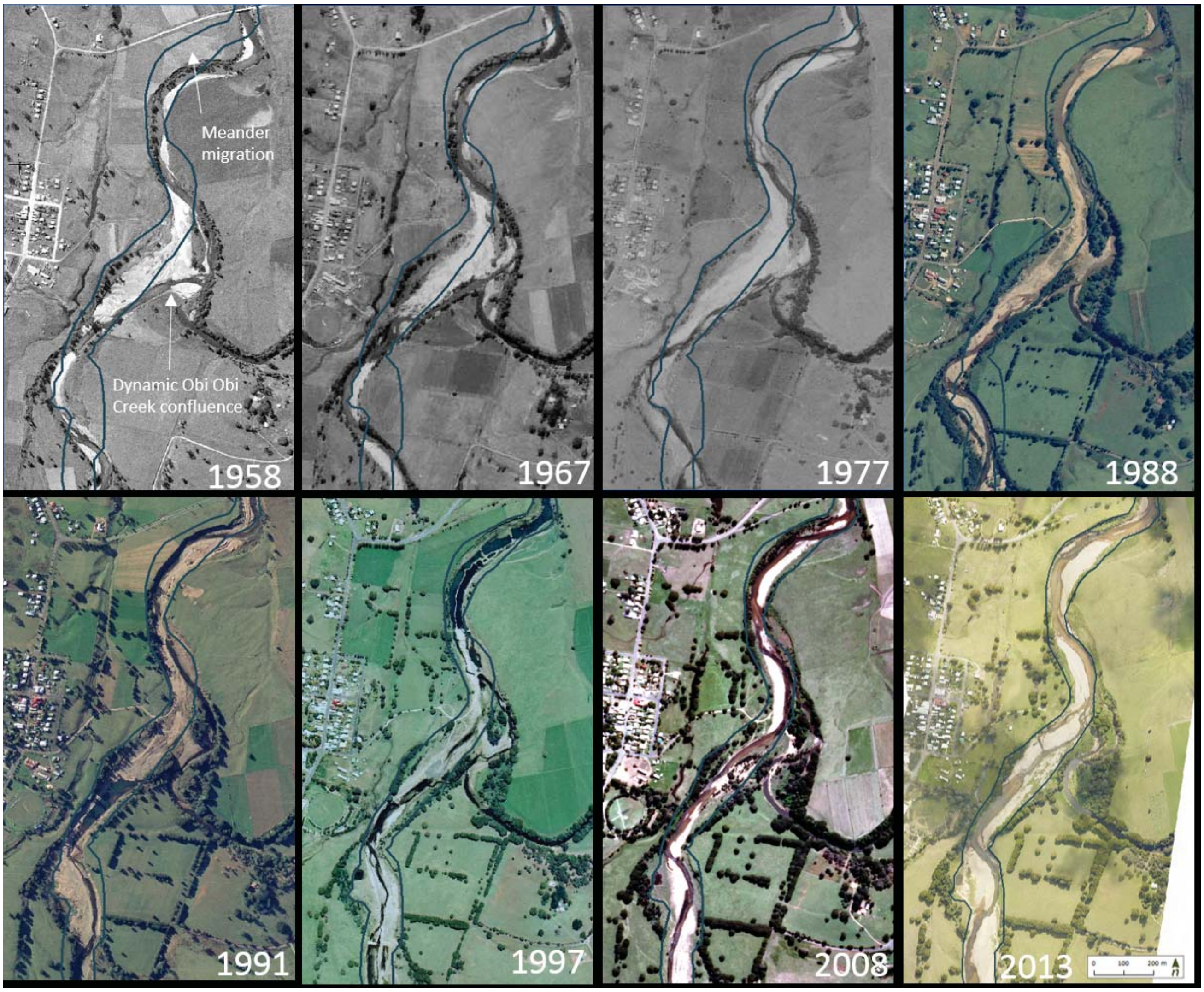


**Figure 2. Comparison of historical imagery near Kenilworth which indicates significant meander migration, channel widening and straightening since 1958. The blue lines show 2013 bank alignment**

## Hydro-geomorphic assessment

A system-wide review of processes within the study area included assessments of bed grade, hydrology, stream power, multi-temporal aerial photography and LiDAR derived Digital Elevation Models (DEMs). The stream power assessments were used to identify reaches of stream that may be predisposed to channel change according to the two and fifty year ARI specific stream power provides a standardised, comparable metric (Alluvium, 2011, Hardie 2005, Bledsoe 2002). The stream power assessment for the two year and fifty year ARI event using the 2008 LiDAR dataset was compared with the major erosion locations identified in the temporal LiDAR analysis.

The assessments indicated that since 1958 the channel upstream of Kenilworth Bridge has undergone approximately 1-2 m of deepening (although there is limited evidence of deepening in the past 15 years). The deepening is likely to have been limited in the upper reaches of the study area by the presence of bedrock as the channel abuts the valley margins. There has also been considerable widening (approx. 40-60 m) and channel straightening since the 1950s which has resulted in an estimated 1,900,000 $m^3$ (9 $m^3$/m/year) of sediment export from this reach. In the recent flood events meander migration and meander development have been the dominant erosional processes. These processes resulted in the mobilisation of over 415,000 $m^3$ of sediment from the stream banks (15 $m^3/m/year$), including 67,000 $m^3$ from the bank adjacent to Kenilworth. During this period there was also deposition of coarse sediment (sands/gravels) on point bars.

The observed processes since the 1950s indicate the reach is in the final stages of an incision cycle. The deepening occurred in response to the sand and gravel extraction and the loss of the armour layer. Excess stream power arising in response to the deepening has been dissipated through channel widening in the past 60 years. In recent years the excess energy has been dissipated on the outside of bends which has resulted in meander migration and meander development which typically results in an increase in stream length and a further reduction in stream power. The observed channel transition is a classic incision and widening cycle which begins with channel incision triggered by anthropomorphic changes (vegetation removal, sand and gravel extraction), followed by widening and then the formation of an inset channel within the larger channel. The Mary River channel near Kennilworth appears to be in the final stages of the incision cycle.

## Stream restoration plan

### *Objectives*

Defining clear objectives is an essential step in effective stream restoration planning, as documented in most contemporary stream restoration guides (e.g. Australian Stream Rehabilitation Manual (Rutherfurd et al. 2000), Technical Guidelines for Waterway Management (Department of Sustainability and Environment 2008), Stream Restoration Design Handbook (US Department of Agriculture 2007)). Clear objectives that are reachable, within the constraints and capabilities of the stream and its riparian area, will lead to better designs that perform as intended (US Department of Agriculture 2007).

The Mary River has a diverse range of uses and as such a stakeholder workshop was held to define objectives for the stream restoration plan. Representatives of the local council, local water authority, the natural resources management group and the community took part in the meeting. The proposed objectives represent the diverse uses of the stream and are shown in Table 1.

**Table 1. Proposed restoration objectives for Mary River, Kenilworth**

| Objective | Values protected |
|---|---|
| **Increase the erosion resistance of channel bed, banks and floodplain so they have a greater probability of withstanding flood events with a similar magnitude as 2013 (i.e. approx. 20 -30 year ARI event) without major channel change.** | • Reduce the loss of public assets (water offtake, parks, roads, utility infrastructure) and private land and assets<br>• Reduce sediment and nutrient loads to downstream receiving waters |
| **Protect and where possible increase Mary River turtle populations through habitat protection and enhancement** | • Mary River turtles<br>• Mary River Cod<br>• Significant frog species including the Giant Barred Frog<br>• Other river health values (i.e. water quality, fish, macroinvertebrates etc.) |
| **Protect and where possible improve water quality through bank stabilisation and riparian management** | • Water supply from the Kenilworth and Noosa Intake |
| **Protect and enhance pools for water supply (i.e. create deeper pools)** | • Private landholder water supply<br>• Other river health values (i.e. water quality, fish, macroinvertebrates etc.) |

## *Risk assessment*

The establishment of high quality, structurally diverse riparian vegetation within the study area can achieve or assist to achieve all the management objectives for this reach of the Mary River. Riparian vegetation provides a robust, long term solution that:

1. Increases the erosion resistance of channel bed, banks and floodplain
2. Creates stable and diverse bank morphology which can provide habitat for Mary River turtles and other terrestrial and aquatic fauna
3. Increases and enhances instream physical form and diversity (including pools) by stabilising instream deposits
4. Traps lateral inflows of sediment and nutrients from adjacent floodplains

However, vegetation will take time to reach a level of maturity, structural diversity and robustness that allows it to perform the desired functions outlined above. Additionally, stream banks in some sections of stream are degraded to a point that natural regeneration of the riparian zone is unlikely to occur, or current pressures are in place that prevent successful establishment of riparian vegetation. In some locations the risk (likelihood and/ or consequence) of erosion is so great that waiting for vegetation to reach a level of maturity required to protect stream banks from erosion may not be acceptable. A range of management options are available to reduce to the rates of erosion, providing the necessary time for the vegetation to reach maturity. These options include bank reprofiling, toe protection (pile fields or roc revetment), stock control and facilitated revegetation.

Given there was limited funds available for river restoration works a risk profile was used to help select appropriate bank erosion treatments throughout the study area. For each section of bank a risk profile was developed. The risk profile comprises the likelihood of bank erosion occurring and the consequence of bank erosion occurring.

## *Likelihood*

To assess the likelihood of bank erosion a semi-qualitative analysis was undertaken which considers a range of erosion factors. The analysis included an assessment of both bank resistance and shear stress (force exerted against the bed and bank). Bank resistance was classified throughout the study area based on the current ability of the banks to resist erosion. The classification of bank resistance was based on:

- The current condition of riparian vegetation
- The bank angle (the steepness of the bank increases the likelihood of bank mass failure)
- The influence of adjacent bedrock if the channel abuts bedrock

Water flowing down an inclined channel exerts an instantaneous shear force on the wetted perimeter of the channel that is equal to the downslope component of its weight. This force is known as the shear stress. The shear stress distribution throughout the reach was estimated using a 1-dimensional hydraulic model (Hec-RAS). Banks were classified into three categories based on the shear stress exerted against the current channel during the ten year ARI event, which is representative of a large flood (for context the January 2011 and 2013 floods approximately equated to 20 year ARI events). It should be noted that the shear stress estimated by the one-dimensional hydraulic model does not take into account channel sinuosity, and is likely to under predict shear stress exerted on the outside of meanders. Critical shear stress is defined as the shear stress at which incipient motion occurs (the boundary material is liberated and entrained in the water column). Critical shear stress estimates were determined for the channel boundary throughout the reach and compared with the distribution of shear stress to determine an initial erosion potential throughout the reach. The assessment of bank resistance and initial erosion potential was then combined with an assessment of the planform of the river (i.e. outside of a meander, inside of a meander, straight section of channel etc.) to determine a likelihood rating (Table 2).

**Table 2. Likelihood rating based on erosion potential of the stream banks**

| Likelihood - Erosion potential | Description |
|---|---|
| **Very high** | High rates of erosion almost certain in future flood events. Very unlikely the vegetation alone would be able to reduce the likelihood of erosion due to the rate of erosion. |
| **High** | High rates of erosion likely in future flood events. Unlikely the vegetation alone would be able to reduce the likelihood of erosion due to the rate of erosion. |
| **Moderate** | Some erosion is likely in future flood events. Vegetation may be able to reduce the likelihood of erosion providing favourable flow condition |
| **Low** | Low likelihood of erosion in future flood events. Vegetation will be able to limit erosion. |

### *Consequence*

High rates of erosion can have a range of consequences including loss of land/assets, loss of instream habitat and impacts on downstream water quality. However the consequence of stream bank erosion is highly dependent on the adjacent land use. To assess the consequence of erosion the area adjacent to each bank was classified into four zones (Table 3).

The consequence ratings are based on public interest and are based on utilising public funds for the works. If private landholders are contributing to the works then the consequence ratings can be altered to account for the significant consequence the loss of their land may have on their individual private enterprise(s).

**Table 3. Consequence rating based on adjacent land use**

| Consequence – Adjacent land use | Description |
|---|---|
| **Very high** | High value public infrastructure (roads, water offtake etc.) and EPBC Matter of National Environmental Significance habitat |
| **High** | High profile public land (i.e. parkland etc.) |
| **Moderate** | Private agricultural land |
| **Low** | Other (not used for private enterprise with limit use by the public) |

### *Risk assessment*

The likelihood of stream bank erosion was assessed against the consequence of the erosion to determine the level of risk associated with stream banks throughout the study area. If a stream bank has high erosion potential and abuts high value public infrastructure it is classified as very high risk and should give high management priority.  Conversely there is generally very low to moderate risk (depending on the consequence) when there is low erosion potential.

Even when the land that is eroding is of limited economic or social value the stream bank erosion still has consequences in the form of impacting downstream water quality and habitat. As a result wherever there is high to very high erosion potential there is still moderate to high risk to the system. The risk for the reach is shown in Figure 3.

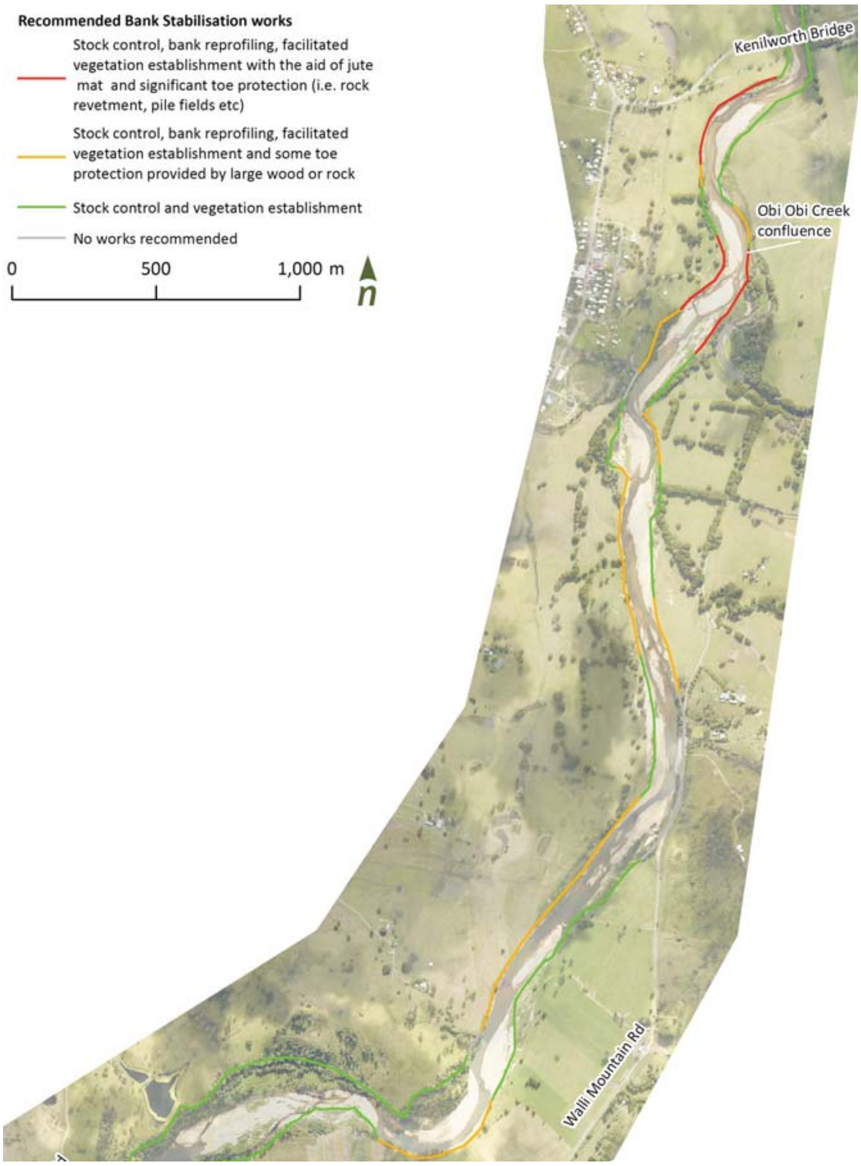


**Figure 3. Recommended bank stabilisation works based on risk assessment, risk ranges from high in red to very low in grey**

## Case study: high risk zone works

A high risk zone on the outside of a meander was identified as a site for stream restoration works. The site is within a Sunshine Coast Council (SCC) reserve opposite the Ob Obi Creek confluence. Bed and bank erosion has caused substantial loss of public land and increased channel width by up to 70 m in the most affected area. Between 2008 and 2013 approximately 70,000 m³ of sediment loss occurred from this area. The bank is currently near vertical and ongoing erosion was likely without management intervention (Figure 4). Due to the steep nature of the bank and location within a public reserve the bank posed a public safety risk Additionally, the site is within a known Mary River Turtle nesting reach of the Mary River and is located just upstream of the sub-surface Seqwater water offtake, which is the town's water supply. The water offtake was at risk due to the erosion of the sand filter provided by the depositional bar at the site.

The rehabilitation works included bank stabilization through bank reprofiling (battering) and revegetation and the installation of pile fields with associated rock protection. The pile fields also enabled natural bank habitat suitable for the establishment of vegetation for the majority of area (as opposed to rock revetment). The pile fields also promote sediment (sand) deposition along the lower bank and surrounding the water offtake, improving the filtration of town water supply. Some limited rock beaching at the toe of the stream bank upstream of the pile fields was also required. The works were completed in July 2015 and pioneer species have begun to colonise the works (Figure 5). A recent flood reached the top of the pile fields and the works were unaffected.

**Figure 4. Before works - Mary River, Kenilworth (view looking upstream 7/7/2014)**

**Figure 5. Post works - Mary River, Kenilworth (view looking upstream 26/03/2016)**

## Conclusions

Channel erosion is caused by fluvial geomorphic processes. Understanding these geomorphic processes and their likely future trajectory is important in delivering a cost efficient stream management program. However, stream management in the absence of knowledge of the stakeholder values of that stream may lead to inefficient investment and a lack of community support. Developing a process understanding allowed for identification of where ongoing channel change is likely and the scale of intervention required to provide an effective management response, whilst understanding the values allowed for identification of the impacts of erosion on various stakeholders including the community.

Combining these understandings through a risk prioritisation process allowed for the development of a robust and cost effective stream management plan. The plan promoted investment in areas that were at high risk of erosion whilst meeting the objectives of the community.

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