DESIGN LOADING RATES – ORIGINS and DEVELOPMENT in ON-SITE WASTEWATER MANUALS and STANDARDS

Introduction

This paper reviews the origins and development of design loading rates for on-site wastewater land application systems in New Zealand. Initial requirements for sizing septic tank effluent trenches were based around US Public Health Service (USPHS) guidelines where system sizing criteria were linked to clean water soakage rates in minutes per inch recorded from a subsoil percolation test. As deficiencies in the percolation test approach were evaluated by research and field studies in the US, design loading rates became set according to soil texture classes. This approach then expanded to take account of first, both soil texture and structure, and second, improved effluent quality as secondary treatment systems became available for on-site wastewater management.

NZ standards, manuals and guidelines have evolved over the years as follows:

- CP44:1961 Disposal of Effluent from Household Septic Tanks (NZ Standards Institute Code of Recommended Practice)
- NZS 4610:1982 Household Septic Tank Systems (NZ Standard – Standards Association of NZ)
- TP58 1989 On-site Wastewater Disposal from Households and Institutions (Auckland Regional Water Board Technical Publication No. 58)
- TP58 1994 On-site Wastewater Disposal from Households and Institutions (Auckland Regional Council Technical Publication No. 58, Second Edition)
- AS/NZS 1547:2000 On-site domestic wastewater management (Standards Australia, Standards New Zealand)
- TP58 2004 On-site Wastewater Systems: Design and Management Manual (Auckland Regional Council Technical Publication No. 58, Third Edition)
- AS/NZS 1547:2012 On-site domestic wastewater management (Standards Australia, Standards New Zealand)
- GD006 2018 Guideline Document: On-site Wastewater Management in the Auckland Region (Auckland Council Guideline Document 2018:006, Draft for Consultation)

Pre-1980s Developments

USPHS

During the 1930s Henry Ryon, a Sanitarian in New York State, developed a simple percolation test using clean water in a standard dimensioned hole in the subsoil to measure the rate at which clean water drained out of the test hole. The decrease over time of the water level in the test hole was converted to a soakage rate in minutes per inch. Ryon then carried out a programme of percolation testing for existing septic effluent soakage trench installations to check subsoil clean water soakage rate against trench performance for actual trench loading rates. This enabled him to plot a relationship between effluent hydraulic loading rate in US gal/ft^2/day against time for water to fall one inch where the resulting curve defined the boundary between failing trench systems (points above the curve) and non-failing systems (points below the curve).

During the 1950s the USPHS extended Ryon's work via extensive studies of "trouble-free" and "troubled" systems with the resulting plotted data (Figure 1) being used to develop a loading rate curve along with tables for sizing septic tank effluent trenches, seepage beds and seepage pits. This led to the publication of the USPHS Manual of Septic Tank Practice in 1957 with a revised version issued 1967 (Ref. 1).

Figure 2 from the USPHS Manual (Figure 19) was set up for sizing "soil absorption areas" for institutions, recreational areas and other establishments where design capacity was based on flow rather than population. It is almost identical to the Ryon/USPHS curve of Figure 1 developed from field investigations.

Figure 1: Ryon's Percolation Test Data versus USPHS Data [Ref. 2]

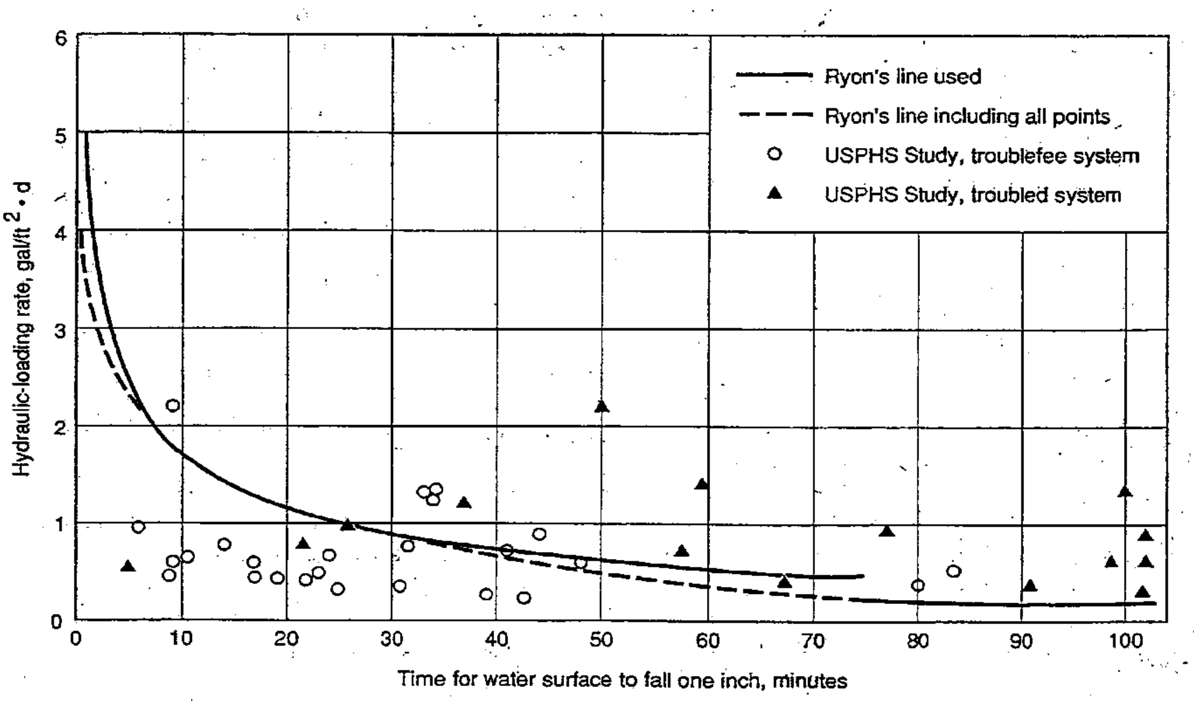


FIGURE 14-20
Permissible hydraulic loading rates for subsurface soil absorption systems for various percolation rates [31].

Figure 2: USPHS 1967 Design Loading Rates versus Percolation Test Results [Ref. 1]

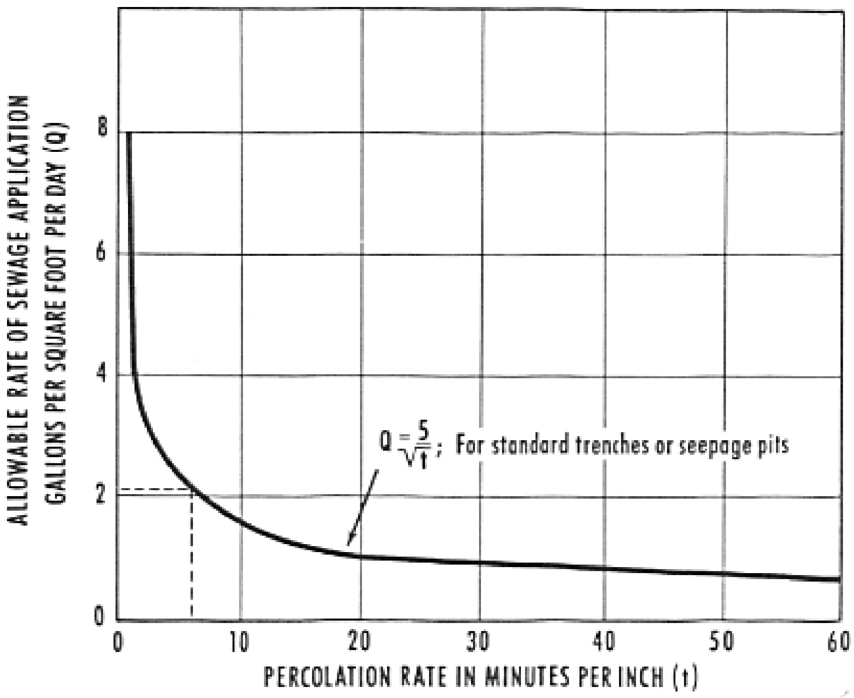


Figure 19.—Graph showing relation between percolation rate and allowable rate of sewage application.

For households the design approach was based on a table of percolation rates versus design area in square feet per bedroom (Table 1). The USPHS Manual does not outline the population basis nor the daily flow volume on which the absorption area per bedroom is based.

Table 1: USPHS Absorption Area Requirements for Individual Residences[1]

Percolation Rate (time required for water to fall one inch, in minutes)	Required absorption area in sq. ft. per bedroom	Percolation Rate (time required for water to fall one inch, in minutes)	Required absorption area in sq. ft. per bedroom
1 or less	70	10	165
2	85	15	190
3	100	20	250
4	115	45	300
5	125	60[2]	330

1. Provides for garbage grinder and automatic clothes washing machines.
2. Trenches unsuitable as absorption systems for percolation rates over 60 minutes per inch

New Zealand Standards Institute

In 1961 the NZ Standards Institute published its Code of Recommended Practice (CRP) for the disposal of effluent from household septic tanks (Ref. 3). One amendment was added in 1962 and then the CRP was reprinted by the Standards Association of NZ several times from 1968 through to 1977.

The sizing requirements for trench bottom areas (and seepage pit sidewalls) was based on a table of sq. ft. per bedroom for subsoil percolation test results as per Table 2.

Table 2: CRP:44 TABLE A
Factors for Determining Absorption Area[1]

Percolation Rate (time in minutes required for water to fall one inch,)	Required absorption area in sq. ft. per bedroom	Percolation Rate (time required for water to fall one inch, in minutes)	Required absorption area in sq. ft. per bedroom
2 or less	85	15	190
3	100	30	250
4	115	45	300
5	125	60	330
10	165	Over 60	Unsuitable for shallow absorption system

1. With both garbage grinder and automatic sequence washer.

It is clearly evident that Table 2 mimics almost exactly Table 1 so that design sizing criteria for both US practice and NZ practice are the same. No adjustment has been made for the difference in design flow values in which US gallons are 83% smaller than Imperial gallons so this would appear to overload the trench system. However, this discrepancy is likely compensated for by the fact US householders produce higher per capita on-site wastewater flows than NZ householders.

1960s LTAR Research, University of California

The prescriptive approach in sizing effluent trenches according to percolation test results was found inadequate in preventing high failure rates through the 1950s into the 1960s both in the US and NZ.

In the early 1960s research into trench failure mechanisms at the University of California, Berkeley, established the significance of infiltration surface clogging mats and led to an understanding of the concept of “long term acceptance rate” (LTAR). LTAR represented the infiltration rate through the biological slime developed via soil bacteria on the design surface to which effluent is applied. The default rate regardless of soil texture was assessed at around 10mm/day or 0.25 US gal/ft^2/day which is the bottom of the Ryon/USPHS curve of Figure 1. This led the research team at Berkeley to conclude that given the “vagaries associated with identification and classification of soils based on limited field testing, the variability of most soils, the variability of the percolation test results and the minimal maintenance that most on-site systems receive” then a single hydraulic loading rate of 10mm/day regardless of soil permeability should be used (Ref. 2).

Subsequent extensive research by several of the land-grant universities throughout the US led to changes in State rules for design and location of on-site wastewater systems, and provided community support for rural residential on-site wastewater development via Extension Services. Some of these research and extension service efforts, such as the Wisconsin Small Flows Project, extended over many years and led to development of alternative wastewater pre-treatment technologies and land-application ("disposal") system methods. The US Environmental Protection Agency (USEPA) then produced a comprehensive design manual in 1980 incorporating current research results and practices, and set up the National Small Flows Clearinghouse (NSFC) at the University of West Virginia as a technical advisory and information service.

1980s Developments in NZ

A New Standard to Replace CP44.
Both New Zealand (and Australia) in the 1950s and 60s based their on-site wastewater practice on the prescriptive approach of the US Public Health Service (USPHS) manual. Septic tanks and soakage trench systems enjoyed no better success rate than in the US (nor Australia), and in 1968 the Health Department recommended the phasing out of on-site systems in urban fringe area development as well as rural residential villages and small towns, and advocated that full sewerage services be provided. Septic tank systems were seen as but a temporary servicing measure until sewers came along. A Government subsidy scheme was introduced to facilitate the replacement of on-site systems.

However, the prevalence of rural residential lifestyle developments meant a continuing role for on-site systems, and in 1982 a new standard for household septic tank systems was produced (Ref. 4). This replaced the approach of the earlier USPHS-based code in order to move the industry away from the prescriptive percolation test design sizing approach for septic effluent trenches into a design approach based on assessment of soil and site constraints. NZS 4610:1982 was produced for un-constrained soil and site conditions, with a design manual approach recommended for all other situations. However, only the US Environmental Protection Agency (USEPA) design manual was available through the 1980s, and designers and regulators fell back on old prescriptive habits.

Findings from 1984 Study Tour
During a 13-month study tour the author accumulated extensive information on design and management practices throughout North America. This was facilitated by information from the National Small Flows Clearinghouse (NSFC) set up as a technical advisory and information service by the USEPA at the University of West Virginia. Dozens of meetings were held with researchers, federal, state and county regulators, consultants involved in design and installation, and sanitarians responsible for inspections and oversight of operation and maintenance. The findings of the study tour subsequently led to the commissioning of a NZ design manual (TP58) by the Auckland Regional Water Board (Ref. 5).

Design loading rate information observed during the 1984 study tour was adapted for use in TP58. For example for trench systems a summary of DLR values based on soil texture assessment is set out in Figure 3. The 12 US agency values show a range between very conservative (loading line E) to much less conservative (loading line A). The 1982 NZS 4610 Standard at loading line C sits in the centre of the range between least conservative and most conservative.

For TP58 the author took the range of values in the US data and prepared a set of loading values at both "most conservative" and "least conservative" to draw up Fig. 8.1 (Figure 4 below). The 1989 1st Edition of TP58 applied the "least conservative" values to combined trench bottom plus sidewalls. The 1994 2nd Edition stated that the DLR values applied to sizing the bottom area of the trench and allows for the fact that sidewall seepage will occur when rising effluent levels pond in over the bottom infiltrative surface (such as during dose loading or under wet weather conditions). TP58 (1994) went on to state that the range between "least" and "most" conservative allows the designer to add in a factor of safety as may seem appropriate in any particular situation, or to make an adjustment to allow for improved effluent quality. Sidewall infiltration is not entered into the design calculation, but acts as a factor of safety against sealing of the trench bottom area. Narrower trenches provided a higher ratio of sidewall to bottom area, and hence can be loaded at the "least" conservative rates.

Figure 3: Trench Design Loading Rates and Soil Texture – 1984 US Study Tour

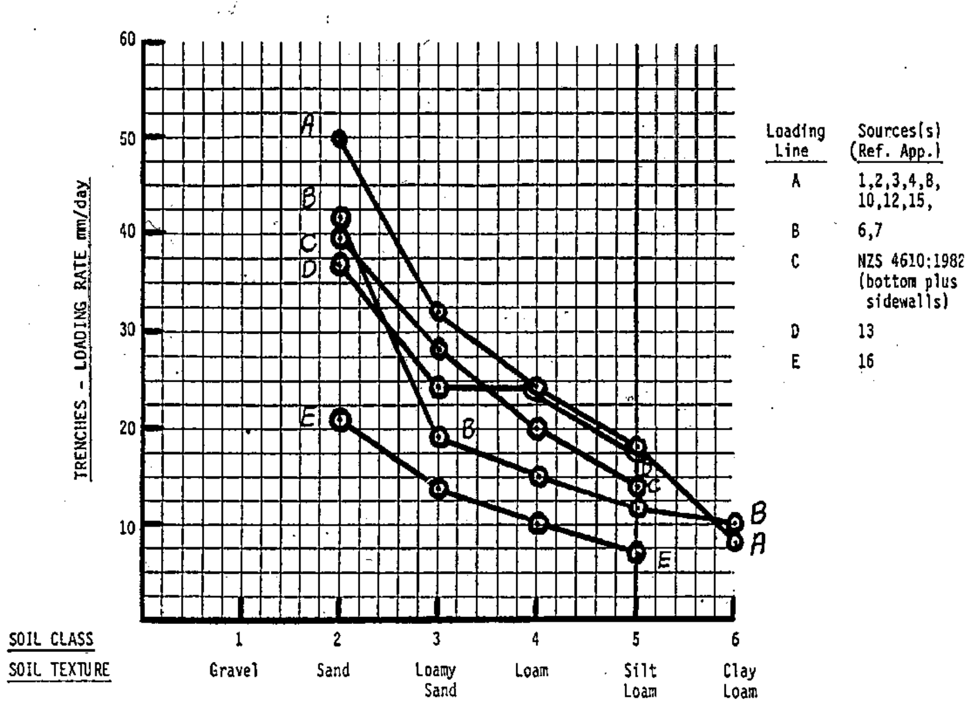
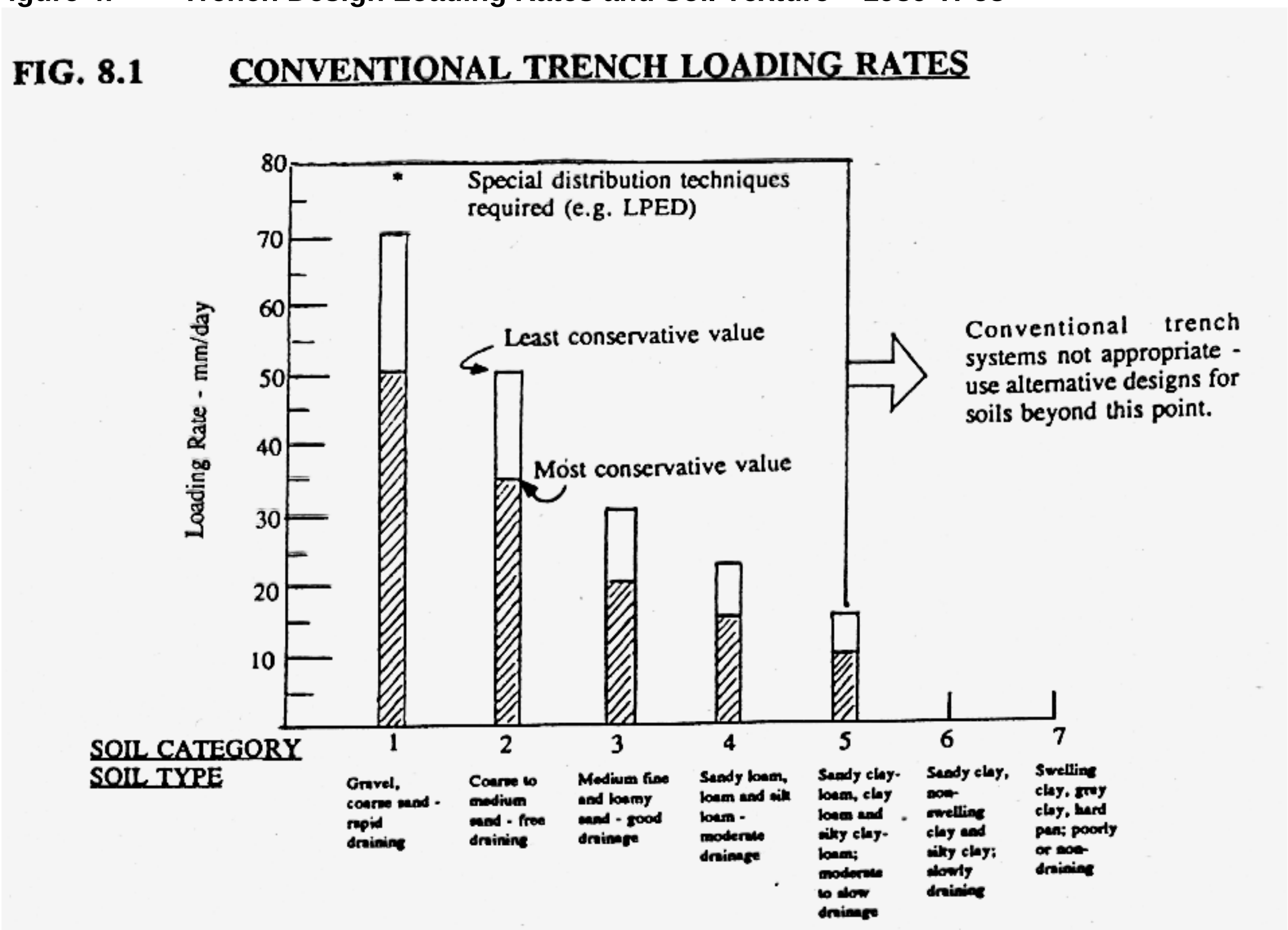


Figure 4: Trench Design Loading Rates and Soil Texture – 1989 TP58



1980s Developments in Australia

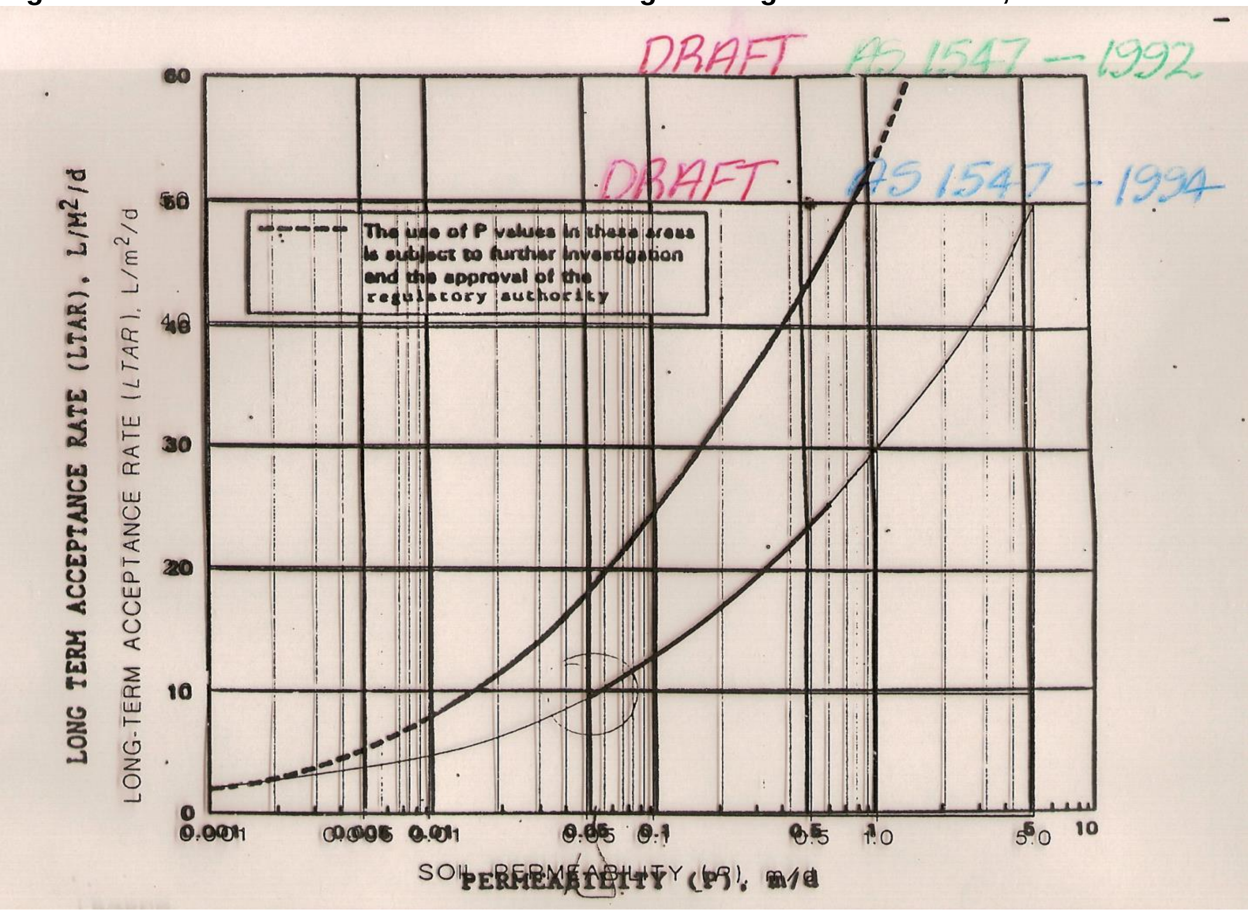
Australian on-site wastewater practice through the 1950s and 60s followed the prescriptive approach of the US. However, local problems of high failure rates led to two major studies in the 1970s and 1980s. Joost Brouwer completed his PhD on an investigation into existing septic tank systems around Melbourne, linking soil permeability test results (K_{sat} values) to failure rates, a more scientifically valid approach to that taken by Henry Ryon. Little of this work translated into amended design approaches outside of Victoria. In 1986 the Caldwell Connell 4½ year investigation into on-site systems in Western Australia concluded that conventional soakage systems could sustain loading rates of 10 to 20mm/day, relatively independent of soil type. This supported the LTAR clogging mat findings of the 1960s Berkeley research, and confirmed the “most conservative” design loading rate for developed clogging layers of 10mm/day. At the end of the 1980s Standards Australia initiated a review of on-site domestic wastewater practice with the aim of producing a new Standard.

Australia New Zealand Development of Joint Standard AS/NZS 1547 On-site Domestic Wastewater Management – 1994 to 2000

Background

During the early 1990s Standards Australia carried out development of a new Standard for on-site wastewater systems subsequently published as AS 1547:1994 “Disposal Systems for Effluent from Domestic Premises”. Sizing criteria for trenches adopted a prescriptive approach utilising the data points from Joost Brower’s Victorian investigations along with the findings from Western Australia re the significance of LTAR to set LTAR values against soil permeability. The initial design sizing curve in the 1992 draft published for consultation was heavily criticised and resulted in a revised design curve being adopted in the final 1994 version of the Standard (Figure 5).

Figure 5: Australian DLR Variations During Drafting of AS/NZS 1547, 1992 to 1994



What is evident from the difference in the two LTAR curves is that the original 1992 draft values of LTAR were arbitrarily halved to produce the final 1994 design curve. The other notable factor in the design approach was that the DLR (LTAR) values were used for sizing combined trench bottom area plus sidewall.

Subsequently concerns were raised throughout Australia where individual States were not happy with the validity of the national Standard, and resulted in Standards Australia approaching Standards NZ in 1994 to set up a Joint Standards Committee to review AS 1547:1994.

Review of Design Loading Rates

When the combined group of Australian and New Zealand specialists appointed to the joint committee were assigned the task of drawing up a replacement for the newly issued AS 1547-1994 “Disposal Systems for Effluent from Domestic Premises” and making the resulting document relevant to both countries, they began by examining the design rules for sizing effluent soakage systems in current practice. Australian, New Zealand and North American practice was assessed, and this turned up very significant differences in design loading rates for equivalent household wastewater flows into equivalent soil types (See Table 3). It is clear from the wide variation in design loading rates that the agencies responsible for them have probably developed the present numbers through an evolutionary process based on a response to historical field performance problems. This has resulted in a shift from less conservative to more conservative design criteria with the objective of increasing the factor of safety in design so as to compensate for:

- poor soil assessment practices;
- flawed design loading rate choices;
- inadequate supervision of construction;
- short cuts in installation practices; and
- negligible operation and maintenance attention.

Taking trench soakage systems as an example, the relationship between selected design loading rate (mm/d) and its application over either trench bottom area alone, trench bottom area plus sidewall area, or trench sidewall area alone, results in wide variations in size of installed system. This is illustrated in Table 4 which draws on a range of loading rates from Table 3, and applies them to a 3 bedroom dwelling with 5 persons producing 900 litres/day septic tank effluent which is disposed into a 450 mm wide trench system with 225 mm sidewall depth (for design purposes). The soil categories relate to NZ designations for soils as set out in the ARC TP58 design manual.

The wide variations shown in Table 4 throw into question the whole basis upon which design criteria are selected. The approach to loading rate determination appears to be very much “ad hoc”, rather than based upon technical merit or certainty. There is clearly no scientifically or technically based approach which has universal acceptance in achieving a design outcome. This presented a significant challenge to the Committee in developing a joint Standard applicable to two separate countries with widely varying regulatory structures and design practices. The Committee decided that there was no universally agreed technical basis for sizing soil soakage systems that it could claim would be superior to all the design codes and rules already in use. A new approach was required. It therefore set about developing a Standard based on guiding the process of implementation of on-site systems to achieve sustainable performance, and decided on DLR values by consensus.

The Committee agreed that the approach to revising AS 1547 had to centre on the “performance” of the implementation processes that achieve on-site wastewater servicing, and the “performance” of those persons who have responsibility for carrying out those implementation processes. The approach needed to be flexible enough to provide for different administrative structures in both countries, and to take into account variations in design, regulatory approval procedures, geographic and topographic characteristics, and land development pressures and methodologies. Given that much of on-site wastewater design practice has been more an “art” than a “science”, sufficient factors of safety are required to ensure that performance objectives are met. The Standard must thus set up a framework to ensure that:

- a quality implementation process is set in place, and
- levels and lines of responsibility for implementation are clearly defined.

The move away from prescriptive requirements for “effluent disposal” in setting DLR rates to the “management” of the process of on-site wastewater practice was reflected in the change in title for the Standard, “Disposal Systems for Effluent from Domestic Premises” becoming “On-site Domestic Wastewater Management”.

Table 3: Review of Septic Tank Effluent Soakage Trench Design Loading Rates [Ref. 6]

AGENCY and/or TECHNICAL GUIDELINE	SOIL CATEGORY (NZ) and LOADING RATES mm/day (litres/m^2/day)						
	1 **Gravel, course sand; rapid draining**	**2** **Course to medium sand; free draining**	**3** **Medium fine and loamy sand; good drainage**	**4** **Sandy loam, loam and silt loam; moderate drainage**	**5** **Sandy clay-loam, clay-loam and silty clay-loam; moderate to slow drainage**	**6** **Sandy clay, non-swelling clay and silty clay; slowly draining**	**7** **Swelling clay, grey clay, hardpan; poorly or non-draining**
1. Auckland Regional Council Environment and Planning Division-Technical Publication No. 58: 1994	50 to 70	35 to 50	20 to 30	15 to 22	10 to 15	-	-
		Bottom	area	design	loading		
2. NZS 4610:1982	78	78	39	39	26	Special designs necessary	Special designs necessary
	(Bottom area with special trench design)	Equivalent	bottom area	design	loading		
3. NZS 4610:1982	39	39	19	19	13	-	-
	Bottom	area plus	sidewall	design	loading		
4. US-EPA: 1980	-	49	33	24	18	8	-
		Bottom	area	design	loading		
5. AS 1547:1990 [Draft]	-	60	47	38	30	18	(10)
		Bottom	area plus	sidewall	design	loading	
6. AS 1547:1994	-	32	25	20	15	10	(5)
		Bottom	area plus	sidewall	design	loading	
7. State of Maine: 1984	-	40	20	16	12	10	-
		Bottom	area	design	loading		
8. Larimer County, Colorado: 1984	-	22	14	10	7	-	-
		Bottom	area	design	loading		
9. Jenssen & Siegrist (Water Science Technology Vol. 22 No. 3/4): 1990	50	50	25	25	10	10	-
		Bottom	area	design	loading		
10. South Australia Standard: 1998	-	15	15	15	15	10	<10
		Bottom	area	design	loading		
11. Metcalf & Eddy: 1991	-	8	8	8	6	6	6
	Sidewall	area [Based on	design LTAR	loading = clogging	[six mat	monthly values]	alternation]

Table 4: Trench total length for NZ Category 3 and 5 soils for land application of 900 litres per day (3 bedroom household) [Ref. 6]

Agency and/or Technical Guideline		Length of 450 by 450 mmTrench	
		<u>Category 3 (NZ) Soil</u> (Medium fine and loamy sand; good drainage)	<u>Category 5 (NZ) Soil</u> (Sandy clay-loam, clay-loam and silty clay-loam; moderate to slow drainage)
1.	AS 1547:1994 (bottom plus sidewall)	40 m	67 m
2.	NZS 4610:1982 (bottom plus sidewall)	51 m	77 m
3.	US-EPA:1980 (bottom area)	61 m	111 m
4.	State of Maine:1984 (bottom area)	100 m	167 m
5.	TP 58 (Auckland Regional Council:1989) (bottom area; most conservative value)	100 m	200 m
6.	Metcalf and Eddy:1991 (sidewall area)	125 m	167 m
7.	South Australia:1988 (bottom area)	133 m	133 m
8.	Larimer County, CO:1984 (bottom area)	143 m	285 m

DLR values TP58 (1994) versus the AS/NZS 1547 (2000)

At the commencement of the Joint Standards Committee review of AS 1547 the NZ design manual TP58 (1994) provided a reference source for which no equivalent manual was available in Australia. Thus in setting DLR values the Committee utilised TP58 along with the US Environmental Protection Agency (USEPA) 1980 design manual. Hence the assignment of DLR values to soil texture and structure classes (Table 5) was the result of Committee consideration of values in existing practice.

The Committee was also influenced by the aerated wastewater treatment industry representatives on its membership who submitted that reduced DLR values should be used for secondary quality effluent land application. This arose from the fact that there had been a move in Australia away from septic tank systems to aerated wastewater treatment systems (AWTS) in an effort to counter the high failure rates of septic tank trench systems countrywide. Widespread adoption of AWTS systems discharging to garden lawns and backyards via spray irrigation had become widely utilised. However lack of management and regulatory oversight of spray irrigation of secondary effluent generated significant “failure” rates in many areas – the mind-set that setting appropriate DIR (design irrigation rate) values was all that was required to achieve satisfactory effluent disposal still persisted. The importance of proper operation and maintenance management was ignored. Hence the industry asked for relaxed DLR values to facilitate design of subsurface (trench) application of secondary effluent.

Tables 5 and 6 set out a comparison between trench DLR values for AS/NZS 1547:2000, TP58 (1994) and the updated EPA design manual of 2002 for septic effluent and secondary effluent respectively.

Table 5: COMPARISON of SEPTIC TANK EFFLUENT DESIGN LOADING RATES (DLR) for TRENCHES AS/NZS 1547 (2000) versus TP 58 (1994) versus EPA (2002)[1]

AS/NZS 1547:2000 On-site domestic wastewater management (Standard)

Soil Category	Texture (Structure)	DLR Conservative mm/day	DLR Maximum mm/day
1	Gravels and sands (structureless)	20	35
2	Sandy loams (weak) (massive)	 20 15	 35 25
3	Loams (high/moderate) (weak)	 15 10	 25 15
4	Clay loams (high/moderate) (weak) (massive)	 10 6 4	 15 10 5
5	Light clays (strong) (moderate) (weak)	 5 NA NA	 8 5 NA
6	Medium to heavy clays (strong) (moderate) (weak)	 NA NA NA	 NA NA NA

TP 58 (1994) Auckland Regional Council (Design Manual)

Soil Category	Texture (Structure)	DLR Conservative mm/day	DLR Maximum mm/day
1	Gravel, coarse sand	50	70
2	Coarse to medium sand	35	50
3	Medium fine and loamy sand	20	30
4	Sandy loam, loam, silt loam	15	22.5
5	Sandy clay loam, clay loam, silty clay loam	10	15
5A	Windblown sand		
6	Sandy clay, non swelling clay, silty clay	NA	NA
6A	Windblown sand		
7	Swelling clay, grey clay, hard pan	NA	NA

EPA (2002) Onsite wastewater treatment systems (Manual)

Soil Category [2]	Texture	(Structure)	DLR mm/day
1	Coarse sand, loamy course sand, loamy sand	(structureless)	32
3	Coarse sandy loam, sandy loam	Non-platy[3] (moderate) (weak)	 24 16
5 & 6	Loam Silt loam	Non-platy[3] (moderate) (weak)	 24 16
7	Sandy clay loam, clay loam, silty clay loam	Non-platy[3] (moderate) (weak)	 16 8
8	Sandy clay, clay, Silty clay	Non-platy[3] (moderate) (weak)	 8 NA
2	Fine sand, very fine sand, loamy fine sand	(structureless)	16
4	Fine and very fine sandy loam	(moderate) (weak)	16 8

Notes:
1. Information sources - AS/NZS 1547 (2000), Table 4.2A1, page 116; TP 58 (1994), Fig 8.1, page 67; EPA (2002) Table 4-3, page 4-12.
2. The Maximum DLR for Category 4 Clay loams of high/moderate structure was set inadvertently at 10mm/day – this is corrected to 15mm/day in this comparison Table.
3. The EPA Soil Categories are not specifically numbered. The numbers in this column represent the order in which they are listed in Table 4-3.
4. The EPA structure classes include "Platy", and "Prismatic, blocky, granular". The information given in the above table relates to only the "Prismatic, blocky, granular" category, and therefore labeled "non-platy". Category 3 platy soil has 8 mm/day assigned to it. All other platy structured soils have no recommended loading rates.

Table 6: COMPARISON of SECONDARY EFFLUENT DESIGN LOADING RATES (DLR) for TRENCHES AS/NZS 1547 (2000) versus TP 58 (1994) versus EPA (2002)[1]

AS/NZS 1547:2000 On-site domestic wastewater management (Standard)

Soil Category	Texture (Structure)	DLR mm/day
1	Gravels and sands (structureless)	50
2	Sandy loams (weak) (massive)	 50 50
3	Loams (high/moderate) (weak)	 50 30
4	Clay loams (high/moderate) (weak) (massive)	 30 20 10
5	Light clays (strong) (moderate) (weak)	 12 10 8
6	Medium to heavy clays (strong) (moderate) (weak)	 NA NA NA

TP 58 (1994) Auckland Regional Council (Design Manual)

Soil Category	Texture (Structure)	DLR mm/day
1	Gravel, coarse sand	NA
2	Coarse to medium sand	NA
3	Medium fine and loamy sand	NA
4	Sandy loam, loam, silt loam	NA
5	Sandy clay loam, clay loam, silty clay loam	NA
5A	Windblown sand	
6	Sandy clay, non swelling clay, silty clay	NA
6A	Windblown sand	
7	Swelling clay, grey clay, hard pan	NA

EPA (2002) Onsite wastewater treatment systems (Manual)

Soil Category[2]	Texture	(Structure)	DLR mm/day
1	Coarse sand, loamy course sand, loamy sand	(structureless)	65
3	Coarse sandy loam, sandy loam	Non-platy[3] (moderate) (weak)	 40 28
5 & 6	Loam Silt loam	Non-platy[3] (moderate) (weak)	 32 24
7	Sandy clay loam, clay loam, silty clay loam	Non-platy[3] (moderate) (weak)	 24 12
8	Sandy clay, clay, Silty clay	Non-platy[3] (moderate) (weak)	 12 NA
2	Fine sand, very fine sand, loamy fine sand	(structureless)	40
4	Fine and very fine sandy loam	(moderate) (weak)	32 24

Notes:
1. Information sources - AS/NZS 1547 (2000), Table 4.2A1, page 116; EPA (2002) Table 4-3, page 4-12. [The 1994 Edition of TP 58 provides no secondary effluent DLR values]
2. The EPA Soil Categories are not specifically Numbered. The numbers in this column represent the order in which they are listed in Table 4-3.
3. The EPA structure classes include "Platy", and "Prismatic, blocky, granular". The information given in the above table relates to only the "Prismatic, blocky, granular" category, and therefore labeled "non-platy". Category 3 platy soil has 20 mm/day assigned to it. All other platy structured soils have no recommended loading rates.
4. For Soil Category 1 an LPED distribution system is required for TP58 trenches. This has been improved in AS/NZS 1547:2000 by requiring discharge control trenches in Category 1.

For AS/NZS 1547:2000 the Committee adopted 6 soil categories instead of the seven in TP58. Effectively TP58 categories 1, 2 and 3 have being merged into AS/NZS 1547 Categories 1 and 2 with an overlap into Category 3. The LPED distribution requirement of TP58 for course texture soils was upgraded to using discharge control trenches in AS/NZS 1547 for soil Category 1

AS/NZS 1547 made a significant reduction in DLR for the course texture soils of TP58 Categories 1 and 2. Table 5 shows that there is a close correlation in DLR values and soil categories AS/NZS 1547 Categories 2 to 4 with TP58 equivalent Categories 3 to 5. However AS/NZS 1547 introduces soil structure classes (which reflects the approach adopted by the USEPA) within each soil texture Category, and provides graduated DLR values accordingly. For Category 4 this introduces a range of three DLR values as soil texture tightens up compared to the single DLR value for TP58 Category 5.

Table 6 is a comparison between secondary treated effluent DLR values for trench systems for AS/NZS 1547 and USEPA. TP58 (1994) made reference to use of “least conservative” DLR values for improved effluent quality (such as from secondary treatment). Except for the upper limits on DLR secondary treated effluent of 50mm/day for gravels and sands in Categories 1 and 2, secondary effluent DLR values in AS/NZS 1547 were two times the maximum (least conservative) primary effluent values, as had been advocated by the Australia AWTS industry.

Developments from 2000 to 2018

Update of TP58 from 2nd Edition 1994 to 3rd Edition 2004

During a review of TP58 undertaken by the Auckland Regional Council (ARC) differences in DLR values were developed between the 2004 and 1994 editions as shown in Table 7.

Table 7: DLR for Trenches – Comparison TP58 (1994) and TP58 (2004)

Soil Categ.	Soil type	Loading Rate(DLR) mm/day				
		TP58 (1994) [Primary Effluent]		TP58 (2004) [Primary Effluent]		TP58 (2004) [Secondary Effluent – AS/NZS 1547] (Not permitted in Auckland Region)
		Most Conservative (minimum)	Least Conservative (maximum)	Most Conservative (minimum)	Least Conservative (maximum)	
1	Gravel, coarse sand – rapid draining [special effluent distribution techniques required, e.g. LPED]	50	70	35	50	50
2	Coarse to medium sand – free draining	35	50	25	35	50
3	Medium fine and loamy sand – good drainage	20	30	20	30	30 to 50
4	Sandy loam, loam and silt loam – moderate drainage	15	22.5	15	20	30
5	Sandy clay, clay loam and silty clay loam – moderate to slow drainage	10	15	5	10	10 to 30
6 & 7	Clay type soils of slow to non-raining characteristics	Conventional trenches not appropriate		Conventional trenches not appropriate		8 to 12

The reductions in DLR values for soil Categories 1, 2 and 5 between TP58 1994 to 2004 were in line with AS/NZS 1547:2000. In addition the ARC rejected use of reduced DLR values for secondary effluent into trenches, noting that the recommended values in AS/NZS 1547 were around two-times the most conservative DLR for primary (septic) effluent and were “not permitted in the Auckland Region”.

Revision of AS/NZS 1547:2000 and production of AS/NZS 1547:2012
The revision of the 2000 version restructured the content and introduced risk management sections into the Standard. The methodology of implementing on-site wastewater systems remained unchanged, with DLR values for trench systems being retained, Table 4.2A1 being replaced by Table L1.

Update of TP58 from 3rd Edition 2004 to Draft Guideline Document GD006 2018
Following the merging of the ARC and local bodies in the Auckland region to become Auckland City, the Council set about reviewing all Technical Publications and converting them to "guideline" documents. The review of TP58 began in 2015 culminating in the issue of a "draft for consultation" in July 2018.

Table 8 sets out a comparison between the GD006 (2018 – Draft) DLR values for trench systems and those in TP58 (2004) and AS/NZS 1547 (2012). GD006 has done away with the range of DLR values set out in the "most conservative" and "least conservative" categories of TP58 and AS/NZS 1547, and adopted a single DLR primary effluent set of values at the lower conservative rates of these two documents. However GD006 has introduced secondary effluent loading rates which were originally cited as "not permitted in the Auckland Region" in TP58 (2004)

The main differences in GD006 compared to TP58 and AS/NZS 1547 are that:
- GD006 introduces six soil Categories to replace the seven of TP58;
- the single set of DLR values in GD006 is set at the conservative (minimum) rate of AS/NZS 1547;
- GD006 DLR values for soil categories 1 and 2 are lower than in TP58, with a range of structure related values in soil Categories 3 and 4.
- secondary effluent DLR values for trenches are introduced by GD006 for the Auckland region; and
- the secondary treated effluent DLR values for soil Categories 1 and 2 are significantly lower than those in AS/NZS 1547.

The more conservative approach taken in GD006 in abandoning least conservative (maximum) DLR values and reducing secondary effluent DLR values for porous soil categories appears to be based on regulatory policy considerations rather than any new scientific or field performance evaluations relating DLR to LTAR..

Findings

1.) The early 1950s approaches to trench system sizing based on percolation testing was found wanting with the relationship between effluent application, soil clogging and LTAR leading to setting of DLR values according to soil texture.
2.) Initial DLR settings in TP58 (1989 and !994) were evaluated by the joint Australia/New Zealand Standards Committee along with design values from the USEPA, resulting in a more conservative approach to sizing trench systems than provided in TP58.
3.) TP58 (2004) adopted the conservative DLR values of AS/NZS 1547:2000, but rejected for the Auckland region the Standard's approach to reduced sizing of trenches for secondary effluent quality
4.) The proposed Guidance Document: On-site Wastewater Management in the Auckland Region (GD006 2018-Draft for Consultation) sets primary treated effluent DLR values at the most conservative (minimum) rate of AS/NZS 1547:2012. However it introduces DLR values for secondary effluent applicant to trench systems, although the values for soil Categories 1 and 2 are significantly lower than those in AS/NZS 1547.

Overall it would appear that development of DLR values for the several standards, manuals and guidelines considered in this review are based more on policy and regulatory requirements than on research and investigation relating soil characteristics to capability in treating and absorbing effluent residuals during subsoil infiltration.

Table 8: DLR for Trenches – Comparison AS/NZS 1547 (2012), TP58 (2004) and GD006 (2018 Draft)

Soil Category [GD006]	Soil Texture [GD006]	Soil Structure [GD006]	Loading Rate (DLR) mm/day					
			AS/NZS 1547 (2012)		TP58 (2004)		GD006 (2018 – Draft)	
			Primary Effluent (conservative rate)	Secondary Effluent	Primary Effluent (conservative rate)	Secondary Effluent (not permitted Auckland Region)	Primary Effluent (conservative rate)	Secondary Effluent
1	Gravel and sand	Structureless	20	50	35	50	20	25
2	Loamy sand, sandy loam	Weakly structured	20	50	25	50	20	25
		Massive	15	50	20	30 to 50	15	30
3	Fine sandy loam, loam and silt loam	High/moderate structure	15	50	15	30	15	30
		Weakly structured or massive	10	30			10	30
4	Sandy clay loam, fine sandy clay, clay loam, silty clay loam	High/moderate structured	10	30	5	10 to 30	10	30
		Weakly structured	6	20			8	20
		Massive	4	10			4	10
5	Sandy clay, light clay, silty clay	Strongly structured	5	12	Not advised	8 to 12	5	12
		Moderately structured	Not advised	10	Not advised		Not advised	10
		Weakly structured or massive	Not advised	8	Not advised		Not advised	8
6	Clays (including swelling and grey), hard pan	Strongly structured	Not advised	Not advised	Not advised	Not advised	Not advised	Not advised
		Moderately structured	Not advised	Not advised	Not advised	Not advised	Not advised	Not advised
		Weakly structured or massive	Not advised	Not advised	Not advised	Not advised	Not advised	Not advised

References

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3. CP44:1961 Disposal of Effluent from Household Septic Tanks (NZ Standards Institute Code of Recommended Practice)
4. NZS 4610:1982 Household Septic Tank Systems (NZ Standard – Standards Association of NZ)
5. TP58 1989 On-site Wastewater Disposal from Households and Institutions (Auckland Regional Water Board Technical Publication No. 58)
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