

Scenario Projection Modelling for Stochastic Water Valuation

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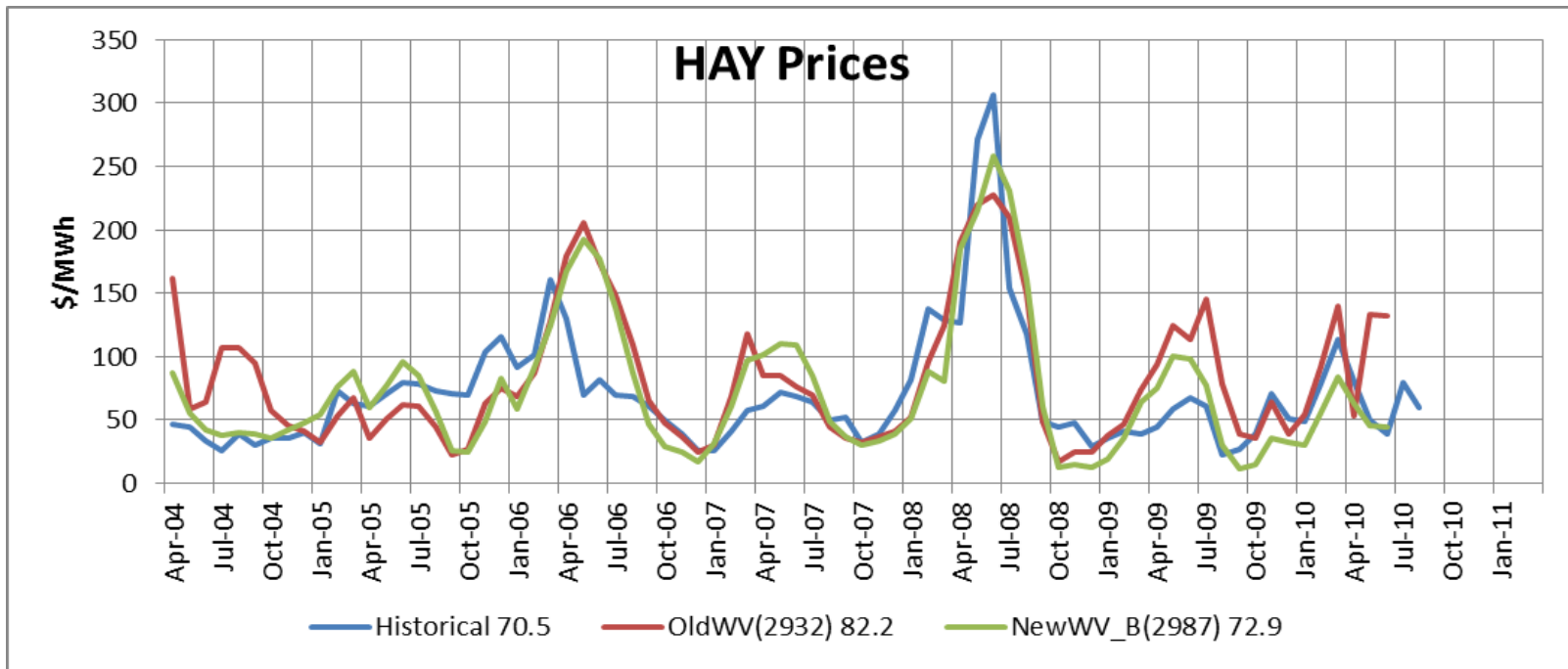
Energy Link Ltd

EMarket

- Energy Link's forecasting model for the NZEM
- A multi-node model
- Used by Energy Link and a number of major market participants
- The water valuation model was upgraded in 2010/11
- The new water value model has been tested by 'backcasting' and by running it alongside the current version of SPECTRA

WV Calculation Upgrade

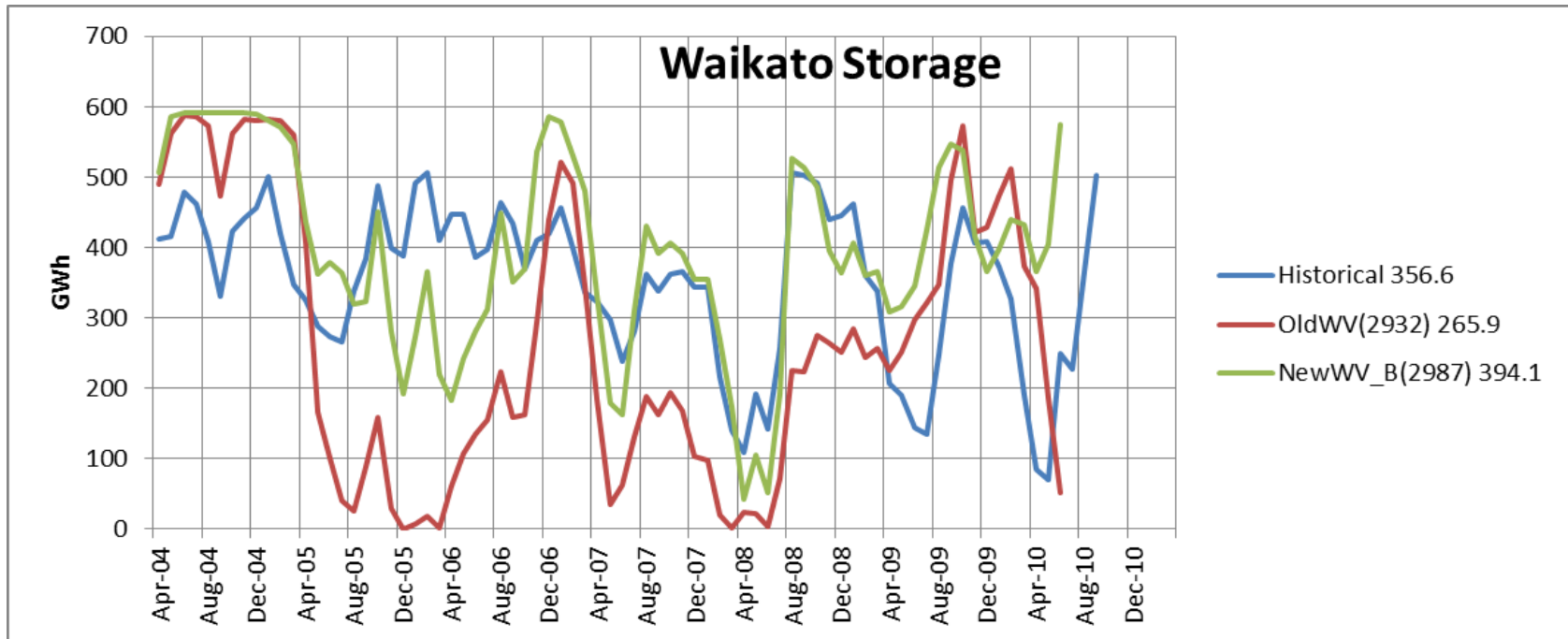
- Give a more realistic assessment of price risk / volatility



*For a comparison refer to EPOC 2009 presentation:
Winter 2008: A Meridian Perspective (ppt) – Grant Telfer*

WV Calculation Upgrade

- A more accurate model of individual participant behaviour



Features of the new Water Valuation Model

- Water value is a function of three parameters: time, local storage and other storage.
- Essentially a Stochastic Dynamic Programming model
- Has a significant adaptation – models serial inflow correlations

Stochastic Dynamic Programming

- SDP can be used to search for a water value function that meets a necessary condition for optimality:

Given a water value function $MWV(t, s)^$ that is used for short term operational optimisation, then $MWV(t, s)$ should equal the expected marginal benefit of storage over all possible futures*

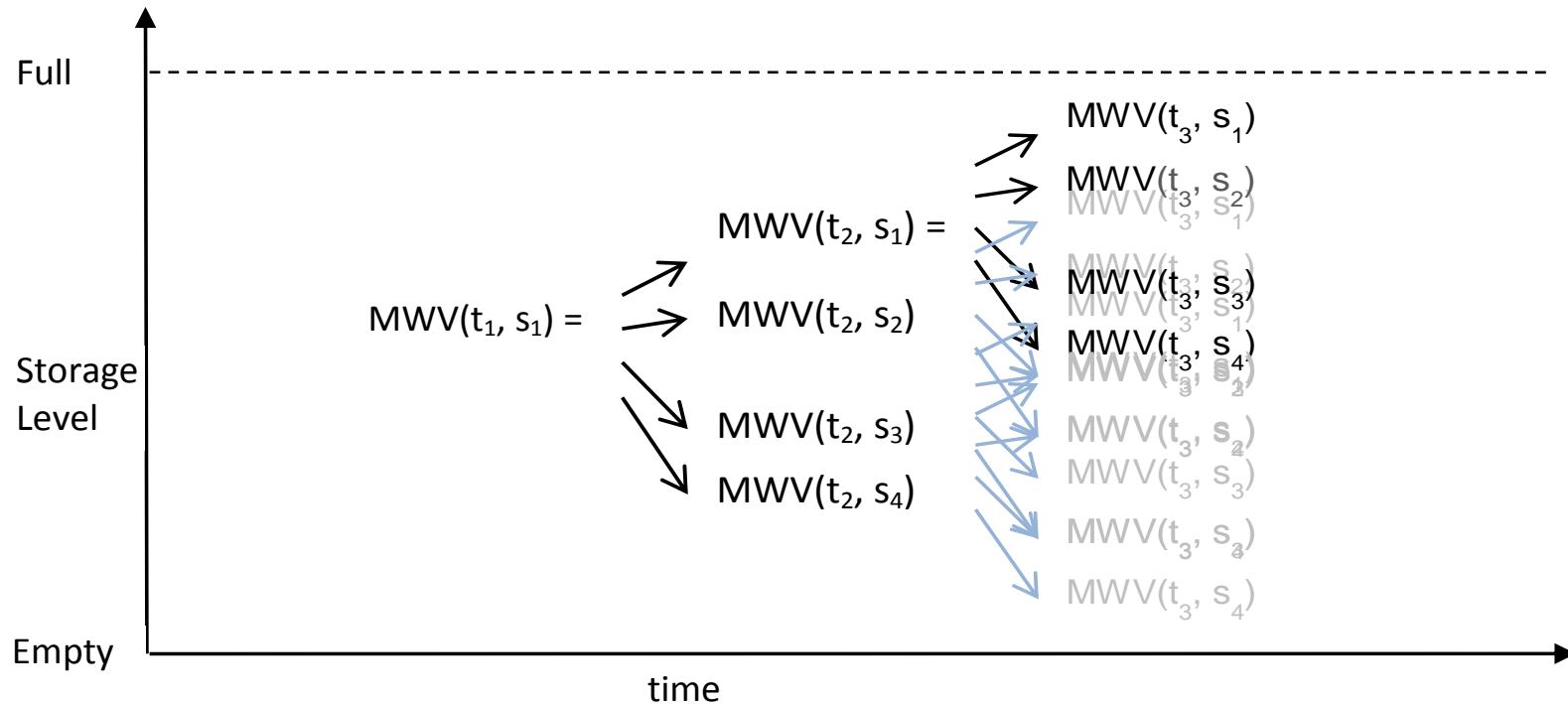
- SDP solves this problem by breaking it into time steps

* t = time, s = storage configuration

Standard SDP

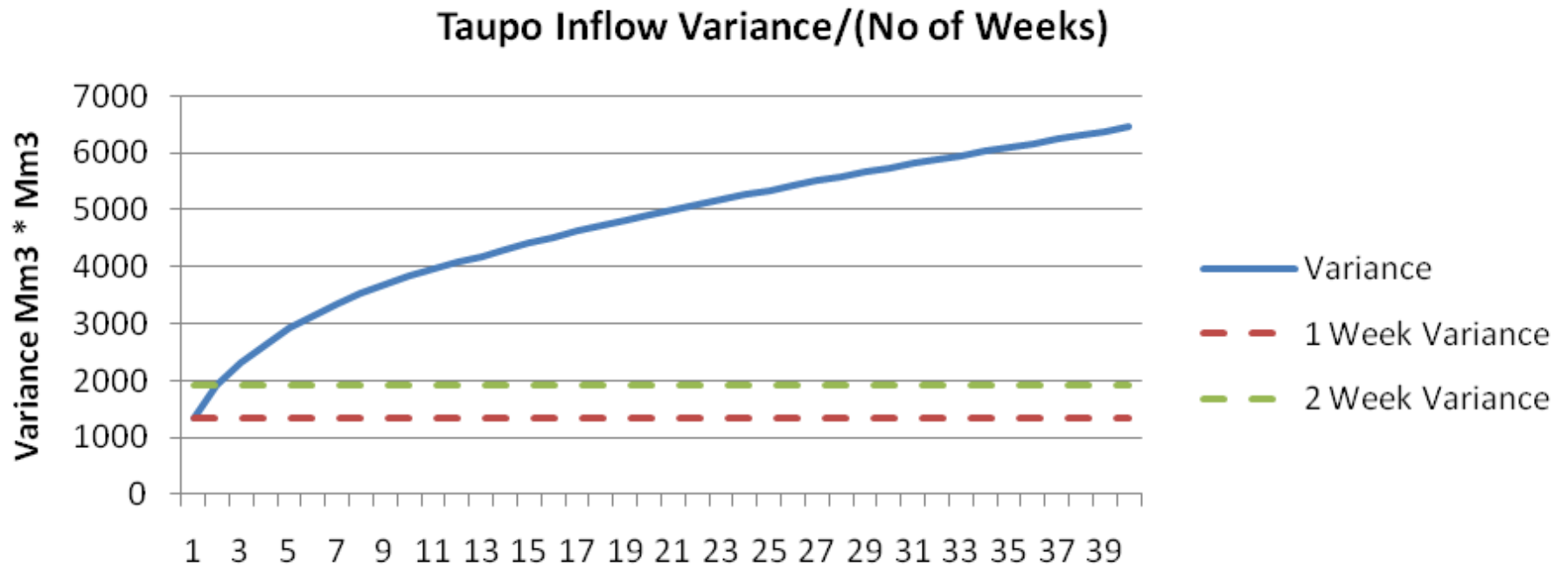
- Where storage is unconstrained (neither full nor empty) water can be conserved without cost, so
$$\text{MWV}(\text{today}) = \text{Expected} [\text{MWV}(\text{tomorrow})]$$
- SDP calculates MWV's for each time t_n from the MWV's in t_{n+1} .
- The stochastic aspect of SDP is the use of a statistically representative set of scenarios to step from t_n to t_{n+1}
- But, any statistical relationship between time periods is lost

SDP – the implied projection of WVs



- The MWV at t_1, s_1 are the weighted average of future MWVs using the probability of reaching those future values along random walks.
- Due to the step by step nature of SDP these random walks are Martingale sequences – which inflows are not

Serial correlation in Inflows



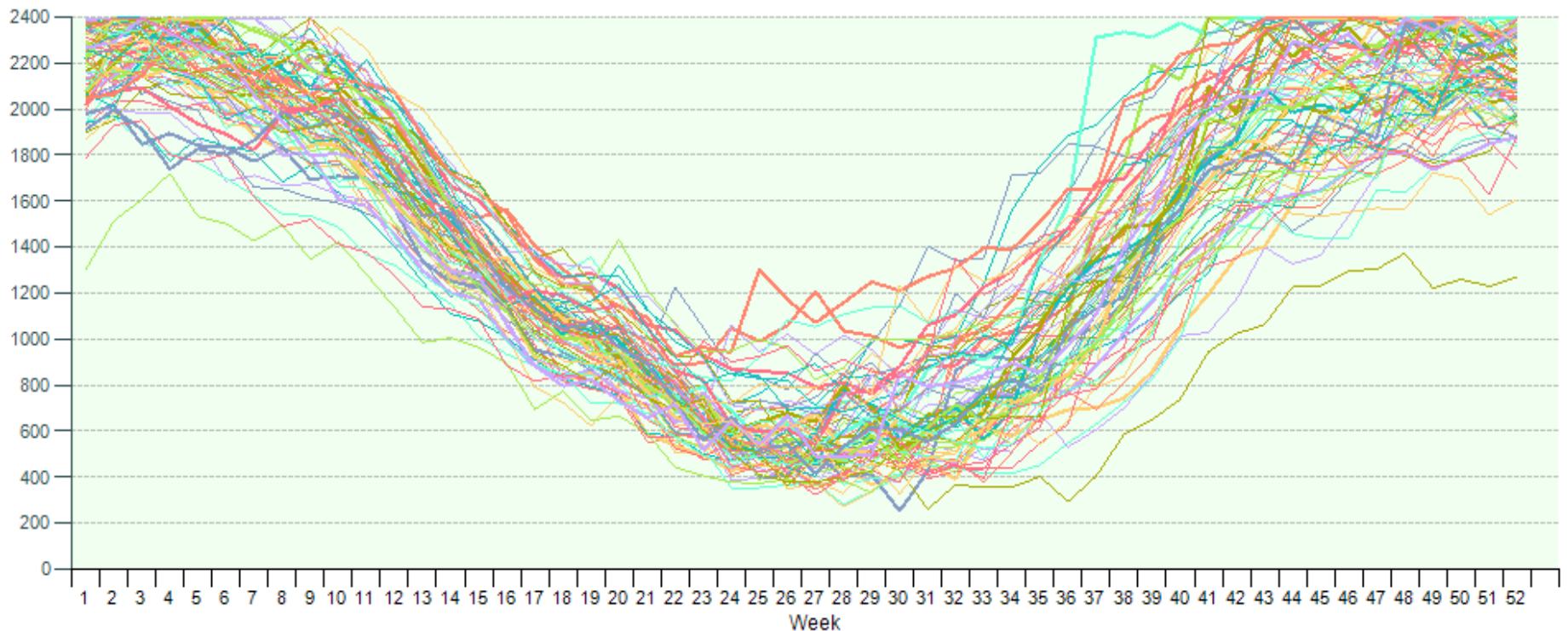
- Variance / time would be constant if weekly inflows were uncorrelated

Serial Correlation in Inflows

- Inflows in New Zealand are notably serially correlated
- Modelling water values and shortage risks while ignoring this correlation is potentially very misleading

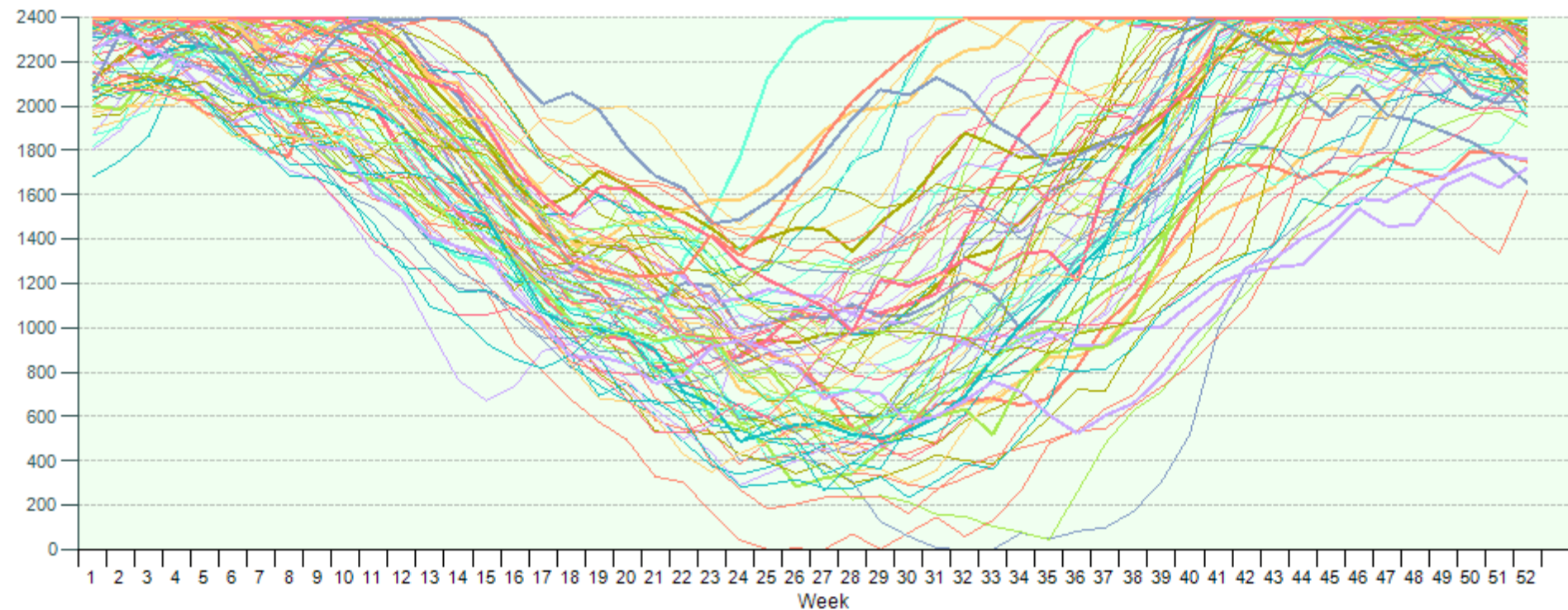
To illustrate this the following slides show the results of modelling total South Island storage with two sets of inflows

Modelling Results with Shuffled Inflows



The inflows for this run have been shuffled so the distributions are the same in each week, but the correlations between weeks have been removed

Modelling Results with Natural Inflows



The inflows used in this run are not shuffled

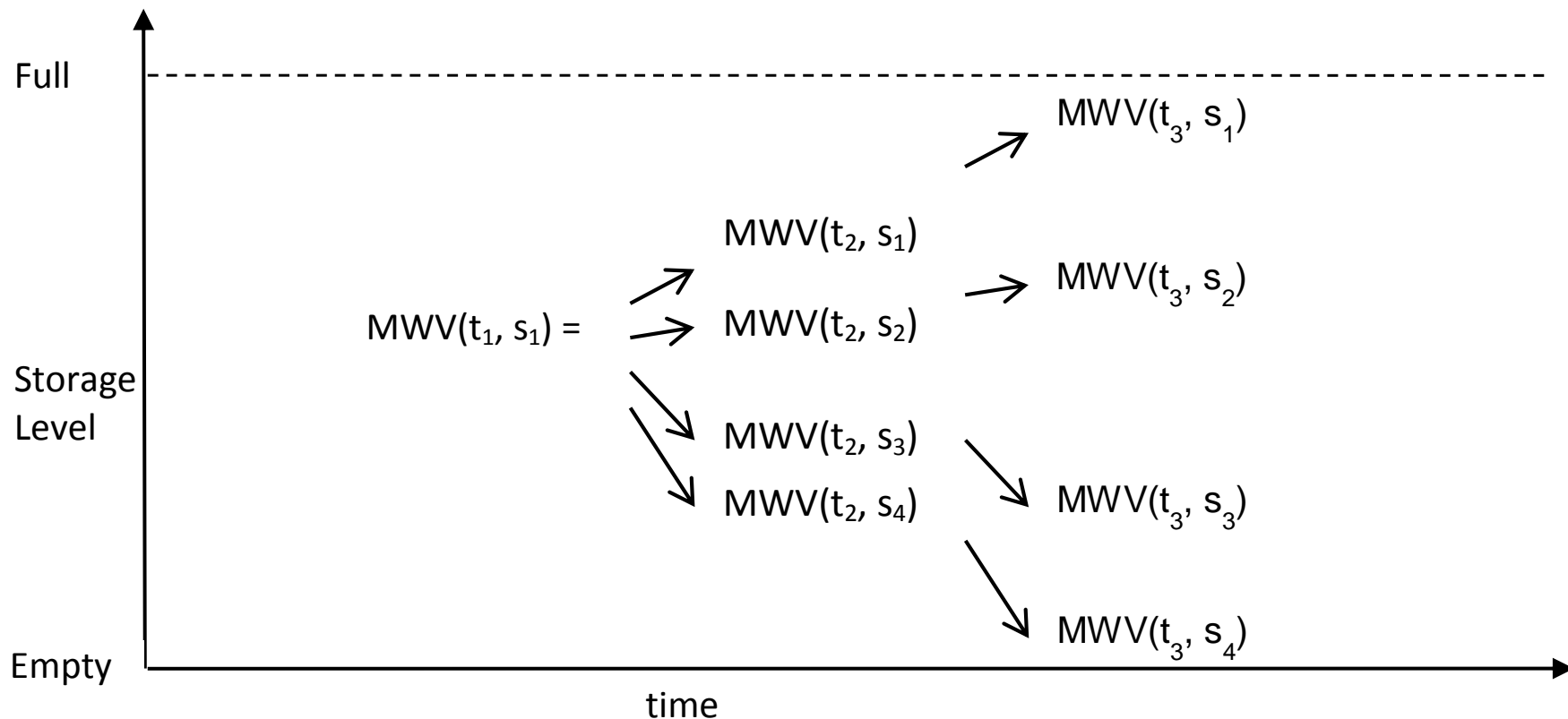
It is clear that the risk of shortage (and overflow) was grossly underestimated in the first model

MWV Calculation with 'Scenario Projection'

The SDP in EMarket is modified so that, for each time step t and storage configuration s (*local x other storage*):

1. $MWV(t, s, k)$ is calculated for each inflow scenario k , using the $MWV(t + 1, s'(k), k)$ values (s' is the projected storage using scenario k).
2. Expected $MWV(t, s)$ is the average $MWV(t, s, k)$ over k
3. Expected MWV is then used to determine the operation of the system (giving new $s'(k)$ values)
4. Steps 1, 2 and 3 are repeated until MWV is solved for.

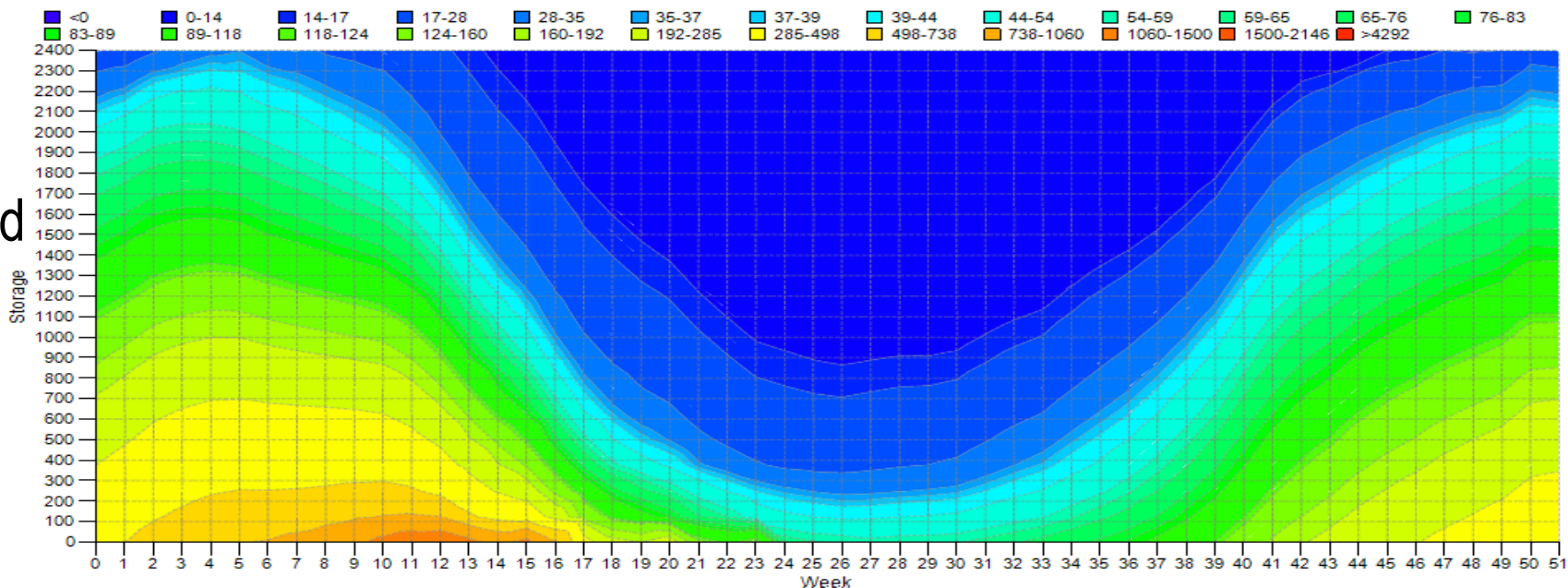
Value propagation in EMarket WV (SP) SDP



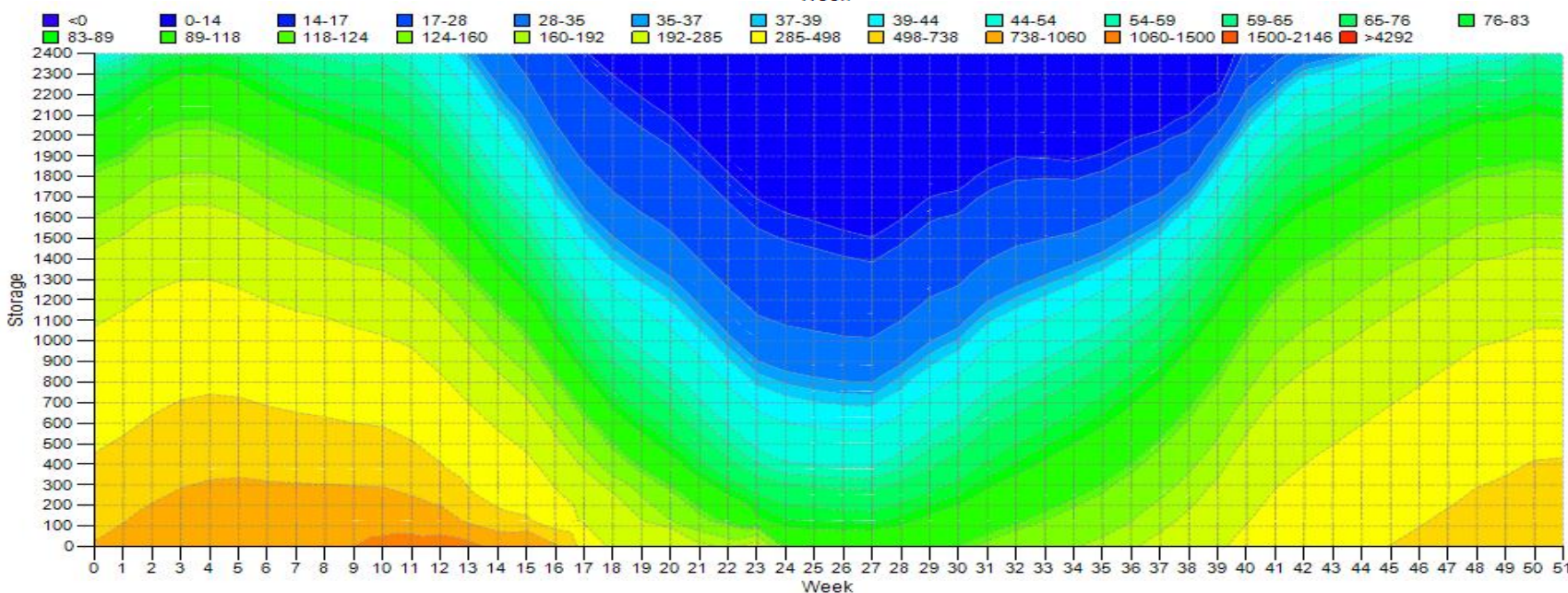
The MWV at t_1, s_1 are the average of future MWVs, each projected using a single scenario until convergence is reached (storage full or empty)

Results – WVs for Waitaki, Other Storage 75%

Standard
SDP

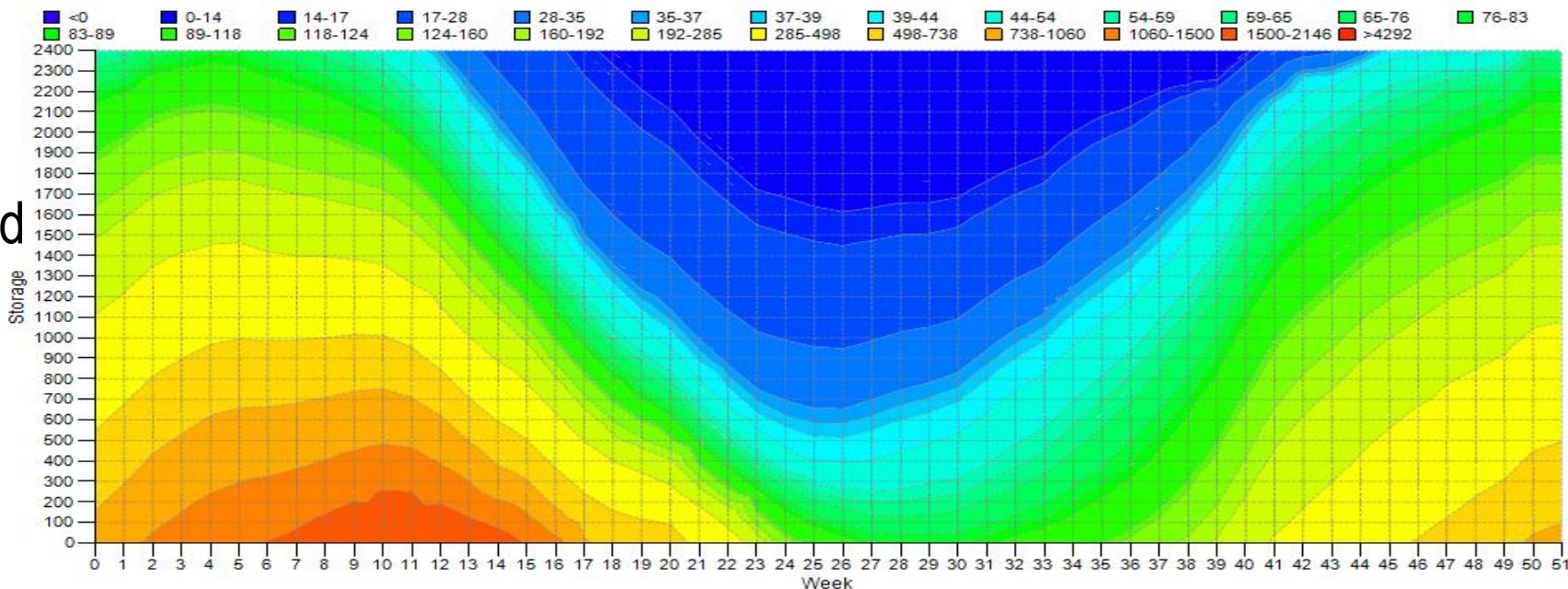


SP
SDP

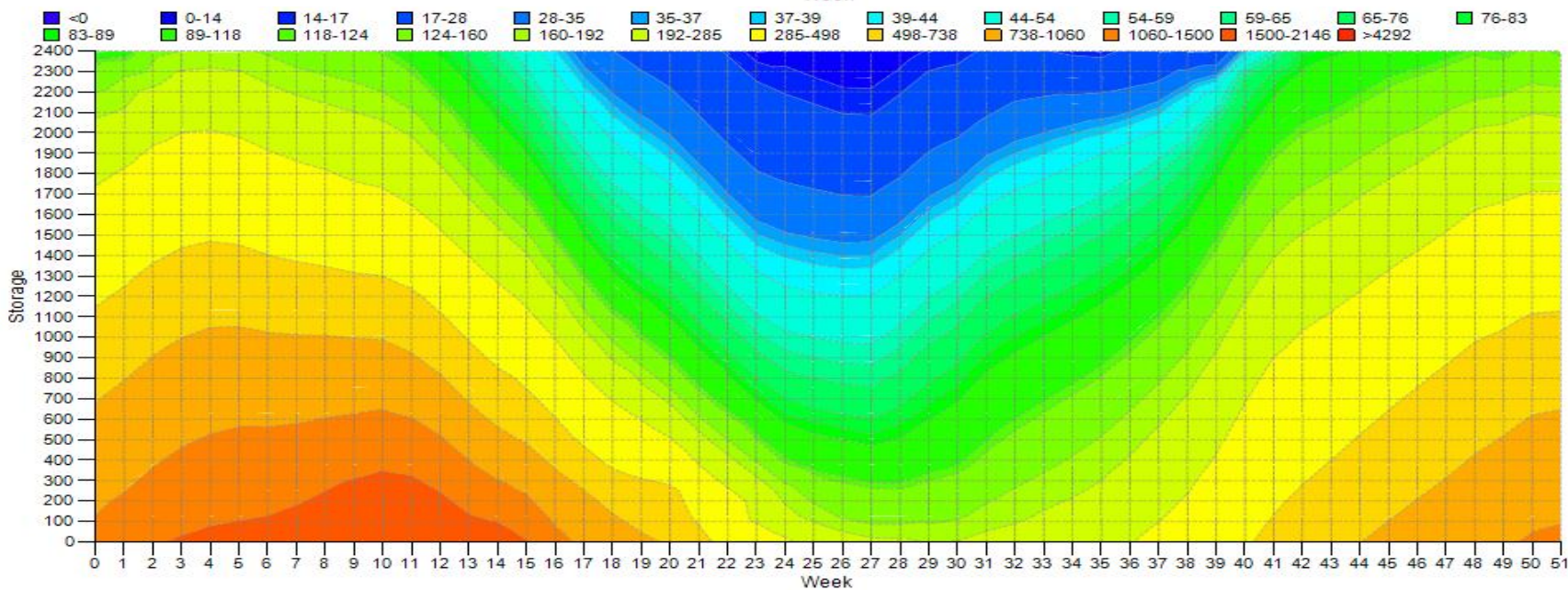


Results – WVs for Waitaki, Other Storage 25%

Standard
SDP



SP
SDP



An Overview of Scenario Projection

- SP is a theoretically sound method, requiring some reasonable assumptions about operator behaviour
- Whereas SDP normally models an exponentially large tree of future paths, SP restricts this to a sample set of future paths
- Convergence is more difficult to achieve than in a standard SDP
- SP models risk using a sequence set and requires no further assumptions about the statistical nature of the sequences
- To date the SP method has produced realistic WV's for EMarket

Thank you