Silverdale River Styles

(22/07/2021)

To: (Auckland Council)

cc: (Jackie Zhou)

From: (Jack Clothier)

Subject: (Silverdale River Styles – Initial Desktop Analysis)

This memo summarises the Stage One River Styles (Brierley & Fryirs, 2005), initial desktop analysis that was carried out by the Waterways Planning team for the Silverdale South & Pine Valley catchments in July 2021. The term 'initial' reflects that this analysis does not demonstrate a completed Stage One River Styles Analysis but rather a preliminary scope that attempts to put the catchment in context before further detailed analysis is carried out.

The main purpose of this initial desktop analysis was to scope areas within the Silverdale South & Pine Valley Catchments that are sensitive to future erosion which require conservation and areas which are currently eroding which require rehabilitation. To understand catchment wide geomorphic diversity and to scope areas sensitive & subject to erosion, concepts discussed within stage one of the River Styles Framework were applied in this study.

The River Styles Framework is a tool that utilises geomorphic approaches to help managers understand river character, behaviour, condition, and recovery potential while also framing approaches to management strategies. In total there are 4 stages of the River Styles Framework, however this summary only covers essential parts of Stage One before fieldwork is carried out to verify findings of a desktop assessment. Stage One of the River Styles is rolled out in three steps:

- Classification and catchment wide survey of river character and behaviour by assessing regional and catchment setting controls (geology, soil type, land use, rainfall etc)

- Defining and mapping observed River Styles through GIS techniques (DEM Hillshade)

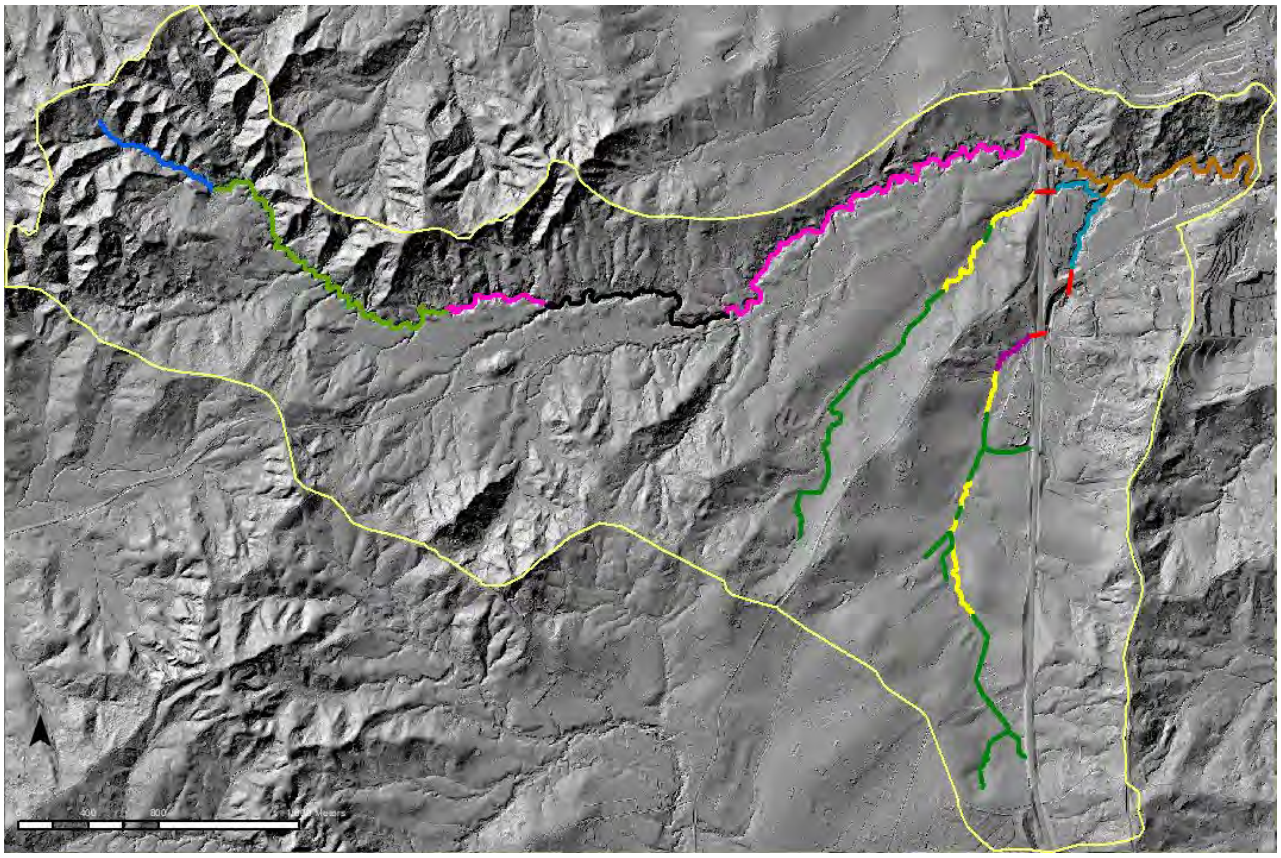
- Interpreting the controls and character, behaviour, and downstream patterns of River Styles.

This memo/summary covers parts of Step One and Step Two with further work to be carried out after field verification.

The Silverdale South & Pine Valley combined catchments are relatively small, are approximately 17km^2 in area and drain two main streams; the Weiti Stream, the main trunk, and John Creek which is a tributary of the Weiti. The catchment is located in Northern Auckland and drains through Silverdale into the Hauraki Gulf. Both rivers are subject to the effects of land use change and have been heavily adjusted over contemporary history.

In total, 10 River Styles (Figure 1 & Table 1) were identified within the Silverdale South & Pine Valley Catchments, indicating the diverse geomorphic and locally forced/altered nature of natural streams within the catchment. These River Styles range from unaltered Steep Confined Headwaters in the Weiti Stream which convey water at high rates in the north west to highly altered landscapes with Partly Confined, Valley Fill riverscapes along John Creek which are indicative of watercourses that have been dug by farmers to increase conveyance/connectivity through historically discontinuous swamplands.

Figure 1 and Table 1 below describe the location and character/behaviour of each River Style based on a GIS/desktop assessment. Although this is a desktop assessment which contains inherent inaccuracies, current boundaries and descriptions are based on geomorphic literature including geomorphic transitions and process morphology linkages. Further fieldwork is required to increase certainty of this analysis.



	Partly Confined, Bedrock Margin Controlled, Channelised Fill
	Partly Confined, Bedrock Margin Controlled, Discontinuous Floodplain, Meandering, Discontinuous Channel
	Partly Confined, Bedrock Margin Controlled, Floodplain Pockets, Meandering
	Partly Confined, Bedrock Margin Controlled, Incised, Low Sinuosity
	Partly Confined, Bedrock Margin Controlled, Discontinuous Floodplain, Incised, Meandering
	Partly Confined, Bedrock Margin Controlled, Discontinuous Floodplain, Low Sinuosity
	Partly Confined, Bedrock Margin Controlled, Occasional Floodplain Pocket, Meandering
	Partly Confined, Terrace Margin Controlled, Incised, Low Sinuosity
	Confined, Headwaters
	Culvert

Figure 1: River Styles Stage One Map.

River Style	Valley setting /Landscape Unit	Elevation (m)	Average channel width (m)	River Character				River behaviour	Ease of adjustment (geomorphic sensitivity)
				Channel planform	Geomorphic unit	Bed material	Bank Material		
Confined, headwaters	Confined/Steep valley	TBC	TBC	n.a.	No floodplains. Likely bedrock waterfalls, potholes, runs	TBC	TBC	Variable mix of imposed (forced) geomorphic units. Highly connected channels with fine sediment flushed through system. Geologic controls limits capacity for channel adjustment in lateral and vertical dimensions.	Low – imposed geologic and geomorphic controls
Partly confined bedrock controlled discontinuous floodplains, incised	Partly confined/ lowland pain	TBC	TBC	Single channel, meandering, moderate adjustment capacity	Point bars, floodplain pockets, likely more.	TBC	TBC	Moderate diversity of instream geomorphic features as fine grained material is flushed through system due to limited capacity for in channel deposition. Available gravels are deposited on inside bends forming point bars. Fine grained discontinuous floodplain pockets are formed and reworked at high flow stage. Bedrock controlled channel provides limited ability for lateral adjustment within partly confined valley setting. Incision through fine grained material evident.	Moderate – Bedrock margin limits capacity for adjustment but potential for discontinuous floodplains to be engaged during high flow events. Upstream incision due to flow concentration from culverts may exacerbate natural sensitivity.
Partly confined, bedrock controlled, incised channel	Partly confined/ rounded foothills	TBC	TBC	Single channel, low sinuosity, moderate adjustment capacity	Sculpted run, scalloped banks, disconnected floodplain pockets	TBC	TBC	Forced incisional environment encouraged by increased connectivity from upstream channelised fills through discontinuous watercourses. Incisional environment limits instream geomorphic features due to efficient flushing of sediment through channel. Widening through bank slumping. Disconnected from floodplains. Incision causing vertical adjustment, with subsequent lateral adjustment from bank failures.	Moderate to High - Bedrock and incised margin limits capacity for lateral adjustment. Bank failures are reworked and does not resulting in significant lateral adjustment. Further adjustment likely to occur through headcuts upstream and further downstream incision.
Partly confined, bedrock controlled, discontinuous floodplain, meandering, discontinuous channel	Partly confined/rounded foothills	TBC	TBC	Single channel, passive meandering, low - moderate adjustment capacity	Sculpted runs, discontinuous floodplains with wetlands.	TBC	TBC	Limited diversity of instream features due to the passive meandering nature of the stream. Naturally formed streams meander across partly confined valleys, connecting upstream and downstream depositional environments. Low to moderate adjustment capacity across valley floor during high flow events. Discontinuous floodplains with wetlands accreting from overbank deposits.	Low to moderate – Channel has the potential to incise through fine grained valley material as the landscape becomes increasingly laterally connected. Some room to adjust across valley floor. Currently a channelised trench with low adjustment occurring. Bedrock limits adjustment at margins.
Partly confined, Terrace controlled, Incised channel	Partly confined/ lowland plain base of escarpment.	TBC	TBC	Single channel, low sinuosity, high	Sculpted run, terraces,	TBC	TBC	Incisional environment leads to limited instream geomorphic, features due to efficient flushing of sediment through channel. Terrace constraints limit	High – High capacity for further vertical adjustment as an upstream culvert concentrates flow from

				adjustment capacity	disconnected floodplain			lateral adjustment, but fine grained valley fill sediment allows for wholesale vertical adjustment. Fluvial terraces with disengaged floodplains represent periods of channel incision and subsequent lateral adjustment.	upstream. Further lateral adjustment due to extremely high banks is likely in future as the stream continues to incise.
Partly confined, bedrock controlled, floodplain pockets, meandering channel	Partly confined/ base of escarpment	TBC	TBC	Single channel, meandering, low - moderate adjustment capacity	Runs, pools, riffles disconnected floodplains, backswamps	TBC	TBC	Limited diversity of instream geomorphic features as fine grained material is flushed through system due to limited capacity for in channel deposition. Past incision defines the current extent of floodplain pockets with vertical accretion occurring along these surfaces during high flow events. Bedrock margin limits wholesale adjustment both across the valley floor and vertically	Low to Moderate – channel is able to adjust channel position and channel dimensions on the valley floor but is ultimately controlled by terrace and bedrock margin controls.
Partly confined, Bedrock Controlled, channelised fill	Partly confined/ rounded foothills and lowland plains	TBC	TBC	Single channel, straight, low to moderate adjustment capacity	Anthropogenic channel, discontinuous floodplains	TBC	TBC	Channel has been cut through valley fill deposits, connecting previously disconnected watercourses. Sediment is able to be reworked and flushed through system. Floodplains are engaged during high flow events depending on depth of channel.	Low to Moderate – channelised trench has low sensitivity to adjustment. Imposed bedrock margins limit widespread adjustment capacity. Adjustment may occur in the vertical sense through incision into valley fill material.
Partly confined, bedrock controlled, occasional floodplain pocket meandering, channel	Partly confined/ rounded foothills and lowland plains	TBC	TBC	Single channel, meandering, low adjustment capacity	Forced runs, pools, riffles, occasional floodplain pockets.	TBC	TBC	Transitions between high and lower sloping topography allows for a diverse set of geomorphic units to be displayed within stream including runs, riffles and pools. Floodplain pockets begin to form in areas of increased accommodation space. Stream is controlled by bedrock in most instances, limiting the potential for lateral and vertical adjustments.	Low – Channel is controlled by bedrock in most instances, adjustment over contemporary management scales is very unlikely
Culvert	N/A	TBC	TBC	Piped Channel, No capacity for adjustment	N/A	N/A	N/A	Anthropogenically inserted pipe to allow flow through transport infrastructure. No geomorphic units area able to form. Pipe conveys flow from point A to point B as fast as possible creating incisional environments downstream.	None - No capacity for adjustment due to concreted underground channel being completely impervious
Partly Confined, Bedrock Controlled, Discontinuous Floodplain, Low Sinuosity	Partly Confined/ Base of Escarpment	TBC	TBC	Single channel, meandering, moderate adjustment capacity	Runs, riffles, discontinuous floodplain.	TBC	TBC	Anthropogenically altered channel forces geomorphic units such as runs and riffles along a single low sinuosity channel. Fine grained material is flushed through these reaches with coarse material deposited in the form of runs/riffles. Floodplains widen to become discontinuous for a time with vertical accretion during high flow events.	Moderate – Channel ultimately controlled by bedrock material to the North but has the ability to rework inset discontinuous floodplain and vertically incise due to the high energy, low sinuosity nature of this River Style.

Analysis of the character and behaviour of each river style allows for a place based, catchment specific understanding of the Silverdale South Catchment, the conditions in which it exists, and the diverse nature of streams that are currently operating within the Catchment. The Weiti Stream and John Creek are considerably different in terms of the conditions they operate within (imposed boundary conditions) and require different management strategies to effectively conserve and restore significant streams. To fully understand the issues that each stream faces it is critical that a whole catchment analysis is explored so that managers can put each stream in its catchment context relative to the various controls that are exerted on these streams. The Weiti Stream behaves in considerably different ways relative to John Creek due to the flux (climatic, land use) (Figure A3) and imposed boundary conditions (geologic) (Figure A1, A2) in which they operate which in turn influences the character of each stream that are observed along the valley floor. These streams therefore experience different risks in terms of the drivers and ultimately the mechanisms of erosion that they are currently/may face in the future.

From this analysis, key areas were identified which are likely sensitive to future or current erosion which require further field verification to confirm these findings:

- Partly Confined, Terrace Margin Controlled, Incised, Low Sinuosity Channel

This section of stream is located between an anthropogenic culvert and the confluence between John Creek and the Weiti Stream. This River Style has been classified as having high sensitivity to erosion due to the currently incised nature of the stream and the terrace margin controls it currently flows through. These terrace margin controls are likely made up of fine grained material and have a high likelihood to continue widening as the channel continues to incise. It is also possible for the stream to laterally adjust as the stream widens if there are no significant margin controls inset within the terrace material. This process is mainly driven by the culvert upstream which has concentrated flow into a channel which was not suited to the flow regime forced by the culvert. This has caused incision into the channel and is the key process that must be addressed when considering management solutions/scenarios.

- Partly Confined, Bedrock Margin Controlled, Incised, Low Sinuosity

This section of stream is located upstream of an anthropogenic culvert structure and drains upstream disconnected landscapes along John Creek. This River Style has been classified as having moderate to high sensitivity due to the incised nature of the stream. The culvert downstream provides a barrier to further incision downstream. However, the main risk for erosion is through headcut propagation upstream into currently discontinuous streams which store large amounts of sediment through limestone dominated valleys. There is minimal possibility for the stream to move laterally due to hillslope margin controls on either side of the stream but there is a high likelihood this section of stream will continue to adjust vertically. This process has likely been driven by the increased longitudinal connectivity streams have seen over contemporary history and the bedrock controls which have not allowed the stream to dissipate energy laterally across wide floodplains and rather has concentrated flow into the bed of the fine-grained stream. The processes that drive incision essentially force the incised morphology of the stream and should be addressed when considering management solutions for John Creek.

- Partly Confined, Bedrock Margin Controlled, Discontinuous Floodplains, Meandering Channel

This section of stream is located in the lowland plains of the Weiti Stream and begins immediately after a culvert drains flow from the Upper Weiti Stream. This River Style has been classified as having moderate sensitivity to adjustment. The area of concern is the upstream part of this River Style which is heavily influenced by the concentration of flow from the culvert installed underneath

transport infrastructure. This section of stream is exceedingly steep for the morphologies that are currently displayed and wholesale adjustment is expected to occur in the form of incision at some point in the future as banks become too steep. Bedrock margin controls provide some form of resistance to incision and subsequent lateral adjustment that is expected with abandoned floodplains (terraces) providing the control on the true right bank. This steepening process is being driven heavily by the concentration of flow being discharged from the culvert which diverges from historical flow regimes, exceeds critical shear stress relationships, and causes incision. These processes which are driving incision and geomorphic change, forcing the stream away from its natural capacity should be addressed upon implementation of management strategies.

- Partly Confined, Bedrock Margin Controlled, Discontinuous Floodplain, Low Sinuosity

This section of the stream is located along the Weiti Stream in the mid catchment and represents a transition zone between relative areas of available accommodation space upstream and downstream. This River Style has been classified as having moderate sensitivity to adjustment due to the low sinuosity nature of the channel and active floodplains on both the true left and right bank stored sediment that is available to be immediately reworked. This stream has been heavily altered by land use change and has possibly been rerouted which has caused the low sinuosity nature of the stream within an inset floodplain. Managers should be aware that there is a possibility that this part of the system is particularly sensitive to perturbations such as storm events in which geomorphic thresholds are crossed. During these events it is possible the stream will adjust instantaneously as to revert to equilibrium settings or force new equilibrium settings based on the new boundary conditions it is subject to. The river is able to adjust both vertically and laterally which managers should be informed about before attempting to apply management strategies to a section of stream that is inherently different to others that are found within the catchment.

- Partly Confined, Bedrock Margin Controlled, Channelised Fill

These sections of stream are located along John Creek and are representative of channels which have been dug by farmers through previously disconnected watercourses, characteristic of swampy wetland areas. This River Style has been classified as having low to moderate sensitivity to adjustment in the contemporary sense but have the ability to flush out large amounts of sediment if headcut processes link up with what are naturally disconnected riverscapes which are in accumulation regimes. Due to the large amount of erodible and fine grained material stored upstream of downstream headcut processes it is essential that managers conserve this area to ensure that currently stored material is not engaged and flushed out of the system. These rivers are currently able to adjust vertically if threshold conditions are met during perturbations, but due to the low sloping topography adjustment is not likely to happen in the near future. It would be encouraged for managers to take into account the potential for sediment to be conveyed out of this system if longitudinal connectivity continues to increase and ensure this does not take place in the future.

As outlined previously further work is required to complete a stage one River Styles Analysis of the Silverdale South Catchment. Field verification is critical to be able ground truth the desktop analysis that has been undertaken using a hillshade layer within ArcPro. The desktop analysis is not able to pick up on key geomorphic units that are hidden beneath canopy cover and it is difficult to correctly interpret geomorphic transitions between various River Styles which are displayed along the valley floor. Along with field verification, a hydrological model which is in the process of being developed by the Lifecycle Team is also critical in verifying the hydrological regime at different points in the catchment. Once field verification and hydrological regime analysis has taken place, council staff will be able to complete Stage One to the required standard as outlined in Brierley & Fryirs (2005) and begin to consider and make sound management decisions which

consider the geomorphic diversity of rivers and the unique steps to applying conservation and restoration efforts to individual river types.

Appendix:

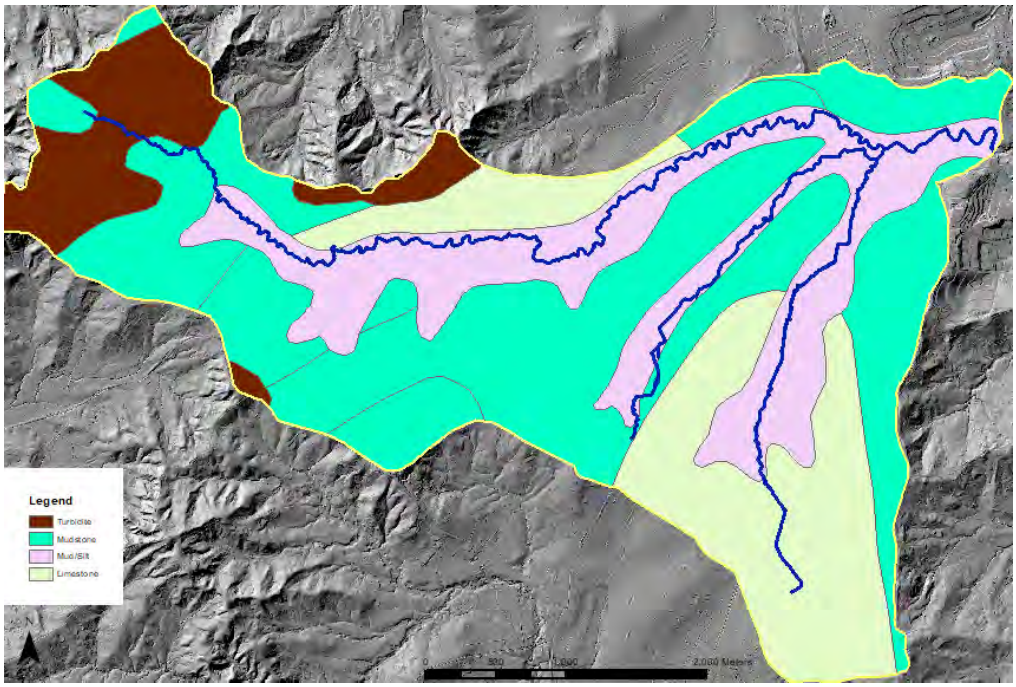


Figure A1: Geological Map of the Silverdale South Catchment

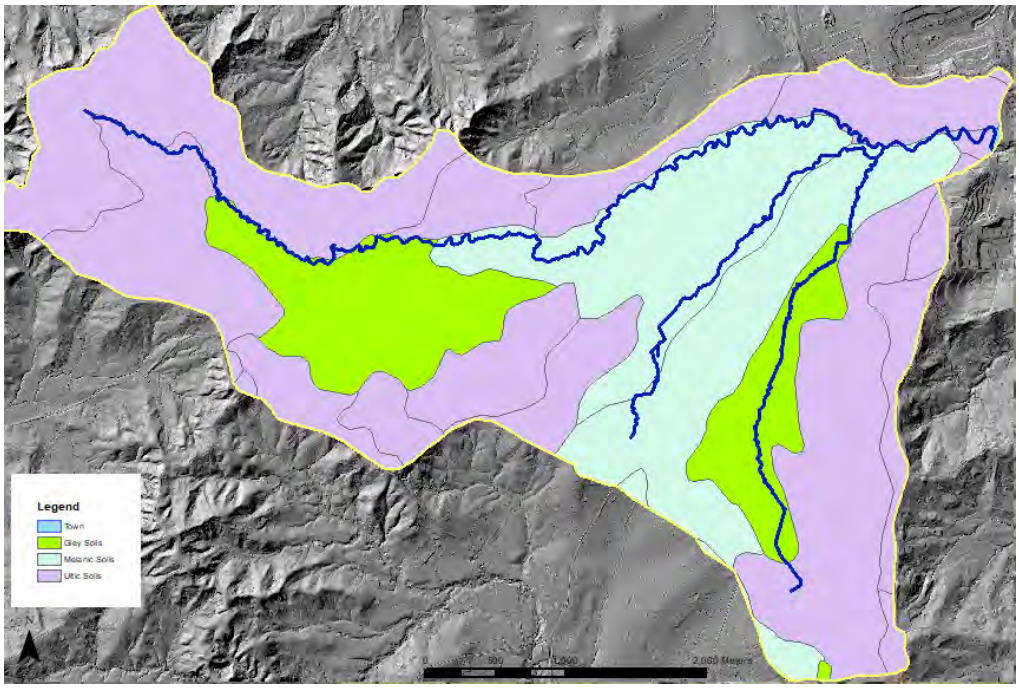


Figure A2: Soil Type Map of the Silverdale South Catchment

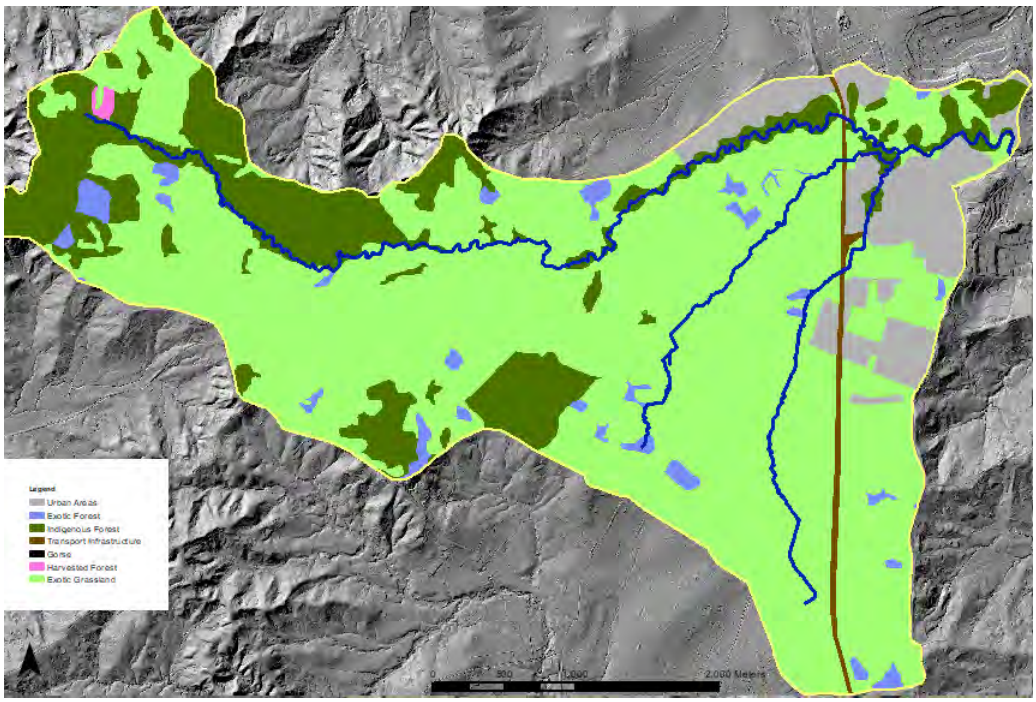


Figure A3: Land Use Map of the Silverdale South Catchment