HENDERSON

DETERMINATION OF PERCENT SAND IN WATERSHEDS
MAY 5, 1986

DISCLAIMER: The results of this report are preliminary and have not been officially approved by this district. Therefore, the views expressed herein are not necessarily the official views of the Fort Worth District or the U.S. Army Corps of Engineers.

INTRODUCTION

The procedure for determining percent sand in a watershed has been a point of confusion for a long time. This confusion is chiefly due to the fact that there has not been a standard method established for computing percent sand and the lack of a good description of a sandy soil. This report will describe sand and clay soils as used in the paper "Effects of Urbanization on Various Frequency Peak Discharges" dated October 1977, by Paul K. Rodman. Also, a standard method for determining percent sand will be given.

The Fort Worth District uses the clay and sandy loam urbanization curves developed by T.L. Nelson and Paul K. Rodman to determine Snyder's tp value for ungaged watersheds. The clay curves were based upon data from watersheds with primarily Houston Blackland clay soils and the sandy loam curves were derived from areas containing mostly Cross Timbers or Crosstell sandy loam soils. The assumptions made in developing the curves dealt more with the characteristic topographical and vegetative features which accompany the soil type rather than the soil texture. Therefore, the actual percent sand contained in the soil morphology should be a minor consideration when computing percent sand for a watershed.

The Houston Blackland clay soil under natural conditions is generally prairie land with grasses or row crops for vegetative cover. Also, this soil usually has well defined channels with slopes from 0 to 3 percent. The Houston clay is a moderately alkaline soil to a depth of 80 inches or more and has a very slow permeability rate that is less than 0.06 inches per hour.

The Crosstell soil generally contains more trees and brush throughout the watershed which retard flow. Also, this soil has channels which are smaller in capacity and less defined. Typically, the surface layer for the Crosstell Series is made up of brown fine sandy loam about 5 inches thick with a relatively impervious clay underneath. Permeabilities range from 0.6 to 2.0 inches per hour for the sandy loam layer to less than 0.06 inches per hour for the clay sublayer.

PERCENT SAND COMPUTATION METHODS

In order to determine the best procedure to compute percent sand, the following methods were evaluated as identified by a Hydrologic Engineering Section task group: Soil Conservation Service (SCS) hydrologic soil groups, United States Geological Survey (USGS) 7.5 minute quad maps, sieve size, United States Department of Agriculture (USDA) soil description, and permeability rate. The assumptions of percent sand for each of these methods are discussed below.

The SCS has divided soils into four hydrologic soil groups which are used to estimate runoff. The four groups are A, B, C, D with A having the lowest runoff potential and D having the highest runoff potential. For the purpose of this paper, group A was assigned a percent sand of 100 and group D 0 percent with groups B and C 66 and 33 percent, respectively. A weighted percent sand is computed based upon the amount of each soil group in the watershed.

Using USGS quad maps, the green areas are assigned a percent sand value of 100 percent and the white areas 0 percent sand. A weighted percent sand is determined based upon the amount of green and white areas in the watershed.

The sieve method uses the table of physical and chemical properties found in the SCS soil surveys. This table gives the percent clay which will pass a 0.002 millimeter sieve. The percent sand for each soil type is found by subtracting the percent clay from 100. This method only measures the amount of soil which is not clay. A weighted percent sand is determined based upon the percent sand derived for each soil type in the subarea.

The USDA soil description procedure is based upon the textural classification chart which has twelve classes ranging from clay to sand. The percent sand for each soil type is determined using the maximum percent sand given on the textural chart, figure 1, for each of the twelve soil classes. The percent sand for the watershed is computed by weighting the percent sand for each soil in the area.

The permeability rate method uses the range of permeabilities found in the table of physical and chemical properties in the SCS soil surveys for multiple soil classifications and assigns a percent sand to each of the seven ranges. A percent sand of 0 is given to any soil with a permeability less than 0.06 inches per hour which corresponds to the permeability of the Houston Blackland clay upon which the clay urban curves are based. Also, a percent sand of 100 is given to any soil with a rate of 0.6 to 2.0 inches per hour which corresponds to the Crosstell series soil upon which the sandy loam curves are based. The percent sand for the permeability ranges 0.06 to 0.2 inches, 0.2 to 0.6 inches, 2.0 to 6.0 inches, 6.0 to 20.0 inches, and greater than 20 inches are 33, 66, 133, 166, 200 percent sand, respectively. Each soil in the watershed is assigned a percent sand based upon its permeability and a weighted average is computed.

The various methods of determining percent sand were applied to four drainage basins: Walnut Creek near Mansfield, Texas; a subarea of Singing Hills Creek in Watauga, Texas; a second subarea of Singing Hills Creek in Watauga, Texas; and Little Fossil Creek near Haltom City, Texas. The results of this analysis are shown in tables 1, 2 and 3.

Of all the methods studied, the permeability method of determining percent sand was determined to be the best method. The permeability method gave fairly consistant results and replicated earlier studies well. The other methods have severe limitations which preclude their applicability.

Little Fossil Creek near Haltom City was one of the drainage areas used in developing the Fort Worth-Dallas Clay Urbanization Curves. In that study, the percent sand of the watershed was determined to be 0 percent. Applying the permeability method to the 1981 detailed soil survey of Tarrant County yielded a percent sand of 23. The increase in percent sand may be attributable to the availability of more detailed soil maps which identified pockets of more permeable soil. The soil maps used during the development of the urbanization curves were dated in the 1920's.

Walnut Creek near Mansfield was used in developing the Fort Worth-Dallas Sandy Loam Urbanization Curves. In that study, the percent sand of this watershed was determined to be 90 percent. Applying the permeability method to the 1924 soil survey of Tarrant County yielded a percent sand of 90. Applying the permeability method to the 1981 detailed soil survey of Tarrant County yielded a percent sand of 92. These replications of the original study support the use of the permeability method to determine percent sand. The permeability method can be applied to any soils map as long as there is a correlation between soil type and permeability.

PERCENT SAND COMPUTATION METHOD DISADVANTAGES

The major disadvantage of the hydrologic soil group method is the Crosstell soil and the Houston Blackland soil are in the same hydrologic soil group, group D. However, Crosstell soil is considered 100 percent sand and the Houston Blackland soil is considered 0 percent sand. An area totally comprised of Crosstell soil would be 0 percent sand using the hydrologic soil group method, but it should be 100 percent sand by definition using the Dallas-Ft. Worth Sandy Loam Urban Curves.

The major disadvantage of using the USGS 7.5 minute topographic maps is the over-simplification of actual field conditions. Another problem is that urbanization shown on the map gives no clue as to the underlying soil type. The advantage of using topographic maps is that it yields a quick result, though not necessarily an accurate one. Ground sampling in the watershed is necessary for this method to become a useful estimate of percent sand.

The major disadvantage of the sieve method is it measures the amount of clay by grain size in a soil, then assumes the rest of the material is sand. This leads to an over-estimation of percent sand.

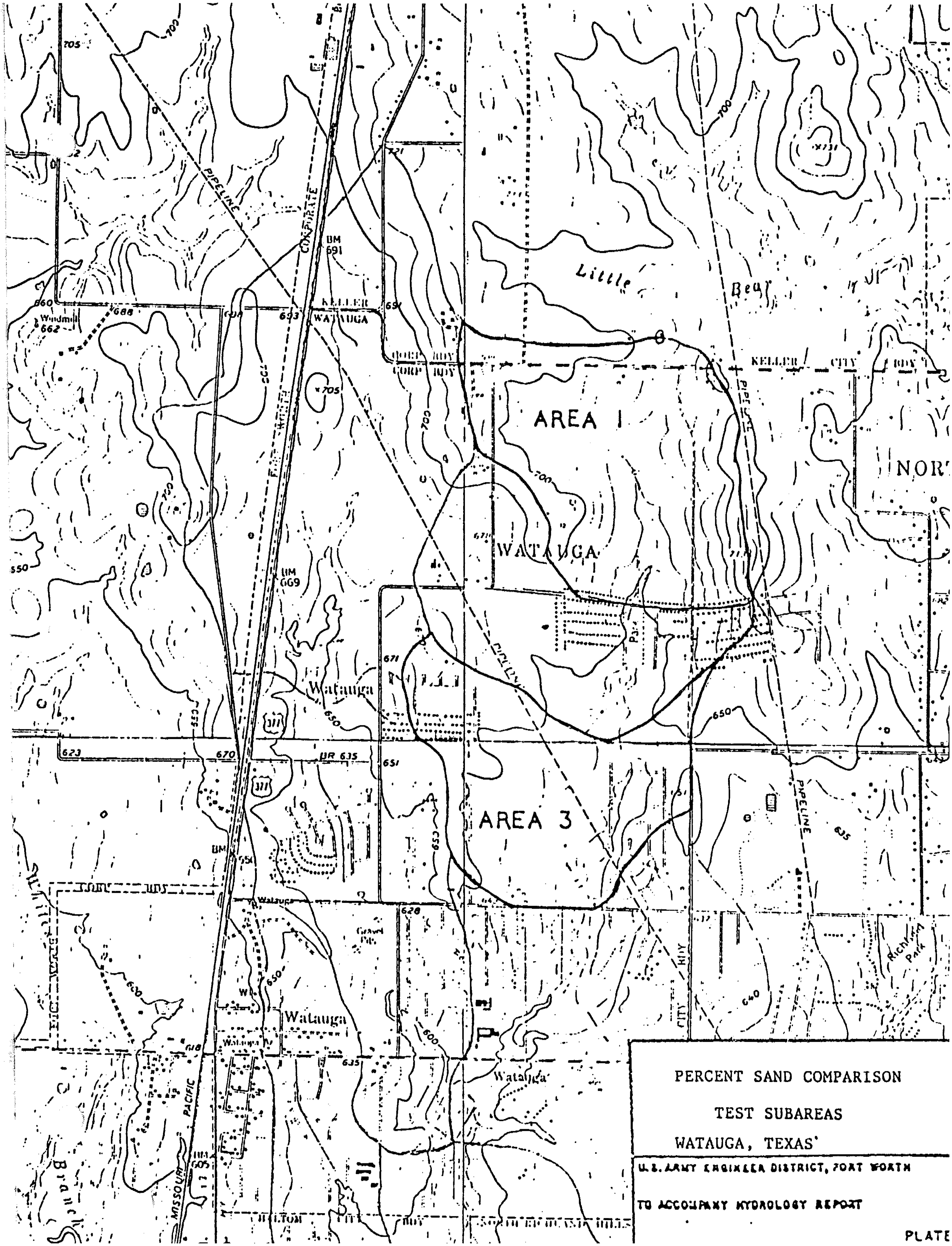
The major disadvantage of the USDA soil description is the difficulty of assigning a value of percent sand to each soil description. Clay can contain up to 45 percent sand according to the USDA. For this study, a range of values was developed. This range attempts to indicate the average sand percentage to the maximum sand percentage in the watershed. Again, which percent sand value to pick is a difficult choice.

The major disadvantages of the permeability rate method are, the potential of computing over 100 percent sand and the lack of data on soils classified as urban land. On soils with very high permeability rates, the percent sand computation can be greater than 100 percent sand. The reasonableness of percent sand values greater than 100% must be verifiable and documented. Also, urban land can not be classified by this method as a sand or clay because of the unavailability of physical data.

CONCLUSIONS

The permeability method should not be used indiscriminately. Consideration should be given to other factors in the watershed such as vegetative cover. For instance, the Houston Blackland clay soil is typically covered by grasses or row crops whereas Crosstell sand soil is typically covered by more trees and brush. A clayey soil covered by forest may tend to hydrologically respond more like a sandy soil. It is therefore up to the engineer to determine if the results from the permeability method are reasonable or need adjustment.

The purpose of this paper was to present a standard method for determining percent sand of a drainage basin. After considering several alternative methods, the permeability method was determined to be the best. This method replicated earlier studies well and is easily applied to any drainage basin as long as a correlation between soil groupings and permeability exists.



PERCENT SAND COMPARISON

TEST SUBAREAS

WATAUGA, TEXAS

U.S. ARMY ENGINEER DISTRICT, FORT WORTH

TO ACCOMPANY HYDROLOGY REPORT

PLATE

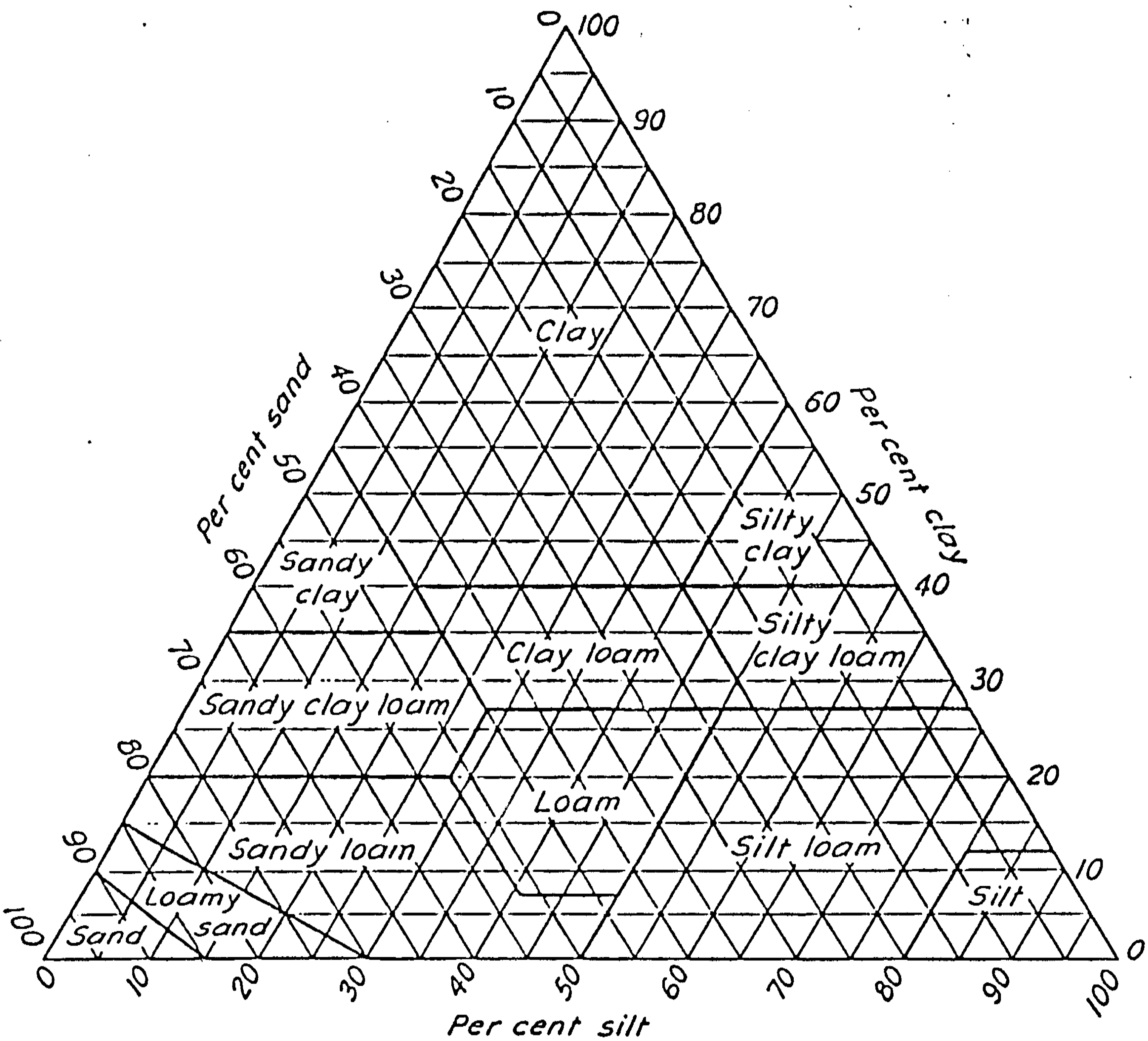


FIGURE 1. Triangular textural classification chart used by the U. S. Department of Agriculture.

Table 1

Percent Sand Determination
Methods Comparison

Singing Hills Creek
Watauga, Texas

Area	Method				
	USGS 7.5 Minute Topographic Map	Hydrologic Soil Group	Permeability	USDA Soil Description	Sieve Method
1	0	1	37	30-47	62
3	0	10	30	23-42	56

Table 2

Percent Sand Determination
Methods Comparison

Walnut Creek
Mansfield, Texas

	Method			
	Hydrologic Soil Group	USGS 7.5 Minute Topographic Map	Permeability	
			1924 Soil Survey of Tarrant County	1981 Soil Survey of Tarrant County
Percent Sand	30	40	90	92

Table 3

Percent Sand Determination
Methods Comparison

Little Fossil Creek
Haltom City, Texas

Method

	Hydrologic Soil Group	Permeability	USDA Soil Description
Percent Sand	9	23	23-42